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Putting the pieces together: The connection between detail orientation, verbal ability, and object categorization in autism

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Putting the Pieces Together: The Connection between Detail Orientation, Verbal Ability and Object Categorization in Autism

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Abstract

Autism is a pervasive developmental disorder characterized by disrupted language development, social deficits, and atypical patterns of interacting with objects. Evidence suggests that this stems from a tendency for children with autism to not focus on relationships between details in their environments (e.g., Happé & Booth, 2008). Typically developing (TD) children, on the other hand, tend to focus on overall impressions, a bias that appears to follow a prescribed developmental course. For example, while early on TD children tend to focus on fine grain detail to categorize objects, later on they focus on an objects’ overall shape (Pereira & Smith, 2009; Smith, 2003). The current study investigates whether the same developmental progression holds for children with autism. In particular, the study explores how the vocabulary size of children with autism relates to their ability to categorize objects on the basis of their overall shape (vs. fine-grain detail) and how this relation compares to typically developing children. This is a first step towards mapping out the relation between autism and the development of an adaptive tendency to detect higher-order Gestalts.
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# Table of Contents

List of Figures

<table>
<thead>
<tr>
<th>Chapter I: Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter II: Experiment</td>
</tr>
<tr>
<td>Participants</td>
</tr>
<tr>
<td>Stimuli</td>
</tr>
<tr>
<td>Language Measure</td>
</tr>
<tr>
<td>Procedure</td>
</tr>
<tr>
<td>Chapter III: Results</td>
</tr>
<tr>
<td>Preliminary Analysis: Performance on the Language Measure</td>
</tr>
<tr>
<td>Preliminary Analysis: Effects of Gender and Test Version</td>
</tr>
<tr>
<td>TD Categorization Performance</td>
</tr>
<tr>
<td>Autistic Categorization Performance</td>
</tr>
<tr>
<td>Comparative Analyses</td>
</tr>
<tr>
<td>Chapter IV: Discussion</td>
</tr>
<tr>
<td>References</td>
</tr>
<tr>
<td>Appendix</td>
</tr>
</tbody>
</table>
List of Tables and Figures

Table 1. Number of TD Participants in Each Vocabulary Group, Their Mean and Range for Age, and Their Mean Vocabulary Size as Measured by the MCDI Separated by 3 Vocabulary Groups for the Current TD Results and Those from Pereira & Smith (2009).

Table 2. Number of TD(Both Full-Sample and Matched Sample) and Participants with Autism, Mean Value and Range for Age and Number of Count-Nouns in Productive Vocabulary as Measured by the MCDI Separated by 2 Vocabulary Groups Using Criteria from Smith (2003).

Table 3. Number of Participants with Autism, Mean Value and Range for Age and Number of Count-Nouns in Productive Vocabulary as Measured by the MCDI Separated by 3 Vocabulary Groups using Criteria from Pereira & Smith (2009).

Figure 1. Two test stimuli as described by Ozonoff et al. (1994) and Plaisted et al. (1999), showing (A) a Gestalt “H” comprised of small “Ss” and (B) a Gestalt “H” comprised of small “Hs.”

Figure 2. Examples of stimuli taken from Kimchi (1990; Experiment 1) showing (a) a stimulus object consisting of three, proportionally large triangles (top) and two test objects, one which preserves the relative proportion of the triangles, and a second which instead extends the original pattern. The bottom triad (b) shows a stimulus object made of many small triangles (top) and two test objects, one preserving the relative proportions of the stimuli and the other which extends the original pattern.

Figure 3. Example of a stimulus (top) from Caron et al. (2006; Experiment 2) with four test configurations (bottom). Participants were to pick which configuration matched the stimulus.

Figure 4. Examples of (A) a detailed turtle, (B) a rich-shape turtle, and (C) a shape abstraction turtle.

Figure 5. Hypothetical test setup showing a fish, car and pig in the shape abstraction condition.

Figure 6. Typically developing children: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Dashed lines represent vocabulary groups utilizing the methodology of Pereira & Smith (2009).

Figure 7. Difference between performance on (A) detailed objects and shape abstractions and (B) rich-shape objects and shape abstractions for TD children as a function of vocabulary size.
Figure 8. Average percent correct responses for each object condition for current TD participants as compared to Pereira & Smith (2009), by vocabulary group.

Figure 9. Average percent correct responses for each object condition for current TD participants (full sample), current participants with autism, and matched TD participants, by vocabulary group.

Figure 10. Children with autism: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Dashed lines represent vocabulary groups utilizing the methodology of Pereira & Smith (2009). Solid lines represent vocabulary groups using the criteria of Smith (2003).

Figure 11. TD children – matched sample: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Solid lines represent vocabulary groups using the criteria of Smith (2003).
Chapter I: Introduction

Autistic disorder, or “classic” autism, affects an estimated 1 in 500 children (Fombonne, 2009). Considered a pervasive developmental disorder, it is characterized by the presence of restricted patterns of behaviors and interests, as well as significant impairments in socialization and language (DSM-IV-TR; American Psychiatric Association, 2000). According to the diagnostic manual, these impairments manifest in various ways: Children often demonstrate repetitive, self-stimulating behaviors (e.g., arm flapping) and abnormal responses to sensory stimulation. Language impairments may range from a total inability to speak or an inability to use language effectively. Indeed, children with autism who do develop verbal language often have marked difficulties with semantics (Norbury, Griffiths & Nation, 2010). Socially, symptoms usually surround poor eye contact, emotional reciprocity, and joint attention (American Psychiatric Association, 2000; Klinger, Dawson, & Renner, 2003). And despite advances in early interventions, children with autism tend to have poor overall outcomes as adults (Seltzer, Shattuck, & Greenberg, 2004).

An intuitive approach to understanding autism is to search for, or explore, an isolated deficit or abnormality. Such deficit could pertain, for example, to a child’s so-called theory of mind, the degree to which a child understands mental activities (e.g., Baron-Cohen, 1989; Baron-Cohen, Leslie & Frith, 1985; Perner, Frith, Leslie, & Leekam, 1989). Or the deficit could be in areas of a child’s executive function, the top-down mental control that is thought to affect planning, selective attention, or inhibition (e.g., Geurts, Verté, Oosterlaan, Roeyers & Sergeant, 2004; Ozonoff et al., 1991; Ozonoff & Jensen, 1999). Other approaches focus on a deficit in socialization capabilities (e.g., McPartland, Wu, Bailey, Mayes, Schultz & Klin, 2011), or in a deficit in motor coordination and planning (e.g., Fournier, Hass, Naik, Lodha & Cauraugh, 2010;
Jansiewicz, Goldberg, Newschaffer, Denckla, Landa & Mostofsky, 2006; Marsh, Richardson, & Schmidt, 2009). The current research focuses on what one might consider a deficit in children’s ability to connect pieces of information into higher-order Gestalts, also known as the weak-central-coherence theory (e.g., Frith, 1989, Happé & Frith, 2006, Happé & Booth, 2008).

While very different in their emphasis, these proposals are all based on the same implicit assumption, namely that the identified competence is clearly established in typical development. This assumption might not be warranted, however. For example, there are disputes in the question of children’s theory of mind or a child’s executive function (for a summary, Ellis & Bjorklund, 2005). Across domains, performance of typically developing child appears to be strongly dependent on the immediate task context (e.g., Smith, Thelen, Titzer & McLin, 1999), undermining the idea that the healthy development of a particular competence is well understood. In turn, this strong context dependence of task performance undermines an approach that seeks to establish the difference in a competence to account for the difference in autism. A more fruitful approach might be to compare typically developing children and children with autism on the degree to which context affects performance. In the current paper, I explore such an approach, using the general domain of central coherence.

I will first discuss the central-coherence hypothesis, illustrating the notorious context dependence of tasks that measure the degree to which typically developing children are biased towards global Gestalts. I will then turn to findings with autism that show a decreased bias towards Gestalt. However, rather than exploring a difference in bias, I will explore the degree to which changes in context affects performance differently in autism versus typical development.
Global Bias in Typical Development and Context Dependence

Adaptive functioning is centrally dependent on our ability to combine pieces of information into larger wholes and discover higher-order patterns (e.g., Thagard, 1994). For example, to acquire a language, one needs to discover the higher-order statistical regularizes, despite idiosyncratic exceptions in language rules. And to participate in a social interaction, one has to attend to various higher-order rhythms, such as turn taking or synchronization in motion. Indeed, typically developing individuals appear to come equipped with an ability to combine pieces of information into larger wholes, even displaying a bias towards higher-order Gestalt (e.g., Baylis & Driver, 1993; Herrmann & Bosch, 2001; Humphreys, Olson, Romani, & Riddoch, 1996; Kahneman & Henik, 1981; Kahneman & Treisman, 1984; Kramer & Jacobson, 1991; Moore & Egeth, 1997; Navon, 1977).

A classic example of the Gestalt bias comes from a matching task that used displays such as those shown in Figure 1. Figure 1a shows an array of small “S” letters that make up a large letter “H”, and Figure 1b shows an array of small “H” letters that make up a larger letter “H.” The critical task is to decide as quickly as possible whether two items match in the small letters. Findings show a slower reaction time when there is a mismatch between small and large letters than when there is a match, both in adults (Navon, 1977) and typically developing children (Ozonoff et al., 1994; Plaisted et al., 1999). This slowing of performance is not found when the task is to decide whether two items match in the large letter. In other words, the overall shape of the letter composition interferes with how they process the details, but not the other way around (see also Kimchi, 1992; Maurer, Le Grand, & Mondloch, 2002; Pellicano & Rhodes, 2003).

A very different example of a Gestalt bias, relevant for the manipulation of the current study, comes from children’s categorization patterns. After learning the label of a novel object,
2- and 3-year-old children are more likely to extend the label to an object that shares the same overall shape than to an object that shares details in texture or color (e.g., Diesendruck & Bloom, 2003; Landau, Smith, & Jones, 1988; Samuelson & Smith, 2005). This so-called shape bias is similar to a Gestalt bias because children initially focus on a global characteristic of an object (its overall shape) instead of other, more detailed features.

**Figure 1.** Two test stimuli as described by Ozonoff et al. (1994) and Plaisted et al. (1999), showing (A) a Gestalt “H” comprised of small “Ss” and (B) a Gestalt “H” comprised of small “Hs.”

Despite widespread agreement about a bias towards higher-order Gestalt, it is important to note that this bias is not an all-or-none process. It appears that the right context needs to be in place before this bias can be detected. Take, for example, the configural displays shown in Figure 2. Kimchi (1990) showed that the relative size of local elements affects the degree to which children focus on higher-order Gestalts over local details. Kimchi showed children two types of stimuli consisting of configurations of small shapes. In one set of stimuli, the detailed shapes were small in number and relatively large in comparison to the overall configuration (top
of Figure 2a). In the other set, the detailed shapes were large in number and small in comparison to the overall configuration (top of Figure 2b). Children were then asked to select a target object that best matched the initial stimulus. One target choice preserved the number of objects from the original, but increased their size (as if the original was zoomed in). The second increased the number of objects but preserved their intimal size (as if to extend the pattern of the original stimulus). If children were presented with a stimulus like the one at the top of Figure 2a, they matched it with the target which preserved the number of detailed elements. If presented with a stimulus similar to the one at the top of 2b, they selected the target which preserved the size of the local elements, but increased their number. Thus, it appeared that how details relate to one another impacts whether children focus on global (e.g., the overall pattern) or local aspects of a display.

Figure 2. Examples of stimuli taken from Kimchi (1990; Experiment 1) showing (a) a stimulus object consisting of three, proportionally large triangles (top) and two test objects, one which preserves the relative proportion of the triangles, and a second which instead extends the original pattern. The bottom triad (b) shows a stimulus object made of many small triangles (top) and two test objects, one preserving the relative proportions of the stimuli and the other which extends the original pattern.
Similar dependence on the specifics of the task context was reported in children’s tendency to focus on the shape of objects (e.g., Collin & McMullen, 2005). Collin and McMullen showed children images of known objects that were passed through one of two types of filters – low-pass (which remove sharp edges and contrasts, thus “smoothing” an image) or high-pass (which increase contrast and edges). When children had to differentiate between basic categories (e.g., dogs versus cars), they performed well under either filter condition. However, when differentiating subordinate categories (e.g., types of cars) they performed well only in the high-pass filter condition (when fine-grain detail was exaggerated). Performance decreased in the low-pass filter condition (when then fine grain detail was removed). Thus, it seems that overall shape is most important for differentiating basic categories, but identifying subordinate categories requires examining detail.

Together, these examples indicate that a bias toward overall Gestalt does not appear to be all-or-none phenomena. Instead, they seem to depend on the specific task context. Therefore, a documented difference in bias between typical development and autism is likely to be too simplistic. While children with autism do not demonstrate the same bias towards higher-order Gestalt documented in typically developing children, this difference is likely to be modulated by the specifics of the task context. This point is elaborated in the next section.

**Weak Global Bias in Autism and Context Dependence**

Compared to their typically developing peers (TD), children with autism do not show the same effects of global interference (e.g., Happé, 2000; Happé & Booth, 2008; Happé & Frith, 2006). Consider, for example, the displays shown in Figure 1, used in the matching task described in the previous section. Unlike TD children, children with autism do not show differentiated performance as a function of stimuli type when making judgments about local
stimuli (e.g., Happé, 2000; Happé & Frith, 2006). They perform equally fast regardless of whether the large letter matches the small letter. This suggests that they do not initially look for overall Gestalts like TD children do. Analogously, when local stimuli pertained to separate tones from a soundscape, children with autism are not affected by melodic interference (Foxton et al., 2003). Similarly, children with autism are more likely than TD children to have perfect pitch, meaning that they can replicate or identify individual musical tones without any assistance (Bonnel et al., 2003; Heaton, Hermelin, & Pring, 1998).

A finding more directly related to a weak global bias comes from face perception in children with autism. Unlike TD children, children with autism tend to focus on individual features and not the relations between facial features when asked to identify faces (Deruelle, Rondan, Salle-Collemiche, Bastard-Rosset, & Da Fonséca 2008). The task, for example, was to decide whether two faces match in features such as gender, where stimuli were filtered either through either a high-pass filter (exaggerating local features) or a low-pass filter (exaggerating global features). Children with autism performed better when faces were filtered through the high-pass filter, which was opposite to the pattern seen in TD children. It seems as though children with autism were geared toward focusing on local details over global impressions. A similar weak global bias is displayed when children with autism read aloud. For example, they are less likely than TD children to use the context of a word in a sentence to disambiguate homographs (e.g., determine how to pronounce the word “read”; Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999; Lopez & Leekam, 2003).

Further atypical processing of global and local details can be seen in how children with autism complete drawing tasks. When copying images, children with autism tend to focus on local details before arriving at an overall image (Booth, Charlton, Hughes, & Happé, 2003).
Booth and colleagues gave children with high functioning autism, children with ADHD and TD children a task in which they were to copy drawings. In this context, it was possible to separate whether children with autism had a detailed drawing style which still resulted in an accurate copy, or whether they demonstrated a violation of overall configuration of the image (thus focusing on local details without considering the whole). Both detailed drawing styles were more common in children with autism than either comparison group. This suggested that while at times, children with autism were able to focus on both global and local features (but focus on local features first), a focus on local details also had the effect of distorting the overall drawing.

Despite numerous examples of a diminished or absent global bias in autism, whether or not they focus on global or local details in any given task is subject to context effects. For example, when examining Muller-Lyer illusions, children with autism appear to be more susceptible when asked, “which line looks longer,” versus “which line is longer” (Brosnan et al., 2004). Similar effects of task instructions on processing style in autism can be seen in reading tasks (Snowling & Frith, 1986). Snowling and Frith gave children with autism a task in which they were asked to read aloud sentences that contained homographs. Each participant’s attention was explicitly directed to these words, which dramatically increased reading accuracy.

Context effects on how children with autism process detailed and global information were found even when instructions stayed the same (Caron et al, 2006; Happé & Frith, 2006). Caron and colleagues found that, on a task which mimicked the classic Wechsler Block Design Task\(^1\), children with autism tended to perform as well or better than TD children. Further, in a second experiment from the same study, a “reverse task” was implemented in which children with autism demonstrated the ability to view Gestalts. Children were presented with a target

\(^1\) In this task, children are presented with blocks, all of which have two sides that are red, two sides that are white, and two sides which are divided between red and white diagonally. Children are then shown a target visual pattern and told to recreate it with the blocks.
image similar to the Wechsler Block Design on a computer. But, instead of being told to recreate the image, participants were shown arrangements of segmented “blocks” and asked which out of four possibilities matched the target, as shown in Figure 3. While the first experiment required examining an overall image and breaking it down into its component parts, the second involved processing configurations of individual parts as Gestalt images. Again, children with autism performed as well as TD children. Combined, these studies demonstrate that depending on the task at hand, children with autism can focus on details or global impressions.

*Figure 3. Example of a stimulus (top) from Caron et al. (2006; Experiment 2) with four test configurations (bottom). Participants were to pick which configuration matched the stimulus.*

In sum, there is general agreement about the weak global bias in children with autism – one that fits well with the symptomology of this disorder. However, environmental contexts seem to play an important role in how children with autism view details and global features, just as with how context affects the global bias in TD children. The changing nature of both biases
suggests that children with autism and TD children may adapt to tasks in different ways, as discussed next.

**Connecting Bias, Context, and Adaptive Functioning**

It is reasonable to conceptualize the global bias as a way to organize large amounts of information through combining small bits into larger, more manageable wholes. This can be seen in how children and adults complete problem solving tasks. In general, both TD children and adults were found to switch from local (e.g., detail-oriented) strategies to global strategies the longer they work on a problem-solving task (Boncoddo, Dixon, & Kelley, 2010; Stephen, Dixon, & Isenhower, 2009). However, adults tend to make the switch to examining higher order, or global, features faster on difficult tasks than easier tasks (Stephen, Dixon, & Isenhower, 2009). Stephen and colleagues showed TD adults a static image of interconnected gears on a computer screen. Participants were given information about the direction the first gear supposedly rotated and were asked to determine based on that, what direction the final gear should rotate. They would usually begin the task by using their finger to trace the rotation of each gear (i.e., examining local features) but would eventually group gears based on the fact that there was an alternating pattern of rotation (i.e., examining global relationships). They switched faster if the static image was made to randomly move around the screen than if it stayed in place. In a sense, adults tend to be more primed toward focusing on global relationships during difficult tasks. This phenomenon, however, seems to have a developmental course.

An analogous finding about the development of the adaptive function of a Gestalt bias can be seen in language learning, especially when it comes to the acquisition of a second language. Adults who learn a second language as children tend to pick up on idiosyncratic grammatical rules more easily than those who learn as adults (Newport, 1990). Newport found
that adults who learned a language as children tend to be able to switch between grammatical structures which only apply to certain words or cases while still demonstrating competencies with more regular linguistic “rules” (or global features of a language). Those who learn as adults tend to make more mistakes of generalizing grammatical structures across contexts where it is inappropriate (for example: in English, saying “mooses” for the plural of moose). These differences may be due to the fact that young children process irregular and regular grammatical rules in the same way- individually. They are not able to make generalizations. As they develop, they show the emergence of the ability to both process linguistic rules globally and maintain previously learned local rules. They are learning the complexities of language at a time that their generalization skills are also developing. Adults, who already have good generalization skills, make a leap to focusing on global features of language without first looking at detail. This is not to say that children, or adults who learned a language as children, never make generalization errors, rather, adults who learn a language later tend to make more errors than adults who learned as children. It seems that TD individuals develop the propensity to generalize information within difficult tasks – it appears easier (though sometimes incorrect) for most TD individuals to focus on Gestalts. Indeed, the development of adaptive biases toward global features is not limited to the above examples and can be seen in the shape bias.

Even the shape bias introduced above seems to have an adaptive component. In particular, the bias appears to be linked to the size of a child’s productive count-noun vocabulary – or the number of object labels they are able to say (Gershkoff-Stowe & Smith, 2004; Smith, 2003). Toddlers with smaller vocabularies appear to require more detail when identifying objects. While most TD children can identify known detailed objects, toddlers with higher vocabularies tend to more accurately identify versions that only demonstrate overall shape and
lack any detail (Smith, 2003; Pereira & Smith, 2009). Thus, the bias toward shape develops as a child’s vocabulary develops. This may be due, in part, to the fact that children with larger vocabularies have more words to organize and differentiate between, that is, more possible categories for objects to fall into. Thus, they would need to use more efficient grouping criteria. In this example, it is not an external context which promotes the switch from focusing on details to global features, but rather an internal factor – vocabulary size.

The changing nature of what children focus on suggests that children with autism and TD children may adapt to tasks in different ways. Better understanding these types of relationships may be integral to understanding autism itself. The current study aims to be a first attempt at filling a gap in this area of research. In what follows, I describe a study which explores the relationship between vocabulary size and object categorization style in children with autism.

The Present Study

My central hypothesis is that the adaptive connection between context and the focus on detail/global information is different in children with autism. In an effort to test this hypothesis, I focus explicitly on children’s shape bias and its connection with vocabulary size. The general method was adapted from Pereira & Smith (2009): Children were presented with three objects at a time and asked to identify the object named by the experimenter. For example, children were presented with a turtle, a car, and a butterfly and asked to point to the car. On some trials, objects were toys with detailed color, texture, and shape information. These detailed objects served to confirm that children were able to identify the object categories themselves. On other trials, objects were constructed from duplicates of the detailed objects covered in modeling clay. The clay served to maintain the detailed shapes of the objects, but remove all color and texture information. Finally, on the remaining trials, objects were constructed out of Styrofoam and
designed to only represent the general geometric shapes of the objects. In the context of the main experiment, the latter category, shape abstractions, provided information about whether children were able to identify global abstractions of objects.

The current study makes the following predictions, which will be based on mixed-measures ANOVAs and correlational analyses. First, I predict that typically children perform consistent with prior research (Pereira & Smith, 2009), despite small differences in procedure. In particular, I expect an interaction between object condition (detailed, rich-shape, shape abstraction) and vocabulary size, in that children with high vocabularies will perform equally well across object conditions while children with low vocabularies will demonstrate stratified performance. Second, I predict that this interaction is attenuated in children with autism. In particular, I expect a weaker relation between vocabulary, the amount of detail in test objects, and task performance. Evidence suggests that children with autism may not possess the same natural bias toward shape as TD children (Tek, Jaffery, Fein, & Naigles, 2008). Thus, they may not be affected by contextual changes (in this case, the internal factor of vocabulary size) in the same manner.
Chapter II: Experiment

Participants

The final sample consisted of 22 children with autism (19 boys and 3 girls) recruited from Memorial Children’s Hospital in South Bend, Indiana and from Cincinnati, Ohio area treatment centers and special needs schools. Their ages ranged from 2:9 to 11:5 years ($M = 5.7$, $SD = 2.10$). Diagnoses of autism were confirmed through contacting their pediatricians or therapists after written consent was obtained from their guardians. Participants in the final sample had no known history of comorbid developmental or intellectual disabilities. A final sample of 59, vocabulary-matched, TD children (33 boys and 26 girls) were recruited from Cincinnati area preschools and the local children’s museum to serve as controls. Their ages ranged from 15 to 29 months-old ($M = 20.92$, $SD = 3.65$). Eleven children with autism were excluded because of fussiness, incomplete parent surveys, or because their vocabularies were above the ceiling of the language measure. Twenty-three TD children were excluded from the final sample due to fussiness or incomplete data.

Stimuli

Stimuli represented 12 noun categories commonly known by young children. These categories were: horse, cow, pig, fish, bird, butterfly, turtle, car, airplane, cake, shoe, and hamburger. Each category was represented by three objects, each from a different feature condition (see Figure 4 for an example of each condition). Detailed objects (Figure 4a) consisted of store-bought toys or models, containing detailed features such as color, texture, and shape information. Rich-shape objects (Figure 4b) were duplicates of the detailed objects but covered with black modeling clay, such that color and texture information was no longer available.
Finally, *shape abstractions* (Figure 4c) were Styrofoam objects designed to represent the overall shape of the object category without providing any detailed information.

![Figure 4. Examples of (A) a detailed turtle, (B) a rich-shape turtle, and (C) a shape abstraction turtle.](image)

In order to determine whether the shape abstractions accurately represented an object category, they were piloted on 18 TD children (11 boys and 7 girls) between the ages of 44 and 52 months ($M = 48.72$, $SD = 3.92$). In forced-choice tasks (similar to the main experiment; see Procedure), children were shown three Shape Abstractions on a laptop computer and asked to point to a target picture (e.g., “Show me the cow.”). Though there was significant difference between the two items that yielded the lowest ($M = 81.48\%, SD = 26.13$) and the highest ($M = 100.00\%, SD = 0.00\%$) accuracy, $t(17) = -3.01$, $p = .008$, performance was very high overall, with an average of 93.98% correct across trials ($SD = 6.41$). These findings demonstrate that the shape abstractions represented each object category fairly well.

**Language Measure**

To assess each child’s vocabulary, parents were asked to fill out the MacAurthur-Bates Communicative Development Inventories (MCDI; Fenson et al, 1994), a standardized survey of language development. Parental reporting of language abilities has been demonstrated to be a
valid measure of both typically developing and autistic children’s language abilities (Bates, Dale & Thal, 1995; Charman et al., 2003; Luyster, Lopez & Lord, 2007; Tomasello, 1994). For ratings of TD children’s productive vocabularies, the MCDI demonstrated strong internal consistency, $\alpha = .97$, and strong inter-rater reliability, $r = .96, p < .01$ (Fenson et al., 1994). When compared to a laboratory sample of children’s language use, it also demonstrated strong concurrent validity, $r = .72, p < .05$ (Bates, Bretherton, & Snyder, 1988). To my knowledge, no specific normative data exists for children with autism. For the purposes of the current study, I only used items representing count-nouns, analogous to the productive count-noun vocabulary used by Smith (2003) and Pereira & Smith (2009).

Figure 5. Hypothetical test setup showing a fish, car and pig in the shape abstraction condition.

Procedure

Participants were tested individually at their homes, schools, treatment centers, or at the Cincinnati Children’s Museum. The procedure for the main task was adapted from Pereira & Smith (2009). In particular, participants were first told that they were going to play with toys from a toy box. They were then presented with 12 testing trials, each trial involving three objects from the same condition (detailed objects, rich-shape objects, or shape abstractions). For
example, they were presented with the shape abstractions of a fish, a cow, and a pig, and asked: “Give me the fish.” The three objects of a trial were placed on a red wooden tray (60 cm by 30 cm) in front of the child so that it was out of reach (see Figure 5 for an example display). The tray served as a platform for stimuli and to help the children focus their attention on the testing space. After the experimenter’s prompt, the tray with the objects was pushed toward the child. Clear pointing or picking up the target were considered correct responses. Regardless of whether or not the child was correct, they were given neutral feedback. The experimenter recorded responses on a laptop computer.

There were four trials for each object condition. Within each of the four trials, the same four objects were used, one of the objects being the target, the two of the remaining three being the distracters. Appendix 1 shows the specific categories used for each set of four objects, separated by test version. Within a test version, a particular category appeared only once, whether as a detailed object, rich-shape object, or shape abstraction. In other words, children never saw multiple conditions of an object. For example, if presented a shape abstraction airplane, they would not see the other two conditions of airplane. Object conditions were balanced across participants. This resulted in one third of the children participating in one of three versions of the categorization task. The order of test trials was randomized across conditions, using Superlab Version 02.
Chapter III: Results

I will first present initial findings pertaining to the performance on the MCDI for both TD and autistic participants. I will then focus on comparing how participants performed across test versions. Then, I will turn to the categorization performance of TD children to evaluate the degree to which current results replicated those from Pereira & Smith (2009). Finally, I will report the results of participants with autism, including comparisons with TD performance.

Preliminary Analysis: Performance on the Language Measure

For current purposes, the relevant measure of language competence measured by the MCDI is the number of produced count nouns (e.g., Pereira & Smith, 2009; Smith, 2003). For simplicity, I will refer to this value as vocabulary size. Overall, vocabulary size was similar between TD participants and participants with autism. It ranged from 0 to 198 words for the TD group ($M = 78.34, SD = 63.49; N = 2$ for 0 words, and $N = 1$ for 198 words) and 0 words to 199 words in the autism group ($M = 75.59, SD = 66.92; N = 1$ for 0 words, and $N = 1$ for 199 words). There was no significant difference between diagnostic groups ($t(79) = 0.08, p = .94$). Vocabulary size was highly correlated with age for TD participants, $r = .72, p < .001$, but not for participants with autism, $r = .26 \ p > .23$.

Preliminary Analysis: Effect of Gender and Test Versions

Categorization performance of a child was reflected in the mean proportion of correct choices across the four trials of each trial type (with chance performance being 0.33). A child therefore obtained three categorization scores: one for detailed objects, one for rich-shape objects, and one for shape abstractions. Gender did not affect performance for TD children in the current study, with boys and girls performing equally well, $F < 1.8$. Therefore, data from both genders was included.
Recall that the three test versions differed in the specific set of items presented in a particular object condition (e.g., detailed cow vs. detailed turtle; see Appendix 1). Three 2 x 3 ANOVAs were conducted (diagnostic group by test version) – one for each object condition – to determine whether test version affected performance. None of the ANOVAs produced a significant effect of test version, \( F_{\text{detail}}(2,75) = .81, p = .45; F_{\text{rich-shape}}(2,75) = 2.72, p = .07; F_{\text{shape abstraction}}(2,75) = 1.73, p = .19 \) and no significant main effect for diagnostic group, \( F_{\text{detail}}(1,75) = 2.57, p = .11; F_{\text{rich-shape}}(1,75) = 2.05, p = .16; F_{\text{shape abstraction}}(1,75) = 3.36, p = .06 \). There also were no significant interactions, \( Fs < 1.5 \). For the subsequent analyses, I therefore collapsed categorization performance across test versions.

**Figure 6.** Typically developing children: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Dashed lines represent vocabulary groups utilizing the methodology of Pereira & Smith (2009).

**TD Categorization Performance**

Figure 6 shows three scatterplots, one for each object condition, to reflect categorization performance of current TD participants as a function of their vocabulary size. And Figure 7 provides information about whether a child’s performance on detailed objects was affected by performance on the other two object conditions. In particular, the scatterplot in Figure 7a shows
the difference in mean performance between detailed objects and shape abstractions; and the scatterplot in Figure 7b shows the difference in mean performance between rich-shape objects and shape abstractions. Difference scores are plotted against vocabulary size to determine whether vocabulary size affects differential performance on shape abstractions.

Figure 7. Difference between performance on (A) detailed objects and shape abstractions and (B) rich-shape objects and shape abstractions for TD children as a function of vocabulary size.

The first question pertains to whether the method used in the current study replicates the findings of Pereira & Smith (2009; hereafter P & S). As was done in P & S, I divided the TD group into a Low-Vocabulary group (i.e., vocabulary size under 50), a Medium-Vocabulary group (i.e., vocabulary size between 50 and 150), and a High-Vocabulary group (i.e., vocabulary size over 150). Dashed vertical lines are added to Figure 1 to illustrate the distribution of children in each vocabulary group. Furthermore, Table 1 provides descriptive statistics on these three groups, as well as the descriptives reported in P & S. Compared to the present sample; P & S had more participants in the High-Vocabulary group (22 vs. 11). Furthermore, P & S children in this group also had a wider range of vocabulary size (up to 309 vs. up to 198). Because of
these differences in the High-Vocabulary group, different performance in this group cannot be attributed to differences in method.

Table 1

*Typically Developing Children

<table>
<thead>
<tr>
<th>Vocabulary Group</th>
<th>&lt; 50 Nouns</th>
<th>51 &lt; 150 Nouns</th>
<th>&gt; 151 Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Study</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M age = 18.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(range = 14-23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M vocab = 18.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(range = 0-41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pereira &amp; Smith (2009)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M age = 19.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(range = 16.5-24.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M vocab = 18.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(range = 0-50)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8 shows categorization performance as averaged across children, both for the current study (left side) and in P & S (right side). Simple mean comparisons between P & S and current data revealed only one difference, $t(31) = 2.45, p = .02$, namely that detailed-objects performance in High-Vocabulary group was better in the current study ($M = 97.73, SD = 7.54$) than in P & S ($M = 79.17, SD = 24.43$). This finding was surprising given that both the age and vocabulary ranges for current sample were narrower than for the P & S sample, however, vocabulary size correlated with participant age to a much lower degree in P & S ($r = .59, p < .001$, and $r = .72, p < .001$, respectively), which may have accounted for this difference.

---

2 Means were estimated from the figures in Pereira & Smith (2009).
As in P & S, a 3 X 3 mixed-measures ANOVA was conducted; with object condition as the within-subject factor, and vocabulary group as the between-group factor. Consistent with the P& S findings, it revealed a significant effect of object condition, $F(2,112) = 13.39$, $p < .001$, with children performing significantly better with detailed objects than with rich-shape objects or shape abstractions (Tukey’s HSD, $\alpha < .05$). There was no difference between rich-shape objects versus shape abstraction. Furthermore, and again consistent with the P & S findings, there was a significant effect of vocabulary group, $F(2,56) = 10.64$, $p < .001$, with children in the High-Vocabulary group and children in the Medium-Vocabulary group outperforming children in the Low-Vocabulary group (Tukey’s HSD, $\alpha < .05$). There was no difference between High- versus Medium-Vocabulary groups.

Despite these similarities in findings, the interaction between object condition and vocabulary group could not be replicated, $F < .5$. In P & S, this interaction was characterized by High-Vocabulary children performing equally well across object conditions, while children in other two vocabulary groups showed stratified performance. Failure to replicate this finding in an overall interaction may relate to the differences in the High-Vocabulary group. I therefore

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Figure 8. Average percent correct responses for each object condition for current TD participants as compared to Pereira & Smith (2009), by vocabulary group.
employed different grouping criteria, following the criteria of Smith (2003). Specifically, I divided the group of children into two groups – one consisting of children whose vocabulary size was below 100 nouns and the second above 100. As Table 2 illustrates, using two vocabulary groups results in more a more equal separation of participants. Performance patterns across object conditions for TD children divided into two vocabulary groups are shown in Figure 9.

Table 2

<table>
<thead>
<tr>
<th>Vocabulary Group</th>
<th>&lt;100 Nouns</th>
<th>&gt;100 Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD</td>
<td>N = 38</td>
<td>N = 21</td>
</tr>
<tr>
<td></td>
<td>M age = 19.24 (range = 14-27)</td>
<td>M age = 23.95 (range = 19-29)</td>
</tr>
<tr>
<td></td>
<td>M vocab = 37.18 (range = 0-87)</td>
<td>M vocab = 152.81 (range = 108-198)</td>
</tr>
<tr>
<td>TD*</td>
<td>N = 11</td>
<td>N = 11</td>
</tr>
<tr>
<td></td>
<td>M age = 18.91 (range = 14-23)</td>
<td>M age = 23.09 (range = 19-28)</td>
</tr>
<tr>
<td></td>
<td>M vocab = 23.36 (range = 0-87)</td>
<td>M vocab = 139.36 (range = 108-198)</td>
</tr>
<tr>
<td>Autism</td>
<td>N = 11</td>
<td>N = 11</td>
</tr>
<tr>
<td></td>
<td>M age = 60.91 (range = 33-119)</td>
<td>M age = 73.09 (range = 33-119)</td>
</tr>
<tr>
<td></td>
<td>M vocab = 23.63 (range = 0-87)</td>
<td>M vocab = 135.55 (range = 102-199)</td>
</tr>
</tbody>
</table>

* Matched Sample

A 3 X 2 (object condition by vocabulary group) mixed-measures ANOVA again did not reveal a significant interaction\(^{3}\). \(F < 1\). Note however that the High-Vocabulary group performed similarly high on shape abstractions and rich-shape objects, whereas the Low-Vocabulary group performed worse on shape abstraction than rich-shape objects. In particular, there was a

\(^{3}\) It revealed a significant effect of object condition, \(F(2,57) = 13.52, p < .001\), with better performance on detailed objects than rich-shape objects or than shape abstractions, \(t(58) > 3.41, p < .001\). And it revealed a significant effect of vocabulary group, \(F(1,57) = 25.99, p < .001\), with better performance in the High-Vocabulary group than the Low-Vocabulary group \(t(57) = 5.10, p < .001\).
significant difference between rich-shape (\(M = 61.84\%\), \(SD = 26.47\%\)) and shape abstraction trials (\(M = 50.00\%\), \(SD = 27.26\%\)) for children in the Low-Vocabulary group; \(t(37) = 2.07, p = .045\), but not for children in the High-Vocabulary group, \(t < .35\). Thus, there is evidence for differentiated performance between vocabulary groups across object conditions, similar to P & S. Though not as strong as the results reported in the previous study, current results allow for the comparison between TD children and children with autism described in a later section.

![Figure 9](image-url)

**Figure 9.** Average percent correct responses for each object condition for current TD participants (full sample), current participants with autism, and matched TD participants, by vocabulary group.

**Autistic Categorization Performance**

To compare the differential effect of object condition on categorization performance across diagnostic groups, participants with autism were also divided into vocabulary groups. Figure 10 shows the average performance for each participant with autism across all object conditions. Dashed lines represent the three vocabulary groups described earlier. The solid black lines represent vocabulary groups if the two groups of Smith (2003) are utilized, with one group consisting of children whose vocabularies were under 100 nouns and those whose vocabularies...
ranged from 100 to 200 nouns. This set of divisions was included due to the nature of the vocabulary size distribution within the autism sample. Table 3 includes the number of participants with autism in each vocabulary group utilizing the three groups of P & S, as well as how their ages and vocabularies differed. Note that when implementing these grouping criteria, only 3 children are included in the High-Vocabulary group. Thus, much like with TD children, there were a disproportionately low number of children in this group. In contrast, using the grouping method of Smith (2003) resulted in an equal number of participants in each vocabulary group, as illustrated in Table 2 which shows the number of participants in each vocabulary group as well as how their ages and vocabularies differed.

![Figure 10. Children with autism: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Dashed lines represent vocabulary groups utilizing the methodology of Pereira & Smith (2009). Solid lines represent vocabulary groups using the criteria of Smith (2003).](image)

Average accuracy as a function of object condition for participants with autism is illustrated in Figure 9. Children from both vocabulary groups performed well across all object conditions. A 3 X 2 mixed-measures ANOVA with object condition as the within-subject factor and vocabulary group as the between-subjects factor revealed only a significant main effect for vocabulary group, \( F(2,20) = 5.08, p < .001 \); children in the High-Vocabulary group (\( M = 89.39\%, SD = 25.79\% \)) outperformed those in the Low-Vocabulary group (\( M = 71.97\%, SD = \)).
28.48%). Performance did not vary as a function of object condition, $F < 2.75$, and the interaction between main effects was not significant, $F < 1$.

Table 3

*Number of Participants with Autism, Mean Value and Range for Age and Number of Count-Nouns in Productive Vocabulary as Measured by the MCDI Separated by 3 Vocabulary Groups using Criteria from Pereira & Smith (2009).*

<table>
<thead>
<tr>
<th>Vocabulary Group</th>
<th>&lt; 50 Nouns</th>
<th>51&lt;150 Nouns</th>
<th>&gt;151 Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 9</td>
<td>N = 10</td>
<td>N = 3</td>
</tr>
<tr>
<td>Autism</td>
<td>$M$ age = 65.56 (range = 33-119)</td>
<td>$M$ age = 56.90 (range = 33-135)</td>
<td>$M$ age = 102.00 (range = 74-137)</td>
</tr>
<tr>
<td></td>
<td>$M$ vocab = 11.89 (range = 0-33)</td>
<td>$M$ vocab = 105.20 (range = 66-143)</td>
<td>$M$ vocab = 197.33 (range = 196-199)</td>
</tr>
</tbody>
</table>

**Comparative Analyses**

In order to compare performance of children with autism to TD children, both groups were separated into two vocabulary groups, as described earlier. Results indicate that the pattern of performance for participants with autism differs from TD participants. Indeed, though children with autism from the High-Vocabulary group performed similar to TD children from the same group across all object conditions ($t$s < 1.60), this was not true for children in the Low-Vocabulary group. Children with autism from the Low-Vocabulary group not only performed as well as corresponding TD children on detailed ($M = 79.55\%, SD = 24.54\%; M = 73.68\%, SD = 23.21\%$, respectively) and rich-shape objects ($M = 65.91\%, SD = 37.54\%; M = 61.84\%, SD = 26.47\%$, respectively), but significantly outperformed them on shape abstraction trials ($M = 70.45\%, SD = 21.85\%; M = 50.00\%, SD = 27.26\%$, respectively); $t(47) = 2.28, p = .03$. The average performance for TD children and children with autism are shown in Figure 9.
The correlations between task performance, age, and productive vocabulary for participants with autism also showed meaningful differences from those of TD children. Age was not significantly correlated to performance for any object condition. For TD children, age was significantly correlated to performance across all three object conditions ($r = .54$, $r = .31$, $r = .35$, for detailed, rich-shape and shape abstraction objects, respectively). Vocabulary, on the other hand was significantly correlated to performance on trials of detailed objects for children with autism ($r = .59$, compared to $r = .51$ for TD children) and rich-shape objects ($r = .44$, compared to $r = .35$ for TD children), but not to performance on shape abstractions ($r = .35$, compared to the significant $r = .42$ for TD children), as shown in Figure 10 for children with autism and Figure 6 for TD children. Thus, unlike TD children, neither age, nor productive count-noun vocabulary appeared to be connected to task performance for children with autism. Furthermore, partial correlations which controlled for age indicate that it did not affect the vocabulary/performance correlations as much as it did in the TD sample.

![Figure 11](image.png)

**Figure 11.** TD children – matched sample: individual average performance for detailed objects, rich-shape objects, and shape abstractions as a function of vocabulary size. Correlations between performance and vocabulary and partial correlations (controlling for age) are indicated in each chart. Solid lines represent vocabulary groups using the criteria of Smith (2003).

To further compare the performance of TD children and children with autism, a subset of TD children was selected to match the autism sample both in number, and as best possible,
vocabulary size. Participants’ data were ordered by vocabulary size and then by order in which they were tested. Starting with the participants possessing the smallest vocabulary size, TD children were matched to the autistic participants. If two TD children had the same vocabulary size, the child who first participated in the study was selected. If a child with autism did not have the same vocabulary size as any TD, the TD child with the most similar vocabulary was used as a match. The final matched samples are illustrated in Appendix 2 and the individual performance of each TD child within each object condition is shown in Figure 11. The performance pattern of the matched TD sample is shown in Figure 9. Performance across all object conditions did not differ significantly between diagnostic groups for both the children in the Low-Vocabulary groups, $t_s < 1.80$, and High-Vocabulary groups, $t_s < 1.95$.

As with the other groups, correlations between age, vocabulary, and performance were calculated for the matched TD sample and are shown in Figure 11, along with partial correlations controlling for age. Like for the children with autism, age did not significantly correlate to performance with any object condition for the matched TD children. Vocabulary size, on the other hand, significantly correlated to performance on detailed objects ($r = .45$, $p = .04$), but not with performance on either of the other two conditions. As noted earlier, for children with autism, vocabulary significantly correlated to performance on both detailed and shape-abstraction objects. Partial correlations for matched TD children also indicate that, like the full TD sample, but unlike the autistic sample, it is difficult to separate the effect of age from the relationship between vocabulary and performance.
Chapter IV: Discussion

The overall goal of the present study was to explore the relation between contextual effects and Gestalt processing in autism and how this relationship compares to the one seen in TD children. It used the child’s vocabulary size as the contextual factor and their ability to focus on overall shape of objects as an example of Gestalt processing. Typically developing children and children with autism were given a forced-choice object identification task involving objects of various levels of abstraction. Their productive count-noun vocabularies were measured by the MCDI, a standardized parent report.

The first step toward the goal of this study was to compare current TD results to the results from Pereira & Smith, 2009. Though not as strong as in the previous study, current results do indicate the presence of differentiated performance patterns for children of different vocabulary sizes. Whereas TD children in the current study with low vocabularies demonstrated stratified performance across all object conditions, children with larger vocabularies, as a whole, performed equally well on shape abstraction objects and rich-shape objects. The second goal of this study was to explore what relationship may exist in children with autism and how it compared to TD children. Results indicated that for children with autism, vocabulary size did not relate to performance on shape abstractions in the same manner. Relative performance across each object condition did not differ between each autistic vocabulary group. Further, children with autism performed at a high level compared to TD children across all conditions.

When interpreting how the current results relate global processing and contextual changes, the current study makes several assumptions. The first assumption is that vocabulary size can be seen as a contextual factor. The second assumption is that categorization of shape abstraction objects translates to the ability to process Gestalt information. The third assumption
is that Gestalt processing is an adaptive function that arises when contexts make tasks difficult (in this case, as vocabulary size increases). Under these assumptions, the fact that children with autism did not demonstrate stratified performance seen in TD children may suggest that they do not adapt to contextual changes in the same manner.

Of course, alternate claims could explain the findings. Most prominent is the issue of how vocabulary was measured. The MCDI only allows parents to indicate words that they believe their child does not know, understand (but cannot say), and words that they understand and say. Many children with autism use alternate forms of communication, such as sign language or exchange cards. Thus, the MCDI may not have been an accurate measure of each child’s true productive count-noun vocabulary. Furthermore, the MCDI only lists words that TD children tend to learn in the first few years of life. Children with autism who learn language later in life may not learn the same first words. Thus, it is possible that a greater proportion of their produced words were not captured by this measure. Given the issues that arose from use of the MCDI, it is possible that a more detailed assessment of language, including receptive vocabulary, could influence results.

Other issues that could affect the interpretation of results include the current sample size of autistic children and the methods used to confirm diagnoses. Only 22 children with autism were included in the final sample. Because of the difference in size between this group and the TD group, a subset of TD children was matched to the autistic group by vocabulary size. When this matched TD sample of 22 children was used in comparative analyses, performance did not differ between diagnostic groups. This may suggest that with a larger sample size, the overall performance pattern of the children with autism could change. The current study also based diagnosis on physician confirmation, rather than using standardized measures, such as the
Autism-Diagnostic Interview – Revised (ADI-R; Lord, Rutter, & Couteur, 1994) or the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). Though best diagnostic practice suggests the inclusion of both the ADOS and ADI-R (Ozonoff, Goodlin-Jones, & Solomon, 2005), the individual practices of clinicians may vary.

Issues surrounding the stimuli used in the current study may also have affected findings. First, the number of objects used in the current study differed from previous work. Pereira & Smith (2009) used a total of 18 objects whereas I used 12. The decreased number of trials presented to each child, plus the possible exclusion of more difficult objects, may have inflated overall performance or changed performance patterns among both diagnostic groups. Second, the actual construction of objects may have afforded children different amounts of information than in previous studies, though stimuli were modeled after those used in prior work (Biederman, 1987; Smith, 2003; Pereira & Smith, 2009).

Even given the alternate explanations for the results of this study, there is evidence from previous research which supports the current claims. First, previous work that explored how children with autism see Gestalts demonstrated that they have the ability to identify both global abstractions and detail-rich objects (e.g., Mottron et al., 2006; Ozonof et al., 1994; Plaisted et al., 1999). Second, there is an indication that children with autism do not possess a shape bias that is similar to TD children (Tek et al., 2008). Combined, these studies suggest that not only do children with autism show a weakened bias toward Global information, but that there is also a weakened connection between Global processing and vocabulary. In the current study, children with autism tended to perform well on shape abstraction objects, regardless of their vocabulary size, indicating that they were, in general, able to categorize objects based on their overall shape.
And, vocabulary, as measured by the MCDI, did not affect the relative performance of children between object categories.

Research involving children with language delays, so called “late-talkers,” may also provide evidence for current claims. In similar object categorization tasks, they demonstrate performance patterns are similar to both TD children and children with autism. Like TD children, late talkers show a developmental trend in their ability to categorize objects by shape (Jones & Smith, 2005). Specifically, Jones and Smith found that neither a late talker’s receptive count-noun vocabulary nor age was significantly related to their ability to categorize objects based on overall shape. Productive count-noun vocabulary size, instead, was related. However, like children with autism, they tend to not show an innate tendency to categorize objects by shape, and thus an atypical shape bias (Jones, 2003). Though this provides evidence that in another clinical group, productive count-noun vocabulary size relates to categorization abilities, it does not address the issue of the accuracy of the MCDI for children with autism.

At the very least, the current study is a preliminary step towards better understanding the relationship between vocabulary size and object categorization style in children with autism. It appears that though they may not have a bias toward global features, even those with poor verbal language skills have the capacity to categorize objects based on overall shape. This alone may have clinical implications.

How do these findings motivate training interventions for children with autism? For typically developing children, the use of teaching props that focus attention on global shape greatly improves learning (Son, Smith, & Goldstone, 2008). Son and colleagues found that TD children with very small vocabularies who are taught new words using objects which omit detail learn the words of the real-world versions of the training objects better than children taught on
detailed exemplars. In this case, focusing children’s attention on the overall shape of objects by removing irrelevant information promotes better learning. Even though children with autism may not demonstrate the same relationship between vocabulary size and categorization style seen in TD children, they may still benefit from this type of teaching method. Results from prior studies suggest that children with autism may not naturally focus on shape, though they have the capability to do so. This latter finding was strengthened by the current study. Research has also demonstrated that in various contexts children with autism greatly benefit from having their attention explicitly directed toward information that is relevant to task completion (e.g., Brosnan et al., 2004; Snowling & Frith, 1986). Thus, it is plausible that directing children with autism to focus on shape by teaching them new words using shape abstractions may show the same types of effects seen in TD children.

The current study may help lay the groundwork for future research that not only explores how other factors that may influence object categorization, but examines how teaching children with autism to focus on objects’ overall shape affects learning. Exploring autistic children’s receptive vocabularies, level of gesturing, and joint attention skills may shed light on what factors influence how they categorize objects. And it is plausible that teaching children with autism new words using shape abstractions may benefit their learning. Though complex, understanding these relationships, and understanding how other contexts affect autistic task performance may have significant impacts on clinical research and practice in the future.
References


Appendix 1.

List of objects in each condition for each test version.

<table>
<thead>
<tr>
<th></th>
<th>Detailed Objects</th>
<th>Rich-Shape Objects</th>
<th>Shape Abstractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Version 1</td>
<td>Cake</td>
<td>Hamburger</td>
<td>Fish</td>
</tr>
<tr>
<td></td>
<td>Car</td>
<td>Airplane</td>
<td>Shoe</td>
</tr>
<tr>
<td></td>
<td>Cow</td>
<td>Pig</td>
<td>Horse</td>
</tr>
<tr>
<td></td>
<td>Turtle</td>
<td>Butterfly</td>
<td>Bird</td>
</tr>
<tr>
<td>Test Version 2</td>
<td>Fish</td>
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<td>Fish</td>
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<td>Shoe</td>
<td>Car</td>
<td>Shoe</td>
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<td>Cow</td>
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<td>Bird</td>
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<td></td>
<td>Pig</td>
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<tr>
<td></td>
<td>Butterfly</td>
<td>Bird</td>
<td>Turtle</td>
</tr>
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</table>
Appendix 2

List of TD children in the matched sample and how their ages and vocabulary sizes compare to the children in the autistic sample.

<table>
<thead>
<tr>
<th>TD</th>
<th>Age</th>
<th>Vocabulary</th>
<th>Autism</th>
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<th>Vocabulary</th>
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<td>35</td>
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