Construction Learning in Children with Autism

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Abstract

While much research has been focused on how social deficits impede autistics' language, little work has considered how other, non-social aspects of autism may affect its development. In this study, autistic children's oft-noted difficulty in generalization is explored as a potential factor in their language delay. In order to address this, we examined the ability of autistic children to generalize over linguistic exemplars en route to learning a novel abstract phrasal construction. In this non-social, computer based design, participants were exposed to videos pairing a novel action (an agent approaching another person) with a novel abstract phrasal form (NP NP V). While children with autism displayed comparable memory for the original examples relative to a typically developing control group, they showed a distinct in*ability to abstract over them. Our results suggest that generalization deficits play a contributing role in both hindering and shaping autistic language.*

Introduction

Autism is a neurodevelopmental disorder defined by a lack of social engagement, significant impairments in language, and a narrow, restricted focus of interest (American Psychiatric Association, 2000). Language has been recognized as an area of profound disturbance in this population, observed to be both delayed (Tager-Flusberg, Paul, & Lord 2005), as well as deviant (Ziatas, Durkin, & Pratt 2003; Prizant 2003). A significant portion of children diagnosed with autism never acquire functional proficiency; it is estimated that roughly half of all children diagnosed as autistic remain non-verbal by middle childhood (Bryson, Clark and Smith 1998).

Much of the work on autistic language delay has focused on the social profile, and converging evidence suggests that autistic children's deficiencies in language are closely tied to their noted deficits in joint attention (Kuhl, Coffrey-Corina, Padden and Dawson 2005). In fact, abilities in joint attention at three and half years of age are a stronger predictor of later language proficiency than both IQ and initial language skills (Mundy, Sigman, and Kasari, 1990). This strong relationship makes sense, insomuch as joint attention has long been recognized as essential to language learning (Bruner, 1978; Tomasello and Farar, 1986; Baldwin, 1995). As a result of this relationship, efforts to teach in joint attention skills have been a large focus in language therapies for this population (Schreibman, 2000)

While much research has been done on the relationship between joint attention and language in autism, relatively less work has done on how other, cognitive features of the disorder might hinder language development. A candidate mechanism is the overall attentional/cognitive style, which has been observed to be abnormal in children with autism. Children with autism have been noted to have an unusually narrow focus of attention, within which their focus may be supernormal (Allen and Courschene, 2001). Relatedly, autistic individuals appear to have a locally biased processing style that arguably comes at the expense of more holistic processing (Frith 1989). Autistic individuals have been observed to "neglect the forest for the trees" showing a strong focus and memory for the details of a given stimulus while showing deficits in perceiving more holistic aspects. There is accumulating evidence that this is a domain general phenomenon, with demonstrations found in vision (Frith and Dakin 2005), audition (DeGelder, Vroomen, & Van der Heide, 1991), and verbal memory (Hermelin and O'Conner, 1967; Happe 1997). This processing style has been contextualized in the weak central coherence model of autism, in which autistics have been described as having difficulty "drawing together diverse information to construct higher-level meaning in context" (Frith and Happe, 1994, p. 117; cf. also Happe and Frith 2006).

It has also been suggested that this locally over-focused attentional style may be closely related to noted difficulties in abstraction (Minschew, Goldstein, Muenz, and Payton, 1992, Klinger and Dawson, 2001). However, it is difficult to gauge how difficulties in abstraction influence categorization and concept formation, and the research into this relationship has yielded mixed results. While it appears that children with autism show an ability to form categories in certain contexts (Ungerer and Sigman, 1987, Tager-Flusberg, 1985a, 1985b) including in the Wisconsin Card Sorting Task (Benenetto et al., 1996) this proficiency may be limited to categorizations based on one dimensional, perceptual stimuli. For example, autistic individuals show difficulties when sorting on the basis of more than one perceptual criteria simultaneously (i. e. red *and* round) (Rutherford and McCintosh, 2006). Autistic individuals also fare poorly when categorization is based on more abstract features (i.e "things that can fly", "things that give light") (Soulieres et al., 2006). However they have demonstrated the ability to sort objects that are animate from those that are inanimate (Baron-Cohen, 1991) exhibiting *some* facility in abstraction.

It has been proposed that, due to their over-focused attention and inability to integrate different aspects across exemplars, children with autism do not appear to form prototypes, but instead, form categories based on rule based strategies (Klinger and Dawson, 1995, Klinger and Dawson, 2001, Rutherford and McCintosh, 2006). Although it appears that individuals with autism do rely more on rule based strategies, there is mixed evidence in favor of a specific deficiency in prototype formation. There is some support for the idea that difficulties in prototype formation may be due to methodological confounds in task difficulty (Molesworth et al. 2008) as well as for the idea that this deficiency may only be characteristic of low, but not high functioning autistic individuals (Molesworth et al. 2005, Molesworth et al. 2008).

Although the root of this deficiency is contentious, autistic individuals do appear to show general deficiencies in categorization and generalization. In a series of studies, Plaisted et al (1998) demonstrated that children with autism were unable to exploit the commonalities between the training and test phases of a perceptual learning task; while they were able to discriminate initial dot patterns, they could not discriminate completely novel patterns from dot patterns which were systematically similar. In essence, children with autism treated the similar dot patterns as being completely novel, and were unable to generalize from the initial trainings. Observations such as this has led some researchers to make specific claims about the autistic profile: "Children with autism differ in their use of similarity: specifically…they represent individual stimuli with very steep generalization gradients and do not perceive stimuli as similar unless they are very close in stimulus space" (Molesworth, Bowler, & Hampton, 2005: 663). How this inability relates to the attentional profile is uncertain (a specific deficit in prototype formation or otherwise), but it does appear that children with autism exhibit a specific deficit in the ability to generalize and make inferences beyond the specifics of their previous experiences.

Thus, deficiencies in generalization are a very well researched and oft-noted feature of autism. In fact, some have argued that it is the most robust and reliable characteristic of the disorder outside of the defining, behavioral criteria (Frith and Happe, 2006). There may be strong reason to believe that this deficiency may have important consequences for language learning. Exactly this type of learning - generalizing from specific instances to general principles, appears to be a crucial skill in acquisition. Language use has been recognized to be open-ended, in that never before heard sentences can both be easily understood and produced (Christiansen and Chater 1994, Tomasello 2003, Goldberg 2006). In order to acquire this linguistic flexibility, a richer and more abstract knowledge of one's language is necessary.

Within any given language, strong correlations exist between formal patterns and semantic meaning. That is, it has long been recognized that irrespective of component words, abstract phrasal forms are strongly associated with a consistent meaning (Bresnan & Kanerva, 1989; Goldberg 1995, 2006). For example, it has long been recognized that the English ditransitive (Subj V Obj Obj2; e.g. *he gave her a book*) is strongly associated with the meaning of transfer(Green 1974; Pinker 1989; Goldberg 1995). This is supported by the fact that individuals overwhelmingly describe a novel verb as meaning "give" when it occurs within the ditransitive construction (e.g. *He* ***mooped*** *him the lorp*) (Goldberg 1992; Ahrens 1995).

Understanding these inherent patterns is key to being able to flexibly use and understand one's language. In order for such knowledge to be acquired, children must generalize over the language exemplars they are exposed to, abstracting this form/meaning pairing from the utterances they hear (Tomasello 2003; Goldberg, 2006). Thus, generalization is a vital skill in language learning, allowing for compositionality.

Despite the crucial role which abstraction plays in language development, no investigations to date have examined how it may play a role in the language delay of autistics – who as noted above, have robust and well-documented deficiencies in generalization and abstraction across a number of different domains. The present paradigm addresses this issue head on, evaluating how children with autism learn and generalize from the language they are exposed to.

Methodology

A computer-based language learning task was used, which had been employed in past experiments with adults and typically developing children of varying ages (Casenhiser & Goldberg, 2005; Boyd, Gottschalk and Goldberg, 2009; Boyd and Goldberg, 2011; Wonnacott et al. 2012). Its computer-based nature is an important aspect of the design, as it reduces the likelihood that the child's social profile unduly influences performance, and therefore provides an opportunity to investigate how deficiencies in categorization may directly influence the learning task.

2.2 *Participants*

Eighteen typically developing 7 year olds, and 16 autistic children aged 8-13, participated in the task. Seven year olds were recruited from nearby summer afterschool programs, while the autistic group was recruited from a nearby middle school. Each child was given a children's book in exchange for their participation.

2.3 *Pre-test*

The program begins first with a series of six trials testing basic language comprehension abilities. Participants are shown two similar videos side by side, with one overlapping auditory description, and are simply asked to point to the video that is being described. For example, in one such video a frog puppet jumps on a king puppet, while in the other the king jumps on the frog. Subjects hear "the frog is jumping on the king", and so should point to the first video to be correct. These trials were included in order to ensure participants had a basic understanding of the task, and of simple language. As will be discussed in more detail later, it was also used in part, to match the two groups. A summary of all six of the pretest trials are provided in Table 1 below:

Table 1. *Pretest items*

Left Video	Right Video
The frog is jumping on the prince	The prince is jumping on the frog
The frog moves around the car	**The frog is moving the car around**
The king bows at the queen	**The king and the queen are bowing**
The monster is rolling on the ball	The monster rolls the ball
The queen waves the flower	**The queen waves at the flower**
The witch waves at the man	The witch and the man wave

Correct video choice boldfaced

2. 4 *Novel phrasal construction*

The goal of this task was to test children on their ability to generalize at the level of the phrasal construction. To this end, a novel construction was used pairing a novel word order with a novel abstract meaning; the form was <NP1 NP2 V>, and the abstract meaning was "approach". In particular, NP1 designated the actor who moved toward the actor designated by NP2. Five different nonsense verbs ending in "o" were used, each denoting a particular manners of motion. This construction does not exist in English and thus provides the opportunity to investigate learning while minimizing the influence of previous linguistic knowledge.

Participants were exposed to 16 brief videos, in which scenes of approach were depicted and narrated by the novel construction. All videos involved the same two characters, a doctor and a construction worker, and lasted approximately 8 seconds each. For example, subjects saw a doctor crawling to a construction worker and heard "the doctor the construction worker moopoed". Half of the time NP1 designated the doctor and NP2, the construction worker, and the other half of the time it was the reverse. While the same two characters were used across all trials, different verbs, depicting different types of approach motion were used. For example, on another trial, instead of crawling, the doctor *hopped* to the construction worker – this time narrated by "The doctor the construction worker vakoes". Five different verbs/approach actions were used across the 16 trials. In line with previous work demonstrating a learning advantage for an input skewed towards a single verb (Casenhiser and Goldberg

2005; Goldberg et al. 2004), *moopoes* was employed 8 of the 16 times, while *vako, keybo, feigo, and sooto* were used twice each. While different approach actions and different verbs were used across the 16 trials, all of the clips retained the same abstract form <NP1 NP2 V-o> and meaning (NP1 approached NP2 in a V-like fashion).

2.5 *Testing Trials*

In order to determine what participants learned during exposure, they were given a forced choice comprehension task that tested their knowledge of this new "approach" construction. All testing trials involved participants watching two videos play simultaneously, side-by-side, while being narrated by an overlapping description. As in the pre-test, participants were simply instructed to point to which video the sentence referred to. Participants were given 16 test items: 6 holistic approach trials, 6 holistic intransitive trials and four linking trials.

The purpose of the holistic trials was to simply determine whether participants could discriminate the meaning of the novel construction from that of a common English construction: the intransitive. All of these testing trials tested whether participants could distinguish a scene of approach from a scene depicting the agents performing a repetitive intransitive action in synchrony (i.g rubbing their stomachs). On approach trials, the narration had the form <NP1 NP2 V>, thus making the correct answer the approach video. In contrast, intransitive trials were narrated by an intransitive form with a novel verb (e.g. *the doctor and construction worker are koobing),* and thus the intransitive video in this instance was the correct choice.

Of crucial interest was whether participants were able to learn the *abstract* form/meaning pairing; i.e., whether the constructional knowledge would transfer to items that differed systematically from the original exemplars. In order to gauge this, these holistic trials differed along three lines of novelty: *old items, new verb*, and *all novel*. On 'old item' trials, the approach video was simply repeated from one seen in exposure. Participants simply needed to recognize this old exemplar and its corresponding narration. In the 'new verb' condition, the target video retained the same characters as in exposure (the doctor and the construction worker), but this time a new verb and a corresponding new action were used. In the all novel trials, both new characters (e.g boxer and princess) and new verbs/actions were used.

Despite manipulating these surface differences, success is still possible on holistic trials given a non-comprehensive understanding of this new construction. It is possible for participants to do well on holistic trials knowing only that two initial NPs are associated with a meaning of approach. Linking trials were used in order to gauge whether participants understood that NP1 was associated with the approaching agent, while NP2 refered to the person being approached. Unlike the holistic trials, linking trials included two videos of approach scenes. In one, the construction worker approached the doctor, while in the other, the doctor approached the construction worker in the same manner. The voiceover was an approach form corresponding to one of the videos. Thus, if the description was, *The construction worker the doctor fagoes,* the video of the construction worker approaching the doctor (and not vice versa) should be selected as being correct. A summary of all testing trials can be found below in Table 2

Table 2. *Summary of the different types of testing trials*

Old Items (Old Verbs/Old Arguments)	Narration: "The doctor the construction worker moopoes" Correct Video: the doctor approaching the construction worker Foil Video: Intransitive action
Intransitives	Narration: "The doctor and the construction worker are lorping" Correct Video: Intransitive action Foil Video: the doctor approaching the construction worker
Partially New (New Verb/Old Arguments)	Narration: "The construction worker the doctor vakoes" Correct Video: the construction worker approaching the doctor Foil Video: Intransitive action
All new (New Verb/New Arguments)	Narration: "The boxer the princess kafoes" Correct Video: the boxer approaches the princess Foil Video: Intransitive action
Linking	Narration: "The doctor the construction worker moopoes" Correct Video: the doctor approaches the construction worker Foil Video: the construction worker approaching the doctor

It has been previously demonstrated that after just 3 minutes of training, typically developing children can learn a novel phrasal construction, and can generalize over the construction to novel linguistic input (Goldberg, Casenhiser and Sethuraman 2004, Casenhiser and Goldberg 2005, Boyd and Goldberg, 2011). However, we might expect that autistic children to not perform comparably in this task, given their difficulties generalizing. We hypothesize that children with autism will perform significantly below their typically developing counterparts on test items requiring generalization.

Results

An overall main effect for accuracy was found, $F(1, 196) = 29.6$; $p<.001$, with typically developing children being more accurate in their responses across all trials ($\bar{x}= .89$, $\sigma = .23$) than the autistic group ($\bar{x} = .68$, $\sigma = .31$). More interesting however is how the different groups matched up on the different types of test items basis (see Figure 1). Trials on this task can be broken down along two main categories: those which do not rely on generalization (pre-test, intransitive, and no novelty items; henceforth "NG" trials), and those which do rely on generalization (new verb, all new and linking trials; henceforth "G" trials). First, one-tailed t-tests were performed for each group on all "O" trials. It was found that both groups did well across the board, performing above chance on pre-test items (autistics: $t(15) = 14.45$, $p < .001$; typical = $t(17) = 15.35$, $p<.001$) intransitive (autistics: $t(15) = 4.04$, $p<.001$; typical = $t(17) = 14.23$, $p<.001$) and no novelty items (autistics: $t(15) = 5.46$, $p<.001$; typical: $t(17) = 10.29$, $p<.001$). Comparing the groups on each of these trials with between subject ANOVAs, no significant differences were found between trials which did not involve generalization. First, there was no significant difference, $F(1, 31) = 2.86$, $p = .1$, between autistic ($\bar{x} = .93$, $\sigma = .10$) and typical developing ($\bar{x} = .98$, $\sigma = .05$) children on pretest items. This was also true of no novelty items, $F(1, 31) = 2.16$, $p = .152$ and intransitive trials, $F(1, 31) = 2.4$, $p=.72$.

However group differences emerge on the performances of "G" trials, which do require generalizations. Again, one-tailed t-tests were run on each group alone, against a chance baseline. The typically developing group showed clear evidence of generalization, performing significantly above chance on novel verb $t(17) = 3.34$, $p = < .01$, all novel $t(17) = 5.33$, $p < .001$ and linking trials $t(17) = 6.89$, $p<.001$. In contrast, the autistic group did poorly on all such trials, performing at chance on novel verb $t(15) = 1.48$, $p = 4$, all novel $t(15) = 1.03$, $p = .54$ and linking trials $t(15) = 1.26$, $p = .49$. Contrasting this with the performance of the typical children, we find that autistic performance on generalization trials is significantly worse on these novel verb items $F(1, 31) = 8.47$, $p = .005$, all novel items $F(1,31) = 6.62$, $p = .015$ and linking rule items $F(1,31) = 18.06$, $p < .001$. See table 1 for a complete list of means.

Figure 1. *Performance of typically developing and autistic groups*

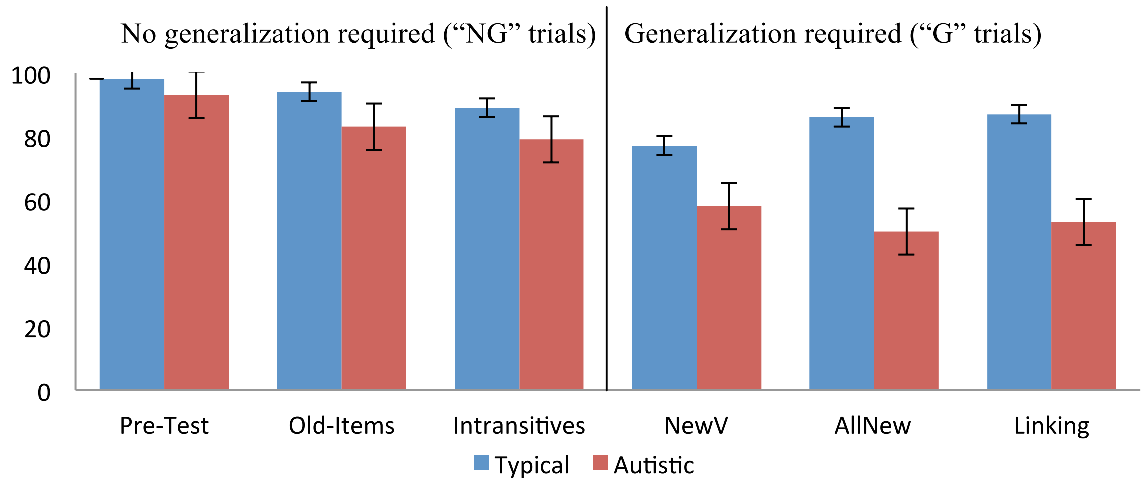

Table 2. *Means (S.D) of typically developing and autistic groups across all trials*

	Pre-Test	Old-Items	Intransitives	NewVerb*	AllNew*	Linking*
Typical	98(.05)	94(.11)	90(.19)	77(.35)	86(.28)	87(.22)
Autistic	93(.10)	83(.25)	78(.19)	58(.33)	50(.32)	53(.23)

*= significant difference (p<.05) between groups on trial type

The large main effect of accuracy does not appear that this reflects global differences in intelligence or ability. Importantly, both groups performed comparably on all No generalization (NG) trials (pretest, old items, and intransitives), which do not require generalization. Instead, these NG trials collectively assess everything that the task requires *except* for generalization: basic language comprehension (pre-test trials and intransitives) and a memory for the previous exemplars (old items). Children with autism were able to discern the 'approach' meaning when the test exemplars did not differ from those seen in original exposure.

However, they did not appear to form an abstract representation of the approach construction, as they were unable to show any evidence of productive transfer to test items that involved any degree of novelty. These novel items necessarily required generalization over the exemplars witnessed during exposure. The interaction in performance suggests that the group difference does not result from potential global differences between groups, but reflects something more specific and more interesting. While memory for individual exemplars is reasonably strong, children with autism showed a specific deficit in generalizing over utterances.

Discussion & Conclusion

We have provided evidence to suggest that children with autism do not readily generalize over the linguistic exemplars they are exposed to. Given the important role that generalization plays in language learning, there is good reason to believe that this may well play a role in hindering autistic language development. Knowledge of language does not consist of a set of unrelated separate exemplars, but rather a rich interrelated network of partially generalized information. Without being able to extract similarities and generalize across exemplars, children with autism are at a disadvantage when trying to learn the rich grammatical patterns of their ambient language.

In general, research into language development in autism has been product-oriented (documenting the peaks and troughs in the language profile) as opposed to process-oriented (looking at the mechanisms at work in the process of development) (Gernsbacher, Geye, & Ellis Weismer, 2005; Swensen, Kelley, Fein & Naigles, 2007; Annaz, Karmiloff-Smith and Thomas, 2008). The study of autistic language appears to be no exception to this general trend. While there have been numerous observations of peculiarities in autistic language, few studies have provided insight about how these qualities come to exist. Noteworthy findings of autistic language are reviewed here, in light of the current findings; linguistic under-generalization may help to explain why autistic language appears as it does.

Overall, autistic language has been has been characterized as involving stored verbatim utterances, exhibiting an overall lack of creativity and productivity (Prizant & Rydell 1984; Dobbison 2000; Perkins, Dobbison, Boucher, Bol and Bloom, 2006). Autistic language often uses the same precise words for general expressions (e.g., "in the middle afternoon" for anytime between 12pm and 7pm), and it appears that many individual words are learned only within strings of longer utterances, as they are not always used appropriately in other contexts (Perkins et al 2006). Relatedly, expressive language in autism is often noted to be better than comprehension (Groen, Zwiers, van der Gaag, and Buitelaar, 2008), which may also reflect an inability to generalize over individually stored chunks of language. If one's base linguistic knowledge only consisted of a series of separate, stored phrases, an individual would be limited in their expressive ability, but they would still be able to use their stored phrases appropriately. However, this would prove much more costly for comprehending language, since the chance that they would happen to hear one of these phrases in the ambient language is lower.

Parallels appear in conversational speech as well, where much of the autistic individual's contribution to the conversation appears to be borrowed directly from their interlocutor. While a certain degree of borrowing is typical in normal conversation (Garrod and Pickering, 2004), with autistics it is often taken to an extreme, jeopardizing basic coherence. The following is a conversation (from Perkins et al., 2006) between an experimenter and an autistic adult named "Gary":

Exp: And can you tell me Gary, in what direction does to the sunset?
Gary: That <u>direction</u>. <u>Whats</u> <u>the</u> <u>sunset</u> <u>does</u>?
Exp: That's when the sunset goes down, isn't it?
Gary: <u>Tell me</u>, <u>isn't</u> <u>it</u> <u>the</u> <u>sunset</u> <u>does</u>?

The underlined words and phrases are those that Gary borrowed directly from the experimenter. Gary's impoverished ability to communicate is typified by an over reliance on his interlocutor for specific linguistic formulations. It may be that autistics lack the abstract representation needed in order to creatively construct meaningful sentences on their own, and therefore resort to borrowing a great deal of the specific linguistic formulations directly from the conversation.

An extreme form of this is the well-noted autistic tendency of echolalia, in which (typically low functioning) individuals will repeatedly say the same verbatim phrase over and over without any apparent communicative purpose (Prizant and Rydell, 1984). It is uncertain even whether the speaker understands the basic meaning of the utterance. And while not all autistic children exhibit echolalia per se, it appears that a general tendency towards repetitive, unproductive speech does, with echolalia representing an extreme end of this continuum.

This work suggests that the language development of children with autism may be hindered by their general cognitive style – a strong attention to details, at the expense of building abstractions. Furthermore, features of the language which do emerge in this population (inflexibility, over-reliance on verbatim utterances) are symptomatic of what one might expect from a population that struggles to learn abstractions. Thus, the 'generalization deficit' may play a large role in both hindering and shaping the autistic language profile.

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