Journal of Developmental and Physical Disabilities, Vol. 18, No. 2, June 2006 (© 2006)
DOI: 10.1007/s10882-006-9007-7

Early Categorization of Animate/Inanimate Concepts in Young Children with Autism

Cynthia R. Johnson[1,3] and D. H. Rakison[2]

Categorization and concept formation deficits along with other cognitive processing deficits have been suggested in individuals with Autism Spectrum Disorders (ASD). A compelling early cognitive deficit is the formation of coherent concepts for animates and inanimates. Development of such concepts is thought to be a crucial building block for young children's emerging understanding that different object kinds possess different physical, psychological, biological, and motion-related properties [Rakison, D. H., and Poulin-Dubois, D. (2001). Psychol. Bull. *127(2): 209–228]. In this preliminary study, 11 preschoolers with ASD participated in two experiments that tested early concept formation. A visually-based habituation paradigm was used to test whether young children with ASD could detect correlations among static and dynamic cues and whether they were selective in the correlations to which they attend. A more interactive imitation task was used to test children's knowledge of simple linear and nonlinear motions of animates and inanimates. Results suggest that the preschoolers with autism are delayed in the processes by which they form categories but nonetheless possess relevant knowledge about the motion properties of animates and inanimates. Implications of this preliminary study are discussed.*

KEY WORDS: autism; categorization; cognitive processes; cognitive development.

---

[1] University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania.
[2] Carnegie Mellon University, Pittsburgh, Pennsylvania.
[3] To whom correspondence should be addressed at University of Pittsburgh School of Medicine, Children's Hospital of Pittsburgh, Autism Center, 3705, 5th Avenue, Pittsburgh, Pennsylvania 15213; e-mail: Cynthia.Johnson@chp.edu.

INTRODUCTION

While defined behaviorally as a disorder of deficits in communication and social interactions as well as restricted interests and atypical behaviors, research characterizing cognitive processing deficits in autism spectrum disorders (ASD) has been the focus of considerable efforts in the past three decades. This has resulted in a number of more clearly defined cognitive deficits in the areas of executive functioning, abstract reasoning, mentalizing, concept development and categorization (Baron-Cohen, 1995; Castelli *et al.*, 2002; Minshew *et al.*, 2000; Ozonoff, 1997); however, this work has been performed almost exclusively with older children, adolescents, and adults. Limited research in younger children (Klinger and Dawson, 2001) suggests that fundamental processes of categorization, a cornerstone of early concept formation (Mandler, 1992; Rakison and Poulin-Dubois, 2001), may be impaired in individuals with ASD.

Categorization Processes in ASD

That there is only a handful of studies that examine category and concept formation in ASD is surprising because it is generally accepted that direct, mass teaching trials are required for young children with ASD to grasp concepts for colors, shapes, size, and function (Leaf and McEachin, 1999; Lovaas, 2003). In a match to sample task, Tager-Flusberg (1985) found no differences in categorization abilities across a small sample of school- aged children with autism, mental retardation, and normal controls. Similarly, no differences were found in a sample of preschool-aged children with ASD in their ability to match perceptual and functional categories (Ungerer and Sigman, 1984). While these collective findings suggest that children with ASD may match as typically developing children in terms of categorization abilities, these early studies did not examine whether mechanisms underlying the categorization ability of each of the sample populations differed. That is, children with ASD and typically developing children may form groupings that appear to be the same, but the basis for such groupings may differ considerably. Along these lines, evidence has been provided to suggest that individuals with ASD may categorize perceptual, surface information but have difficulty with categorization with what the authors refer to as representational objects (Shulman *et al.*, 1995). That is, participants with ASD had no difficulty categorizing geometric shapes but performed poorly on a task requiring the sorting of objects belonging to one of six superordinate categories (i.e., trees, beds, human figures, animals, tools, and vehicles). Hence, when categories were not based on purely surface information, performance of individuals with ASD diminished. In a comparison of 12 participants with ASD, 12 participants with Down Syndrome, and 12 participants with typical development (ages 5–21 years), Klinger and Dawson (2001) suggested the individuals with ASD and Down Syndrome were able correctly to group geometric figures when a rule defined category membership; however, they were unable to do so when successful categorization required the formation of prototypes. Such dissociation between rule-based categorization and more abstract prototype extraction has also been observed in older individuals with ASD (Minshew *et al.*, 2002). Moreover, difficulty with more abstract categories has also been anecdotally described by a prominent individual with autism named Temple Grandin (1995) who described her propensity to remember specific exemplars of a category rather than rely on a more generalized concept of those exemplars.

As described above, one of the crucial aspects of objects such as trees, beds, and animals that help to distinguish them beyond surface appearances relates to their motion properties. Motion as an important variable to infer mental states and social intention has been raised by theory of mind, mentalizing researchers in autism (Castelli *et al.*, 2002). To our knowledge, no studies have examined when and how young children with ASD are able to learn about the motion characteristics of animates and inanimates.

Importance of Animate–Inanimate Categorization in Early Cognitive Development

Ability to *categorize* refers to the ability to group discriminable properties, objects, or events into classes on the basis of a principle or rule. The mental representation that summarizes the relations and structure among members of the category is often labeled as a *concept*. Categorization is one of the fundamental cognitive processes as it is the principal method for coding experience, thereby reducing demands on memory storage and perceptual and reasoning processes (Quinn and Eimas, 1996). Development of concepts for animates and inanimates is probably the most significant of all the concepts formed in the first years because it signifies the most basic division between different ontological kinds and represents a crucial building block for children's emerging understanding of the world around them (Mandler, 1992; Rakison and Poulin-Dubois, 2001).

Several theories have been forwarded in the developmental literature to explain how and when categories and concepts develop for animates and inanimates. There is strong evidence that within the first year of life, infants have the ability to form categories on the basis of various perceptual cues. Infants as young as 3 months of age can form categories based on a prototype, or average, stimulus (e.g., a square is an object with four equal sides) (Slater and Quinn, 2001). More impressive perhaps, by 10 months, infants form categories on the basis of static correlations among features (Younger and Cohen, 1986). That is, when infant were habituated to schematic animals with different attribute correlations (e.g., animals with big ears have fluffy tails, animals with small ears have fan tails) they were able to categorize them into groups on the basis of these shared pairs of features. More recently, it has been found that infants are able to learn correlations present in moving, dynamic stimuli: an ability that is crucial for the developing understanding that distinct object kinds move differently. In one study with the habituation procedure (Rakison and Poulin-Dubois, 2002), 14- and 18-month-old infants were shown novel dynamic geometric figures that contained a number of correlations such as, for example, that between a set of parts and the motion trajectory of the object or that between the parts and the body of the object. The studies revealed that infants at 14 months attended only to the relation between object parts and the motion trajectory of an object (curvilinear or rectilinear) whereas those at 18 months attended to all of the correlations available in the events. Thus, it appears that, at least for novel stimuli, infants at 14 months are biased to attend to ostensibly causal relations between object parts and a more global motion property, and by 18 months they have developed an expectation that this relation exists which is used even if the relation is not present in the perceptual input.

There are differing viewpoints on the nature of the development of the animate–inanimate distinction in infancy and early childhood. According to some theorists, early in life infants begin to abstract into a conceptual form the features of objects that are considered nonperceptual, and in particular, those related to objects' spatial location and movement (e.g., Mandler, 1992, 2000). Others have posited that perceptual features of increasing sophistication continue to play important roles in concept development throughout the emergence of representations for animates and inanimates (Eimas and Quinn, 1994; Jones and Smith, 1993; Rakison and Poulin-Dubois, 2002). Rakison and Poulin-Dubois (2001; Rakison, 2003) have recently proposed that the type of motion of an object is crucial in distinguishing the categories of animate versus inanimate, and they argue that these motions are essentially perceptual in nature. They propose that animates and inanimates can be distinguished by their: 1) onset of motion (self-propelled versus caused motion), 2) line of trajectory (smooth versus irregular, 3) form of causal action (action at a distance versus action from contact, 4) pattern of interaction (contingent versus noncontingent), and 5) type of casual role (agent versus recipient). Rakison and Poulin-Dubois (2001) argue that each of these motions is learned through the association between causally relevant object parts (e.g., legs) and the motion with which it is conjointly dynamic (e.g., irregular motion).

To examine the validity of this view with more realistic stimuli, in a recent study 14-, 18-, and 22-month olds' knowledge of the motion characteristics of animals and vehicles that move on land or in the air was investigated with a novel version of the inductive generalization technique Rakison (2005). Infants observed simple movements modeled with an appropriate category member—for example, a dog walking or a plane flying—after which they were allowed to imitate the action with a similar category member, a dissimilar category member, an exemplar from another category but with similar parts, and an exemplar from another category with dissimilar parts. Results revealed that infants at 18 months imitated land movement with objects that share causally relevant parts with the model (e.g., making a cat and a table "walk") but infants at 22 months imitate land movement only with the objects from the appropriate category for the motion (e.g., making a cat and a dolphin "walk"). A similar pattern was also exhibited by 18- and 22-month-olds when tested with air movement.

The purpose of the present, preliminary investigation was to apply these well-developed paradigms Rakison (2005) and Rakison and Poulin-Dubois (2002) used in infant studies to describe how young preschoolers with ASD perform with respect to categorization of animate and inanimate objects relative to the performance of infants at 14, 18, and 22 months of age.

METHOD

Overview

The present study applied categorization paradigms pioneered by Rakison and colleagues Rakison (2005); Rakison and Poulin-Dubois, 2002). The dynamic and static feature correlation experiment was designed, using a habituation paradigm, to test the extent to which infants and young children encode correlations between specific parts and the motion characteristics of objects. The second kind of task tested knowledge of the motions of animates and inanimates with a novel version of the generalized imitation experiments (Mandler and McDonough, 1996, 1998) in which participants are shown an action (e.g., a toy dog drinking from a cup) and then given the chance to repeat that action with a number of novel stimuli.

Participants

Participants were 11 children with a mean age of 38 months (age range 29–48 months) were diagnosed with an Autism Spectrum Disorder (eight with Autistic Disorder, three diagnosed with Pervasive Developmental Disorder, Not Otherwise Specified) based on clinical evaluation and the administration of the Autism Diagnostic Observation System (ADOS) (Lord *et al.*, 1999). This sample had a mean Verbal IQ of 74 (range of 75–108) and a Nonverbal IQ of 81 (range of 70–124) as assessed using the Stanford–Binet Intelligence Scale: 4th Edition (Thorndike *et al.*, 1986). For two children, no verbal score was obtained. Children were excluded if they also had a diagnosis of congenital rubella, seizure disorder, cytomegalovirus, tuberous sclerosis, fragile-X syndrome, Lesh–Nyan, Rett syndrome, or other genetic etiology for developmental disorder. Participants took part in both Experiment 1 and Experiment 2 and all were tested with Experiment 1 prior to Experiment 2.

Experiment 1

Procedure

Each participant sat facing a computer monitor in a chair attached to a table. The parent, who was instructed to remain neutral and not interact with the participant verbally or otherwise, sat just behind their child. Children were tested using a version of the criterion habituation procedure. During the habituation phase, participants were presented with two computer-generated events during which a geometric figure moves across a computer screen. The events were identical to those used by Rakison and Poulin-Dubois (2002; see also Rakison, 2004). Each one involved an object with distinct body (e.g., red oval shape) and a distinct set of parts (e.g., red cigar shape parts that moved up and down) that moved along a distinct motion trajectory (e.g., nonlinearly). Figure 1 gives an example of the objects and motion paths in the events. As in Rakison and Poulin-Dubois (2002), children were shown two separate events during habituation. Each trial continued until the participant looked away from the screen for longer than 1 s or until 30 s of continuous looking had elapsed. The habituation phase of the experiment continued until a participant's looking time decreased to a criterion level of 50% of their original looking time or until a maximum number of 16 trials were presented. These procedures follow the standard criterion for habituation studies with infants. Once criterion was reached, or 16 trials had passed, four test trials were presented. The four test trials included different combinations of the attributes of the habituation stimuli. Thus, in one trial children were presented with the same body-motion pairing but with the parts of the other event (parts-switch); in another, children were presented with the same parts-motion pairing but the body of the event (body-switch); in another, children were presented with the same

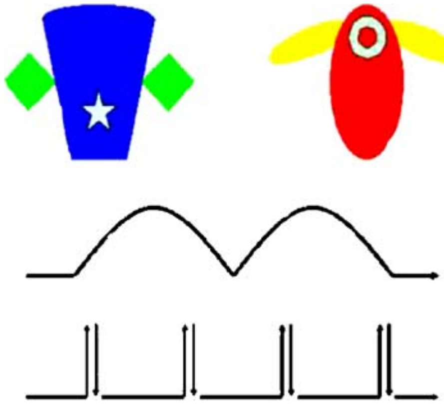

Fig. 1. Example of stimuli and motion path in Experiment 1.

parts-body pairing but the object moved along the motion path of the other event (motion switch); finally, one event was identical to that seen during habituation (familiar).

The order of the four test trials were counterbalanced across the participants. Because participants in Experiment 1 were considerably older than those typically used in habituation studies, participants who fail to habituate within 16 trials were included in the final analysis. Each participant's looking time (in second) to the stimuli was coded online during the experiment. Thus, the dependent variable for the habituation trials and the test trials was looking time in seconds to the stimuli. All sessions were videotaped for later reliability coding by a second experimenter who recoded a random sample of four children. Interrater reliability was 96%.

Experiment 2

Procedure

In this experiment, participants were shown in turn four simple events after which they were encouraged to repeat the events with four novel stimuli. There were two simple motions typical of animates (a dog walking and a bird flying) and two simple motions typical of inanimates (a car rolling and a plane flying). Children were first presented with four stimuli and allowed to interact with them in any way they wish (baseline phase). This phase continued for approximately 1 minute or until no further interaction with the stimuli occurred. The toys were then withdrawn, and an experimenter modeled one of the simple motions described above. The motion was repeated four times (twice from left to right and twice for right to left) and each one was accompanied by an arbitrary vocalization (e.g., "weee"). After the event was modeled, the stimuli from the baseline phase were placed in front of the child who was encouraged, with a movement of the hand and a verbalization from the experiment (e.g., "can you show me 'weee") to repeat the observed motion.

For each event, one of the stimuli was drawn from the appropriate superordinate domain and possessed the appropriate and functional parts for the motion (SPSC: same parts, same category). For example, when the cat was the model exemplar the SPSC exemplar was a dog. Another test stimulus was drawn from the appropriate superordinate domain but did possess the appropriate functional parts for the motion (DPSC: different parts, same category). For example, when the cat was the model exemplar the DPSC exemplar was a dolphin. A third stimulus was from an innappropriate superordinate domain but had the appropriate functional parts for the motion (SPDC: same parts, different category). For example, when the cat was the model exemplar the SPDC exemplar was a table (with four legs). Finally, one stimulus was from an inappropriate superordinate domain for the motion but did not possess the appropriate functional parts (DPDC: different category different parts); when the cat was the model the DPDC exemplar was a car. A full list of the stimuli used in the task in presented in Table I, and the stimuli from the cat "walking" condition can be seen in Fig. 2.

This design is novel in that in previous experiments participants were presented only with two toys during the test phase (e.g., Mandler and McDonough, 1996, 1998): By giving them four toys that varied in whether they were from the appropriate category or possessed the appropriate parts it was possible to examine what participants have learned about the identity of objects that engage in different movements. All sessions were

Table I. Model and Test Exemplars Used in Experiment 2

Motion events	Model	SPSC	SPDC	DPSC	DPDC
Linear land movement	Car	RV	Stroller	Boat	Cow
Nonlinear land movement	Cat	Dog	Bed	Dolphin	Truck
Linear air movement	Cargo Plane	Fighter plane	Dragonfly	Car	Duck
Nonlinear air movement	Eagle	Parrot	Spy plane	Dog	Grasshopper

Note. SPSC refers to object with the appropriate parts that belong to the appropriate category for the motion; SPDC refers to the object with appropriate parts for the motion but that belongs to an inappropriate category; DPSC refers to the object with inappropriate parts for the motion but that belongs to the appropriate category for the motion; DPDC refers to the object with inappropriate parts for the motion and that belongs to an inappropriate category for that motion.

Fig. 2. Example of stimuli used in Experiment 2.

videotaped for later analysis. Coding focused on participants' choice of stimuli to enact the events they had previously observed. The dependent variable was the choice and number of stimuli used to imitate the actions and the order in which the stimuli were manipulated. Interrater reliability was 95%.

RESULTS

Experiment 1

The dependent variable for Experiment 1 was children's looking time in seconds. A repeated-measures ANOVA (parts switch vs. body switch vs. motion switch vs. familiar) was performed to examine the pattern of looking across the four test trials. The analysis revealed that children's visual fixations did not differ significantly across the four test trials, $F(3, 30) = 1.53$, $p > .2$. However, as can be seen in Fig. 4, the failure to discover a significant difference in overall looking times on the test trials may have resulted from the fact that children visually fixated equally long at three

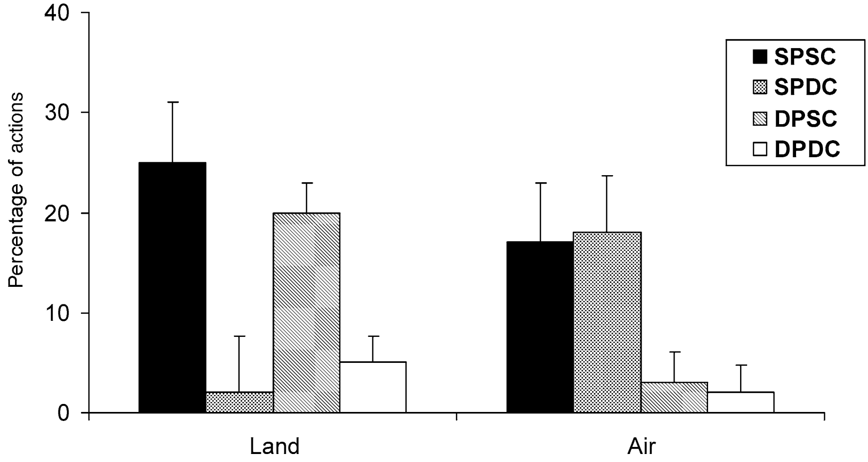

Fig. 3. Land and air motions performed during generalization in Experiment 2.

of the four trials. In line with this prediction, planned comparisons showed that children visually fixated to the parts switch test trial (*M* = 15.65, *SD* = 9.66) significantly longer than to the familiar test trial (*M* = 8.43, *SD* = 7.36), *F*(1, 10) = 6.49, $p < .05$, but they visually fixated equally to the body switch (*M* = 10.63, *SD* = 10.14), *F*(1, 10) = 0.63, $p > .4$, and motion switch (*M* = 11.05, *SD* = 12.37), *F*(1, 11) = 0.34, $p > .5$, as at the familiar test trial.

Summary

The pattern of children's looking in Experiment 1 suggested that during habituation they had learned only the relationship between the parts of the objects and the motion path along which those objects moved. As such, their behavior was akin to that found in normally developing 14-month-olds but unlike that of normally developing 18-month-olds, who instead learned all of the correlations available in the events.

Experiment 2

The primary measure of the participants' behavior in the tasks was the choice of objects with which they demonstrated the motion events. The primary dependent measure was the sum in each task of imitated actions observed with the first, second, third, or fourth objects selected by the infant. In other words, the dependent measure was the number of appropriate motions (range = 0–4, maximum score across the objects for each participant = 4) made with any of the four objects. Preliminary analyses showed that children's behavior was not significantly different on the two land-moving events and on the two air-moving events. Consequently, the data for the two land-related tasks were combined and the data for the two air-related tasks were combined.

Land Motions

Children's behavior on the two land-related tasks was investigated with a repeated-measures ANOVA with exemplar (SPSC vs. SPDC vs. DPSC vs. DPDC) as the within-subjects factor. The data are presented in Fig. 4. The ANOVA showed that children did not choose the stimuli equally to imitate the land actions, $F(3, 30) = 3.75, p < .025$. Further analyses revealed that participants were more likely to imitate the observed motions with the SPSC (e.g., dog for nonlinear motion; $M = 25\%$) exemplar than the DPSC exemplar (e.g., dolphin for nonlinear motion; $M = 2\%$), $F(1, 10) = 7.04$, $p < .025$, and DPDC exemplar (e.g., car for nonlinear motion; $M = 5\%$), $F(1, 10) = 3.69$, $p < .05$. They were also significantly more likely to repeat motions with the SPDC exemplar (e.g., table for nonlinear motion; $M = 20\%$) than the DPSC exemplar,

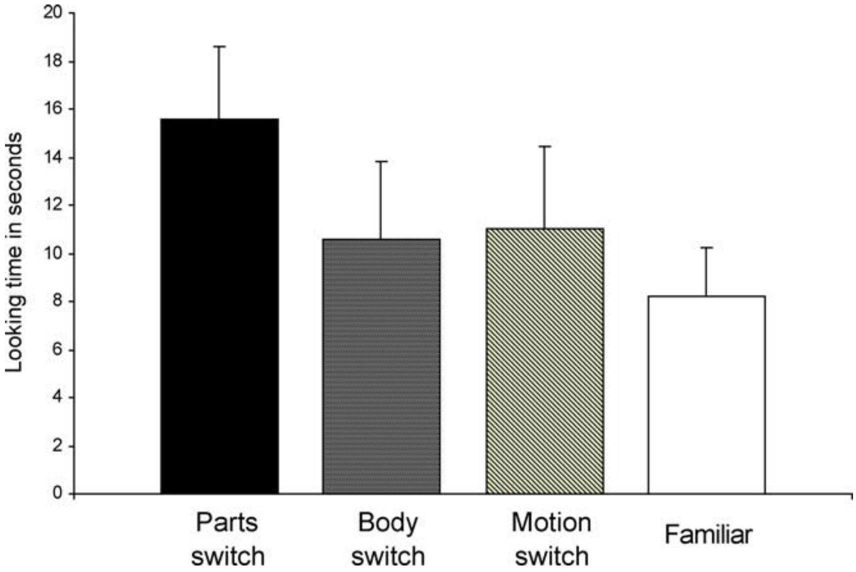

Fig. 4. Looking time to the four test trails in Experiment 1.

$F(1, 10) = 5.71$, $p < .05$, and marginally more likely to use the SPDC exemplar than the DPDC exemplar, $F(1, 10) = 3.56$, $p < .09$. Children were just as likely to chose the SPSC and SPDC exemplars to imitate, $F(1, 10) = 0.17$, $p > .5$, and similarly they were just as likely to repeat actions with the DPSC as the DPDC exemplar, $F(1, 10) = 0.31$, $p > .5$.

Air Motions

Participants' behavior for the two air motions was examined with a repeated-measures ANOVA with exemplar (SPSC vs. SPDC vs. DPSC vs. DPDC) as the within-subjects factor. The data are presented in Fig. 4. The ANOVA showed that children did not choose the stimuli equally to imitate the land actions, $F(3, 30) = 3.89$, $p < .025$. Additional analyses showed that children were more likely to repeat the air motions with the SPSC (e.g., fighter plane for linear motion; $M = 17\%$) exemplar than the SPDC exemplar (e.g., dragonfly for nonlinear motion; $M = 2\%$), $F(1, 10) = 4.81$, $p < .05$, and DPDC exemplar (e.g., duck for linear motion; $M = 2\%$), $F(1, 10) = 12.00$, $p < .005$. They were also marginally more likely to imitate motions with the DPSC (e.g., car for linear motion; $M = 18\%$) exemplar than the SPDC exemplar, $F(1, 10) = 4.87$, $p < .06$, and significantly more likely to use the DPSC exemplar than the DPDC exemplar, $F(1, 10) = 6.81$, $p < .05$. Children were just as likely to chose the SPSC and DPSC exemplars to imitate, $F(1, 10) = 0.08$, $p > .7$, and similarly they were just as likely to repeat actions with the SPDC as the DPDC exemplars, $F(1, 11) = 0.31$, $p > .5$.

Summary

Children in the present experiment generalized land motions to objects with the appropriate parts for those motions (i.e., objects with wheels for linear land motion and objects with legs for nonlinear land motion) but generalized air motions to objects from the appropriate category (e.g., a car for nonlinear motion and a dog for linear motion). The pattern of behavior for the land motions is comparable to that found in normally developing infants at 18 months of age Rakison (2005) but is unlike that found in older infants (those at 22 months of age). In contrast, the pattern of behavior found on the air motion tasks is consistent, although not identical, with that of normally developing infants at 22 months of age; that is, infants at 22 months in two related tasks (one identical to Experiment 2 and one with an ambiguous block as the model) chose the SPSC and DPSC exemplars to repeat the actions.

DISCUSSION

Data from this preliminary set of experiments suggest that young children with ASD possess the same basic learning processes exhibited by normally developing infants and children; that is, they habituate, imitate, and attend to individual features of objects and correlations among those features. However, results revealed that children with ASD in this small sample performed on the habituation tasks as 14-month-old typically developing infants (Rakison and Poulin-Dubois, 2002). That is, they attend specifically to the relationship between moving parts and a motion trajectory, but do no not include the whole objects in the correlation (as 18-month-old infants do). This suggests that young children with ASD attend to dynamic relations that involve apparently causally connections (such as, for example, that between legs and walking) but ignore other important relations that exist in the environment (for example, things with legs also have eyes, desires, and are alive). This form of "selective attention" is important in infancy in that it highlights crucial information concerning the properties of animates and inanimate; however, it is important for a developing knowledge database that other information is acquired. Selective or overselective attention was suggested several decades ago as well as more recently as a deficit in individuals with ASD (Lovaas *et al.*, 1979; Pierce *et al.*, 1997). This kind of selective or overselective attention is consistent with the finding that individuals with autism can group geometric figures when a rule defines category membership but not when categorization requires the formation of prototypes (Klinger and Dawson, 2001).

Results from the generalized imitation task in Experiment 2 further support this conclusion. Recall that participants generalized land motions to objects that possess the appropriate parts for those motions (e.g., legs and wheels) even if the object in question belonged to an inappropriate category (e.g., table for nonlinear land motion). This behavior, which maps onto that found in 18-month-old infants, suggests that children with ASD may have learned that "things with legs move nonlinearly" and that "things with wheels move linearly" rather than that "animals move nonlinearly" and that "vehicle move linearly." Although use of such a rule may help to support inductive inference, it will also lead to erroneous generalization in some cases. It remains to be seen, however, whether application of this kind of rule continues in later life for individuals with ASD, and future research with older participants could help to determine whether such relatively simple rules start to include ever more detailed information over developmental time. For example, generalizing nonlinear land motion to objects with legs and eyes would result in less inductive errors.

At the same time, however, participants in Experiment 2 generalized nonlinear air motions to animals and linear air motions to vehicles. There are two reasons why it is unlikely that this pattern of behavior was due to the participants' greater knowledge about air motions than land motions. First, Rakison (2005) found that infants at 18 and 22 months of age knew little about air motions relative to their understanding of land motions. Second, infants at 22 months generalized air motions to the DPSC exemplars and not the SPSC exemplars when an ambiguous block was used as the model. This suggests that infants, just like the children in the Experiment 2 here, may have interpreted the linear and nonlinear air motions as linear and nonlinear motion more generally (that is, as land motion) and imitated with objects that possessed the appropriate parts for that motion (legs and wheels).

Nonetheless, results of the current experiments suggest that the children with ASD had learned about the appropriate motion properties of animate and inanimate objects, though the represented information for these objects and motions may be speculated to be different from that of typically developing young children. Evidence presented here suggests that children with ASD may attend selectively to specific features and feature correlations, and this attentional bias may underlie or at least contribute to the later observed cognitive deficits in older individuals with ASD. It may also be speculated that this possible differences in early cognitive processes may be related to the early emerging features in ASD such as lack of imitation and symbolic play. Imitation, symbolic play, along with referential gestures and words typically emerge in the second year of like and are considered signs of conceptual abilities (Travis and Sigman, 2001). Although there was some evidence of these abilities in the participants in the current experiments, the overall level of generalization was low relative to that observed in normally developing infants. Thus, it seems that imitation, at least, may be impaired in this small sample of young children with ASD which is consistent with the literature (Rogers *et al.*, 2003; Stone *et al.*, 1997).

Further research in this line of inquiry is greatly needed for several reasons. First, while the cognitive characteristics of older children and adults with ASD have received considerable attention, research characterizing cognitive processes in the preschool years has been much more limited. Yet, it is in the preschool years that we strongly believe intensive intervention may greatly improve long-term prognosis (Dawson and Osterling, 1997) Approaches borne out of the field of applied behavior analysis, most notably discrete trial training, have been demonstrated to result in meaning gains in many children receiving this therapeutic model (Schreibman, 2000; Smith *et al.*, 2000). The programs included in discrete trial training include the mass teaching of fundamental concepts. This is done with the assumption that young children with ASD fail to learn these concepts without this method of one-on-one direct instruction approach. However, it is not know what concepts they may have more difficulty with and those they may easily master. For example, it may be the animate–inanimate distinction is one that is more difficult given the multiple features to process both at a perceptual, surface level and a deeper, more conceptual level (e.g., things with hearts are alive). The present data suggest that those concepts that are relatively simple to learn—that is, those involving a rule-based approach and only a few defining features, may be easiest for children with ASD to learn. Hence, further study about the development of category and concepts in young children with ASD has implication for refinement of discrete trial programming. It may be that teaching of some concepts is necessary while other concepts do not require this level of intervention. Further, the relationship between early categorization processes and early features in ASD warrants further exploration given the presumed relationship between early concept development and imitation behaviors and symbolic play. Finally, while this current study included children over the age of 2 years, future research should explore the presence of early categorization processes in much young children as this may be an early predictor of ASD.

ACKNOWLEDGMENT

Partial support was provided by Seeding Funding, Research Advisory Committee, and Children's Hospital of Pittsburgh.

REFERENCES

Baron-Cohen, S. (1995). *Mind Blindness: An Essay on Autism and Theory of Mind*, MIT Press, Cambridge, MA.

Castelli, F., Frith, C., Happe, F., and Frith, U. (2002). Autism, Asperger Syndrome, and brain mechanisms for the attribution of mental states in animated shapes. *Brain* 125: 1839–1849.

Dawson, G., and Osterling, J. (1997). Early intervention in autism: Effectiveness and common elements of current approaches. In Gurlanick, M. J. (ed.), *Effectiveness of Early Intervention*, Brooks, Baltimore, MD, pp. 307–326.

Eimas, P. D., and Quinn, P. C. (1994). Categorization in early infancy and the continuity of development. *Cognition* 50: 83–93.

Grandin, T. (1995). *Thinking in Pictures*, Vintage Books, New York.

Jones, S. S., and Smith, L. B. (1993). The place of perception in children's concepts. *Cogn. Dev.* 8: 113–119.

Klinger, L., and Dawson, G. (2001). Prototype formation in autism. *Dev. Psychopathol.* 13: 111–124.

Leaf, R., and McEachin, J. (1999). *A Work in Progress: Behavior Management Strategies and a Curriculum for Intensive Behavioral Treatment of Autism*, DRL Books, New York.

Lord, C., Rutter, M., DiLavore, P. C., and Risi, S. (1999). *Autism Diagnostic Observation Schedule: A Standardized Observation of Communicative and Social Behavior*, Western Psychological Services, Los Angeles.

Lovaas, O. I. (2003). *Teaching Individuals with Developmental Delays: Basic Intervention Techniques*, Pro-Ed, Austin, TX.

Lovaas, O. I., Koegel, R., and Schriebman, L. (1979). Stimulus overselectivity in autism. A review of research. *Psychol. Bull.* 86: 1236–1254.

Mandler, J. M. (1992). How to build a baby: II. Conceptual primitives. *Psychol. Rev.* 99: 587–604.

Mandler, J. M. (2000). Perceptual and conceptual processes in infancy. *J. Cogn. Dev.* 1: 3–31.

Mandler, J. M., and McDonough, L. (1996). Drinking and driving don't mix: Inductive generalization in infancy. *Cognition* 59(3): 307–335.

Mandler, J. M., and McDonough, L. (1998). On developing a knowledge base in infancy [Journal Article]. *Dev. Psychol.* 34: 1274–1288.

Minshew, N., Johnson, C. R., and Luna, B. (2000). The cognitive and neural basis of autism: A disorder of complex information processing and dysfunction of neocortical systems. In Glidden, L. M. (ed.), *International Review of Research in Mental Retardation*, Academic, New York, pp. 111–138.

Minshew, N. J., Meyer, J., and Goldstein, G. (2002). Abstract reasoning in autism: A disassociation between concept formation and concept identification. *Neuropsychology* 16: 327–334.

Ozonoff, S. (1997). Components of executive function in autism and other disorders. In Russell, J. (ed.), *Autism as an Executive Disorder*, Oxford University Press, New York, pp. 179–211.

Pierce, K., Glad, K. S., and Schriebman, L. (1997). Social perception in children with autism: An attentional deficit? *J. Autism Dev. Disord.* 27: 265–282.

Quinn, P. C., and Eimas, P. D. (1996). Perceptual organization and categorization in young infants. In Rovee-Collier, C., and Lipsitt, L. P. (eds.), *Advances in Infancy Research*, Vol. 11, Ablex, Norwood, NJ, pp. 1–35.

Rakison, D. (2003). Parts, categorization, and the animate–inanimate distinction in infancy. In Rakison, D. H., and Oakes, L. M. (eds.), *Making Sense of the Blooming Buzzing Confusion: Concept and Category Development in the First Years*, Oxford University Press, New York.

Rakison, D. H. (2004). Infants' sensitivity to correlations among static and dynamic features in a category context. *J. Exp. Child Psychol.* 89: 1–30.

Rakison, D. H. (2005). Developing knowledge of motion properties in infancy. *Cognition* 96: 183–214.

Rakison, D. H., and Poulin-Dubois, D. (2001). Developmental origin of the animate–inanimate distinction. *Psychol. Bull.* 127(2): 209–228.

Rakison, D., and Poulin-Dubois, D. (2002). You go this way and I'll go that way: Developmental changes in infants' detection of correlations among static and dynamic features in motion events. *Child Dev.* 73: 682–699.

Rogers, S., Hepburn, S., Stackhouse, T., and Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental disorders. *J. Child Psychol. Psychiatry* 44: 763–781.

Schreibman, L. (2000). Intensive behavioral/psychoeducational treatments for autism: Research needs and future directions. *J. Autism Dev. Disord.* 30: 373–378.

Shulman, C., Yirmiya, N., and Greenbaum, C. (1995). From categorization to classification: A comparison among individuals with autism, mental retardation, and normal development. *J. Abnorm. Psychol.* 104: 601–609.

Slater, A., and Quinn, P. C. (2001). Face recognition in the newborn infant. *Infant Child Dev.* 10(1–2): 21–24.

Smith, T., Groen, A. D., and Wynn, J. W. (2000). Randomized trial of intensive early intervention for children with pervasive developmental disorder. *Am. J. Ment. Retard.* 105: 269–285.

Stone, W. L., Ousley, O. Y., and Littleford, C. D. (1997). Motor imitation in young children with autism: What's the object? *J. Abnorm. Child Psychol.* 25: 475–485.

Tager-Flusberg, H. (1985). Basic level and superordinate level of categorization in autistic, mentally retarded and normal children. *J. Exp. Child Psychol.* 40: 450–469.

Thorndike, R. L., Hagen, E. P., and Sattler, J. M. (1986). *Stanford–Binet Intelligence Scale*, 4th edn., Riverside, Chicago.

Travis, L., and Sigman, M. (2001). Communication intentions and symbols in autism: Examining a case of altered development. In Burack, J., Charman, T., Yirkiya, N., and Zelazo, P. (eds.), *The Development of Autism: Perspectives from Theory and Research*, Erlbaum, Mahwah, NJ, pp. 279–308.

Ungerer, J. A., and Sigman, M. (1984). The relation of play and sensorimotor behavior to language in the second year. *Child Dev.* 55(4): 1448–1455.

Younger, B. A., and Cohen, L. B. (1986). Developmental change in infants' perception of correlations among attributes. *Child Dev.* 57(3): 803–815.