Categorization in ASD: The Role of Typicality and Development

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There is a growing amount of evidence suggesting that individuals with autism spectrum disorders (ASD) differ in the way in which they cognitively process information. A critical aspect of cognitive processing that is receiving more attention in studies of ASD is categorization. The studies presented here examined the effect of typicality on categorization of objects and gender in high-functioning children, adolescents, and adults with ASD and matched controls. The ASD and control groups showed improved categorization throughout the lifespan for typical and somewhat typical object category members and typical gender faces. However, individuals with ASD took more time to categorize atypical object category members and were less accurate in categorizing atypical gender faces from age 8–12 years through adulthood. We will discuss the implications of these results for teaching categories and category labels to individuals with ASD.

Autism spectrum disorders (ASD) are characterized by qualitative impairments in social interaction and communication and repetitive, stereotyped patterns of behavior, interests, and activities (American Psychiatric Association, 2000). Most research on ASD has focused on social deficits, because they are both necessary and unique to the diagnosis. Recently, researchers have suggested that individuals with ASD may also have significant cognitive deficits (e.g., Frith & Happe, 1994; Mottron & Belleville, 1993; Ozonoff, 1997; Plaisted, O'Riordan, & Baron-Cohen, 1998).

One aspect of cognitive processing that is receiving more attention in studies of ASD is categorization. Categorization is critically important, because it reduces demands on memory and allows individuals to focus on important aspects of objects while ignoring irrelevant details. It also allows children to learn language. It is evident that, within the first year of life, infants begin to form categories (e.g., Lewis & Strauss, 1986; Quinn & Oates, 2004). If individuals with ASD differ in their abilities to categorize early in life, it is possible that these differences could make a significant contribution to the social, communication, and behavioral deficits in ASD.

Temple Grandin, PhD, a well-known individual with ASD, described her experience with categorization in one of her many books:

> When I was a child, I originally categorized dogs from cats by size. That no longer worked when our neighbors got a small dachshund. I had to learn to categorize small dogs from cats by finding a visual feature that all the dogs had and none of the cats had. All dogs, no matter how small, have the same nose. (Grandin, 2006, p. 30)

Grandin did not know the difference between cats and dogs until she was around 5 years of age, when she explicitly began to figure out the categories using features. Grandin's difficulty with categorization of dogs versus cats stands in stark contrast to the significant amount of research that demonstrates that preverbal infants are able to categorize objects (Rakison & Oakes, 2003). It also suggests that categorization may represent a primary implicit process that is deficient in individuals with ASD. Deficiencies or differences in basic categorization abilities could have a profound effect on how one learns about the world and acquires expertise about objects; social information, such as people and faces; and language.

Categorization in Typical Populations

Considering the importance of categorization, it is not surprising that there is substantial research on how categories are formed and used in typically developing children. Traditional theories of categorization held that a few necessary and definitive features define all categories (e.g., the categories of large blue squares versus small red circles). However, it was later recognized that most natural categories do not have simple definitive features but instead have "fuzzy boundaries" and "typicality structures," in which some of the members are more representative or "better examples" of the category and other members are less representative or "worse examples" and therefore less "typical" (Rosch, 1978). For example, most individuals would consider German Shepherds to be relatively typical of dogs in comparison to Chihuahuas, which are considered atypical.

The amount of time it takes to identify typical members of a category is less than the amount of time it takes to identify less typical members. Children also learn the names of typical members of novel categories more quickly than less typical members (e.g., Barrett, 1995). In fact, even 18- and 24-month-old infants can distinguish typical from atypical category members such that they look significantly longer at more typical items than less typical items (Southgate & Meints, 2000). As Rosch (1978) and others (see Murphy, 2002) have discussed, based on our experiences with objects, we abstract a statistical average of the variations and frequency of attributes that vary among members of the category. Categorization of novel category members occurs by comparing the novel object to our statistically averaged prototype.

One of the basic natural categories that must be learned by all individuals is facial gender. The discrimination of facial gender is based on a very fine-grained discrimination of the features that are maximally distinctive between male and female faces. These features include, among others, nose length, chin width, and eye-to-eyebrow distance (Brown & Perrett, 1993; Chronicle et al., 1995; Yamaguchi, Hirukawa, & Kanazawa, 1995). Not only are adults quite skilled at classifying gender, but they are also quicker to identify the gender of a face if that face has been rated as being very typical of its gender. For instance, a male face that has been rated by adults as being very masculine is classified as male in a gender identification task significantly faster than a male face that has been rated as being somewhat less masculine (O'Toole et al., 1998).

Valentine's (1991) multidimensional experience-based framework for representing and storing faces is one of the most useful models for understanding how typically developing individuals organize their developing knowledge of facial information. Similar to object categories, Valentine suggested that faces and prototypical information about faces are stored in an n-dimensional *face space*, representing all possible features used to encode a face, as well as information used to discriminate faces (e.g., age, gender, race). The values of the n-dimensions encoded in the face space depend on an individual's experience with faces. The center of this multidimensional framework represents the central tendency of all facial information (*prototype*). The distribution of facial features and facial information is normally distributed around this central tendency. For example, in human faces, there are variations in dimensions such as the distance between the eyes, the height of the forehead, the width of the

mouth, and so on. The prototype would thus reflect the combined central values across all of these varying dimensions. As an individual gains experience with faces, these faces are represented in the face space framework according to the values of facial information. With experience, the distributions become more refined as more subtle variations are included in the face space, and the central tendencies of facial dimensions become more accurate. When presented with a new face, individuals compare it to their learned prototype and use this information to guide perception, categorization, and recognition.

Categorization in Individuals With ASD

Although many studies have investigated categorization in adults and typically developing children, there is less research on this topic in ASD, and the results have been mixed. Early studies concluded that individuals with ASD are able to form categories successfully. These studies, however, used categories that had simple definitive features, such as color or size, and did not examine whether individuals with ASD process category information in the same manner as typically developing individuals, especially when the categories are more complex (Tager-Flusberg, 1985; Ungerer & Sigman, 1987). It is possible that, while individuals with ASD can successfully categorize on the basis of simple definitive features, they may have difficulty categorizing when categorization is based on more complex or less perceptually apparent features (Klinger & Dawson, 1995; Plaisted, 2000).

Another possible explanation for the mixed findings is that studies of categorization in ASD have failed to control for typicality of the stimuli. It is possible that, while individuals with ASD may be able to categorize typical category members, less typical members may pose more difficulty. As category members become less typical, criterial features become less apparent, and decision processes become more difficult. Therefore, studies using only typical members of a category may not indicate deficits in these individuals. Studies using typical and atypical category members, however, show that individuals with ASD have categorization deficits as the task becomes more difficult (Gastgeb, Strauss, & Minshew, 2006).

Several studies suggest that individuals with ASD can successfully categorize when the task is simple or rule-based but have difficulty when categorization is more abstract or complex. Individuals with ASD do not group words into categories to aid in memorization (e.g., Minshew, Goldstein, Muenz, & Payton, 1992). They also process information in an explicit, rule-based manner, leading to difficulty when tasks require that concepts or categories be abstracted from complex information (e.g., Minshew, Meyer, & Goldstein, 2002). Individuals with ASD can categorize using a rule-based strategy when there is a simple distinctive feature but are unable to extract prototypes or average representations of the features of a category (Gastgeb, Rump, Best, Minshew, & Strauss, 2009; Gastgeb, Wilkinson, Minshew, & Strauss, in press; Klinger & Dawson, 2001; Klinger, Klinger, & Pohlig, 2006; Plaisted, 2000). This is surprising, because studies on prototype formation in children have established that infants are able to abstract prototypes by 3 months of age (Bomba & Siqueland, 1983; Quinn, 1987; Strauss, 1979; Younger & Gotlieb, 1988).

Taken together, the results indicate that individuals with ASD do not have difficulty with simple, well-defined categories but do have difficulty with categorizing atypical exemplars and the extraction of prototypes, suggesting that individuals with ASD may engage in different categorization processes than do typically developing individuals. With respect to natural categories, it is possible that individuals with ASD are able to categorize typical category members efficiently and accurately using simple, definitive features but have difficulty categorizing less typical category members, which require a different, more complex processing strategy.

Another aspect of categorization that has rarely been explored is the developmental course of categorization in individuals with ASD. Though researchers have examined whether children or adults with ASD can categorize, only Gastgeb et al. (2006) examined processing

differences across the lifespan using natural categories and category members that varied in typicality. Similarly, Strauss and colleagues performed parallel studies of gender categorization in the same population (Newell, Best, Gastgeb, Rump, & Strauss, 2010). The remainder of this paper will discuss these studies and the implications of their results for teaching categories and category labels to individuals with ASD.

The Role of Typicality and Development

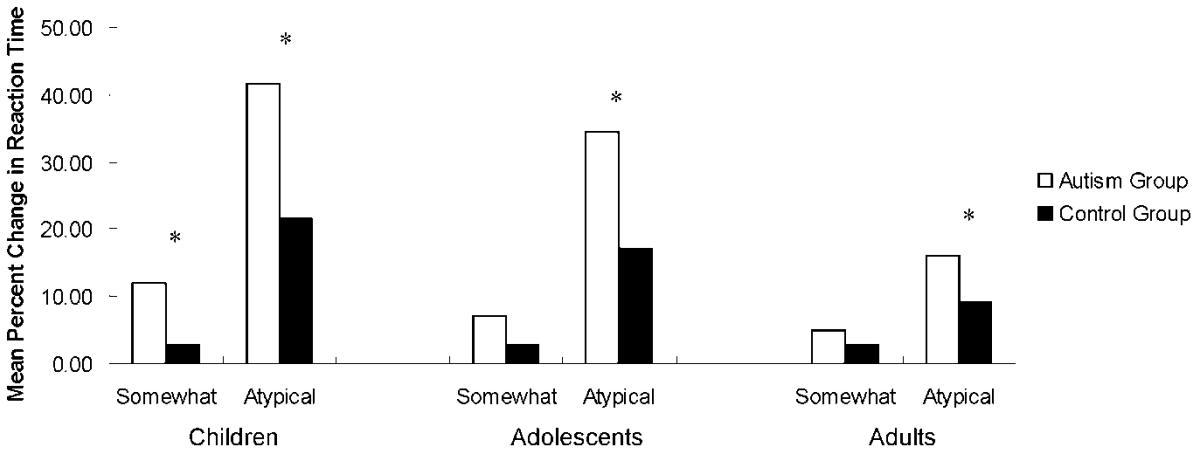
Object Categorization

Gastgeb et al. (2006) examined whether individuals with ASD have difficulty categorizing common objects and whether their categorization abilities are affected by the typicality of objects. Participants first heard a word prime (dog, cat, couch, or chair). They were then shown a picture from one of these categories and asked to press a button to indicate whether the picture was from the same or a different category as the auditory prime (true or false). Reaction times and accuracy were recorded for pictures that varied from typical to somewhat typical to atypical representations of each category (see Figure 1). Researchers tested children (age: 9–12 years), adolescents (age: 13–16 years), and adults (age: 17–48 years) with ASD, as well as matched controls. All individuals with ASD had a clinical diagnosis of ASD according to the Autism Diagnostic Observation Schedule–Generic (ADOS-G; Lord et al., 1989) and the Autism Diagnostic Interview–Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) with confirmation by expert clinical opinion. All participants had an IQ above 80. The control groups were matched to the ASD groups with respect to age, gender, full scale IQ, verbal IQ, and performance IQ.

Figure 1. Examples of Typical, Somewhat Typical, and Atypical Objects

Because the individuals with ASD responded more slowly than did the control participants to all stimuli, the reaction times for both groups were converted into percentage scores, indicating how much more slowly each group responded to the somewhat typical and atypical stimuli in comparison to the typical stimuli. The results are shown in Figure 2. Children with ASD were considerably slower than were the control participants at categorizing somewhat typical and atypical category members. By adolescence, this difference was only evident for atypical category members. Finally, though there was improvement into adulthood, adults with ASD were still significantly slower at categorizing atypical category members relative to the typically developing adults. Results clearly indicated that both individuals with ASD and typically developing individuals showed improvement in their categorization abilities throughout the lifespan for all levels of typicality. However, adolescents and adults with ASD demonstrated a persistent relative difficulty at categorizing atypical category members, as evidenced by significantly longer reaction times to atypical versus typical category members.

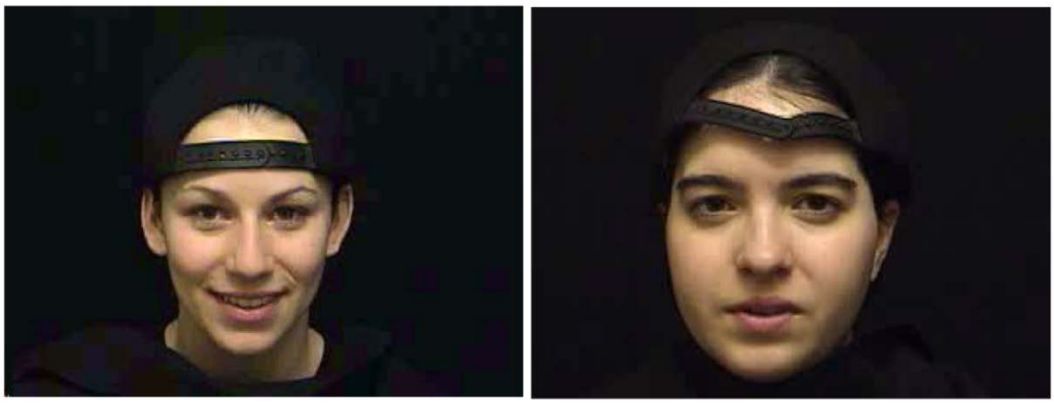
Figure 2. Percent Change in Reaction Time for Children, Adolescents, and Adults on the Object Categorization Task



Gender Categorization

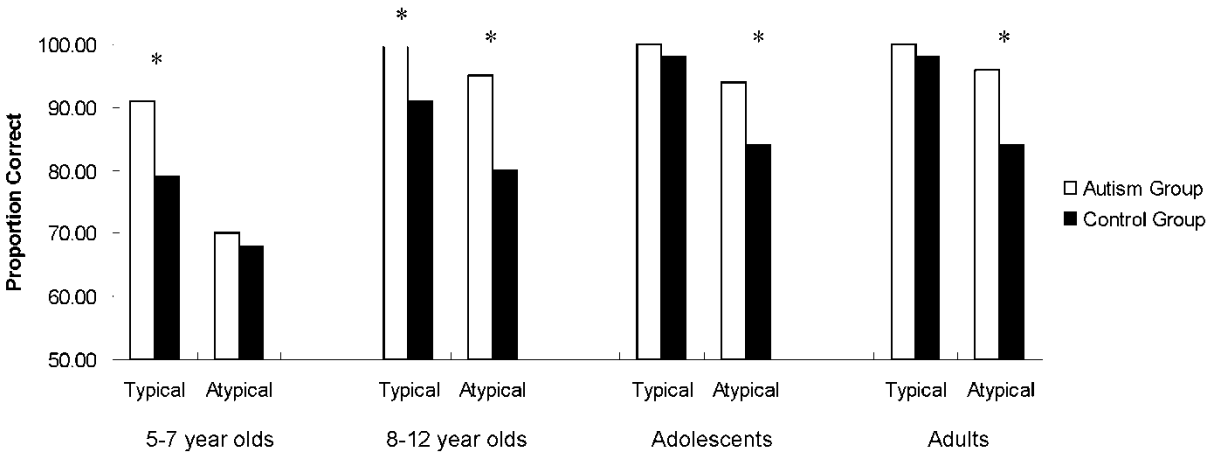
Strauss and colleagues also examined whether individuals with ASD have difficulty categorizing gender and whether their categorization abilities are affected by the typicality of the faces' gender (Newell et al., 2010). Participants were presented with videos of men's and women's faces (hair cues were hidden with a black cap) that varied in typicality from typical to atypical and were asked to identify whether each individual was male or female. Half of the videos were typical faces and half were atypical faces. Examples of typical and atypical female faces are shown in Figure 3. Children (age: 5–7 and 8–12 years), adolescents (age: 13–16 years), and adults (age: 17–53 years) with ASD, as well as matched controls, were tested. Again, all participants had an IQ above 80, and the control groups were matched to the ASD groups with respect to age, gender, full scale IQ, verbal IQ, and performance IQ.

Figure 3. Examples of Typical and Atypical Female Faces



The results for each age group are shown in Figure 4. Whereas the 5- to 7-year-old children with ASD performed worse than did controls on the typical gender faces, both groups were poor at categorizing atypical faces. In contrast, the 8- to 12-year-old children showed group differences in all conditions. Essentially, the control participants had reached adult abilities and categorized both typical and atypical faces with close to 100% accuracy, whereas the children with ASD had persistent difficulty categorizing both typical and atypical gender faces. The adolescent and adult data show that the individuals with ASD "caught up" to the controls in their ability to discriminate typical faces. However, the individuals with ASD were considerably worse at discriminating the atypical gender faces, even as adults. Thus, though there was improvement across development, ASD individuals never reached the abilities that typically developing individuals reached by 8 to 12 years of age. This parallels the results of the Gastgeb et al. (2006) study, suggesting that individuals with ASD have difficulty categorizing atypical category members regardless of whether they are objects or faces.

Figure 4. Accuracy Scores for Children, Adolescents, and Adults on the Gender Categorization Task



Summary

These studies were the first to examine object and gender categorization abilities and the role of typicality in categorization in individuals with ASD across the lifespan. In summary, the findings of the two studies indicate that even though children with ASD had difficulty, with experience, adolescents with ASD were able to categorize somewhat typical members of object categories as efficiently as control adolescents. In contrast, children, adolescents, and adults with ASD responded significantly more slowly than did control adolescents to atypical object category members and had difficulty categorizing atypical gender faces. Thus, categorization of objects improved with development for the somewhat typical category members between childhood and the adolescent years; this was not the case for the atypical object or face category members.

Individuals with ASD evidenced a deficit in processing atypical category members throughout the lifespan, and adults with ASD never reached the proficiency of 8- to 12-year-old typically developing children for faces or the proficiency of typically developing adults for objects. The results of these studies suggest that individuals with ASD can readily categorize when the task involves simple and typical basic objects or faces but have difficulty when categorization is more complex or involves less typical objects or faces. It is likely that individuals with ASD make categorical decisions by consciously learning certain criteria or features, so that essentially their categories do not have typicality structures and have even fuzzier boundaries. This alternative strategy would allow them to categorize typical category members but would cause difficulty when they need to categorize atypical category members that fall at category boundaries.

Implications and Conclusions

Due to the role that categorization plays in language development, the results presented in this paper have direct implications for teaching category labels to children with ASD. First, it is important for speech-language pathologists and other practitioners to begin with typical category members when teaching a child with ASD a new word or category. For example, if teaching the child with ASD the word *dog*, pictures of typical looking dogs, such as German Shepherds or Labrador Retrievers, should be paired with the word *dog* until the category label is learned. However, once the child understands the word and can correctly use the word *dog* to identify and label typical-looking dogs, the practitioner's job is not done, because this understanding and usage is unlikely to generalize to less typical and atypical category members. Given the improvement in categorization from childhood to adolescence, with experience, practitioners can likely increase generalization and the child's actual understanding of the word *dog* by introducing less and less typical category members and increasing the child's experience with all dogs, not just the most typical members. However, due to the variability in the functioning levels of individuals with ASD, some children may only be able to learn the association between typical category members and the word, whereas others may be able to learn somewhat typical or even atypical category members.

The results also suggest that even though an individual with ASD may be able to identify typical category members correctly, this does not mean that he/she truly understands the category or word or that he/she would perform as well for less typical or atypical category members. Therefore, speech-language pathologists and other practitioners need to "test" children with more than typical category members in order to determine whether the child has a true understanding of the category and word.

Finally, even though the example presented above is the category of dogs, the concept of teaching typical members first and then less and less typical members applies to more than just object categories. When teaching individuals with ASD gender of faces, emotions, and even abstract concepts such as bullying and friendship, it is important to first provide a foundation

of understanding with typical examples and then extend the understanding to less typical examples. With repetition and experience, it is likely that at least some individuals with ASD (particularly higher functioning individuals) will be able to gain a broader understanding of words and their meaning so that, rather than just learning a superficial meaning, they will have an enriched meaning that they can generalize to as yet unexperienced situations. Therefore, category learning is a foundational skill that should not be overlooked in the assessment and intervention process when working with children with ASD. It should be noted that additional research needs to be conducted to confirm these implications.

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