Do Children with Autism have an Explanatory Drive?

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Abstract

Do children with autism seek explanations to an unexpected outcome? To answer this question, sixteen children diagnosed with an Autism Spectrum Disorder were tested in a paradigm developed by Povinelli and Dunphy-Lelii (2001) that addressed this question. The task involved standing two identical L-shaped blocks on a table. In the critical trial, unbeknownst to the child, a new block was introduced that contained a small weight that prevented it from standing up. The performance of the children with autism (CWA) was compared with data from 14 typically-developing 5-year-old children (5YO Controls). Results demonstrate that although CWA visually and tactilely explored the sham block as much as controls, there was an overall tendency for CWA to offer more explanations about the defective block. We conclude that the explanatory drive is preserved in CWA and in certain measures may be exceptional compared to typically-developing populations.

Introduction

A fundamental and possibly unique attribute of the human mind is its constant pursuit of explanations (Povinelli, 2000). So, whereas children as young as 3-years of age seek an answer to a problem in an impossible task, chimpanzees do not (Povinelli & Dunphy-Lelii, 2001). That the human mind may be uniquely adapted to explore and explain is not surprising given the many causal terms that exist in our lexicon. Research suggests that questions about 'why?' and 'how come?' appear early in language development (Crowley & Siegler, 1999; Wellman & Gelman, 1998; Bullock & Gelman, 1979; Gopnik & Sobel, 2000; Shultz, 1982; Shultz, Altmann & Asselin, 1986). For instance, by 4- or 5-years of age children are able to produce explicit explanations for events (Crowley & Siegler, 1999; Wellman & Gelman, 1998) and an understanding of abstract causal relations appears to emerge even earlier (Bullock & Gelman, 1979; Gopnik & Sobel, 2000; Shultz, 1982; Shultz, Altmann & Asselin, 1986). This drive to explore and explain continues through adolescence and adulthood.

Young children's drive for explanation has lead some to liken young children to scientists engaged in theory formation and hypothesis-testing (e.g., Carey, 1985; Gopnik, 1988; Keil, 1987; Wellman, 1990). The idea that the human mind is innately equipped with a mechanism for theory formation and hypothesis-testing is buttressed by cross-cultural research demonstrating that the explanatory drive is not a peculiarity of Western Culture. Rather, the need to explain is widespread, appearing in every culture and historical time period that has been studied (Lewis, 1985; Morris, Nisbett & Peng, 1985).

Here, we explore whether this feature of the human mind is preserved in children with autism. On the one hand, the many deficits that characterize Autism Spectrum Disorders suggest that the explanatory drive may be deficient in individuals diagnosed with autism (DSM-IV-R, 2004). For instance, it is well-known that individuals with autism suffer from impairments in the social and linguistic domain (DSM-IV-R, 2004). It is less well-known that children with autism are also appear impaired in tasks that involve abstract reasoning and concept formation (Grant, Riggs, Boucher, 2004; Leekman & Perner, 1991; Minshew, Goldstein, & Siegel, 1997; Minshew, Meyers, & Goldstein, 2003; Minshew, Siegle, Goldstein & Weldy, 1994). Arguably, while these deficits likely impair autistic individual's understanding of the private thoughts, emotions and experiences of others—theory of mind—(Baron-Cohen, 1995; Frith, 1989; Leslie, 1987), they may similarly impair the explanatory drive.

On the other hand, research suggests that individuals with autism may have an exceptional explanatory drive (e.g., Baron-Cohen, 2003). A number of studies have demonstrated that certain high-functioning individuals with autism appear to have exceptional abilities in the physical domain (Baron-Cohen, 1997; 2003; Baron-Cohen, Leslie & Frith, 1986); suggesting that individuals with autism might have a preserved, if not exceptional, explanatory drive. A number of studies suggest as much. In one study, Baron-Cohen, Leslie and Frith (1986) used a picture sequencing task (e.g., Bullock, 1984) to study children's (typically-developing and autistic) understanding of causal relations. Baron-Cohen and colleagues hypothesized that children with autism would understand some events but not others. To this end, they compared three types of picture stories. One type was labeled "mechanical" because it depicted physical-causal relations such as a boulder rolling down a hill and breaking a tree. A second type was called 'behavioral' because in these stories individuals partook of activities and interactions that could be understood in purely behavioral terms (i.e., without attributing mental states). For example, a girl takes the ice cream cone of a boy. However, a third story type—intentional—required an understanding of mental states such as 'false belief' and could not be easily explained using purely behavioral/descriptive terms. These investigators reported that despite the mental age advantage of the children with autism (MA non-verbal = 9.6; MA verbal = 5.7) over the mental age of the control groups [children with Down's Syndrome (MA non-verbal = 5.9; MA verbal = 2.9 and typically developing children (CA = 4.5)], children with autism generated fewer mental state-terms than typically-developing children and children with Down's Syndrome. However, on the mechanical stories, the children with autism were far better than either control group. While intriguing, the autistic group's advantage in the mechanical stories may have been a product of their advanced mental age.

Leslie and Thaiss (1992) followed up this study with a “picture task” where subjects took a Polaroid picture of, for example, a cat on a chair next to the bed. While the film developed, the cat was moved from the chair to the bed. Following that move, the child was asked, “In the photograph, where is the cat?” While less than 70% of a mental-age control group passed the picture task, 100% of the children with autism understood that the photograph had captured where the cat had originally sat (i.e., the chair and not the bed). The children with autism again surpassed normal children when Leslie and Thaiss (1992) presented subjects with a “false map.” In both of these tasks, the performance of children with autism was significantly better than that of the typically-developing controls.

While these studies may suggest that individuals with autism evidence a superior understanding of inanimate objects or observable physical events, it is unknown whether this is the product of greater familiarity with particular objects such as cameras or a heightened sensitivity to observable causal regularities. To our knowledge, no study has directly explored the explanatory drive in an autistic population, used a novel physical problem or evaluated non-verbal as well as verbal responses. Under such circumstances, might individuals with autism show a preserved explanatory drive when compared with age-matched control subjects? Might their non-verbal behaviors reveal a greater interest in the mechanics of the problem? Might their questions be limited to the objects or will children with autism seek out explanations and help from the experimenters and/or their parents?

Methods

Subjects

Children with Autism. Sixteen children diagnosed with an Autism Spectrum Disorder [Autism (n = 11); Asperger Syndrome (n = 1), PDD-NOS (n = 4)] participated in the present study. They were recruited via clinicians who specialize in the treatment of children with autism. Their mean chronological age (CA) was 78.21 (range: 52 – 111). Mean mental Age (MA) was 57.29 (42.5 – 84). Mean Verbal Mental Age (VMA) was 50.60 (range: 12.5 – 69.5). Mean Non-Verbal Mental Age (NV-MA) was 67.84 (range: 38.25 – 114.76). Children were diagnosed by clinicians using DSM-IV standards and diagnoses were independently confirmed by MDR using the ADOS-G (Lord et al., 2000) and ADI-R (Lord, Rutter, & LeCouteur, 1994). Two individuals were discarded because the child refused or was unable to participate.

Typically-Developing (Control) Children. The performance of the children with autism was compared with the performance of children that participated in an earlier study (Povinelli and Dunphy-Lelii, 2001, Exp. 2) that used similar procedures. This control group included 14 typically-developing five-year-olds (range: 60-71 months; mean = 65.36 months) with no history of developmental delay. Consequently, it was assumed that their chronological ages corresponded with their mental ages.

Apparatus

The procedures and methods used to test the subjects have been described in detail elsewhere (Povinelli & Dunphy-Lelii, 2001, Exp. 2 and 3). Briefly, three inverted L-shaped blocks identical in size, color and weight were decorated to look like dogs when stood in the inverted position. Although all the blocks contained a weight that was not visible to the naked eye, in one of the blocks the position of the weight prevented the block from standing upright (hereafter referred to as the "sham" block). The blocks were to be stood atop a white table with two concentric black circles drawn on opposite ends of the table (76 cm apart).

Procedures

After a warming up period where the experimenter interacted with the subjects and played various games (not related to the study), they were led to a testing area where they were introduced to two yellow blocks atop a white table. At this time, the experimenter demonstrated how the blocks were to be stood inside each circle. While the children put stickers on their sticker page (reinforcement), the experimenter took down the blocks from their upright position and placed them on their side in the middle of the table, outside the circles. The children where then asked to stand up the two blocks in their respective circles. This procedure was repeated across two trials (i.e., baseline trials). Prior to the start of the third trial, while the child placed stickers on their sticker page, the experimenter exchanged one of the blocks for the sham block, placed both the sham and the functional block on their side in the center of the table and asked the child to stand the blocks in their circles. This third trial lasted a total of 120s (the manipulation period) during which the experimenter appeared distracted (arranging stickers) in order to discourage the child from seeking direct assistance. If the child insistently appealed to the experimenter, her verbal responses took the form of general encouragement and support: "Can you stand them up on their feet?" After the 120s had elapsed or as soon as the child refused to participate, the experimental trial ended and the experimenter asked the child "Why won't it stand up?" This marked the beginning of the questioning period.

All trials were reviewed by two raters after reading a set of written instructions which assessed whether children engaged in either visual or tactile inspections of the sham block. Visual inspections consisted of (a) looking at the bottom of the block closely and deliberately, (b) moving the block outside the circle or moving the block to the opposite circle and (c) flipping the block and placing it on the table. Tactile inspection consisted of (a) touching the bottom of the sham block or (b) touching the surface of the table. Both raters also produced a transcript of all the spontaneous utterances of the child during the trial. An additional rater independently coded each of these transcripts for the same spontaneous verbal descriptions: (a) child described on-going state of affairs (i.e., It keeps falling down!), (b) child asked 'Why?' (c) used psychological terminology to describe the [sham] block (d) offered a physical cause as an explanation for the sham block's failure (e.g., "Because it's broken"). Inter-rater reliability was high. Kappa values ranged from .94 to .99 in both the verbal and the non-verbal measures (c.f., Table 2).

Results

Non-Verbal Measures: Every child with autism, as well as every typically-developing 5-year old child, stood up the functional block in baseline trials. However, only one of the children successfully stood the sham block. Their failure was not due to a lack of motivation. All the participants spent nearly all of the allotted time (120s) manipulating the block. As can be seen in Table 1, both children with autism and typically-developing control children engaged in equal amounts of tactile and visual inspection of the sham block. Consequently, there were no significant differences between the different types of interventions and manipulations used by children with autism or typically-developing control subjects [X^2 (7) = 1.06, p = .99, Kruskal-Wallis Test]. We also evaluated the number of interventions children engaged in during the two testing periods (manipulation v. questioning) and found a marginally significant main effect for group (X^2 (3) = 6.60, p = .09, Kruskal-Wallis Test). Children with autism inspected the sham block with equal frequency during the manipulation and during the questioning period. Thus, whereas typically-developing children engaged in visual and tactile explorations of the sham block largely during the manipulation period and largely ignored the sham block during the questioning period (Z (32) = -2.57, p < .05, Mann-Whitney Test, one-tailed), children with autism engaged in visual and tactile explorations of the sham block in both the manipulation period and in the questioning period (Z (25) = - 1.31, p = .10, Mann-Whitney Test, one-tailed). This outcome suggests that autistic children were more persistent in their pursuit to answer the problem than the typically developing children who by and large stopped exploring the problem after the manipulation period.

The amount of either visual or tactile explorations that the children with autism engaged in was significantly correlated with non-verbal MA (Spearman's *r* = .65, p < .05, one-tailed). However, performance did not correlate with either verbal mental age (Spearman's *r* = .04, p = .45, one-tailed) or with chronological age (Spearman's *r* = .09, p = .39, one-tailed).

Verbal Measures: Of the 14 children with autism tested, 10 offered verbal comments, explanations and/or descriptions of the problem. We evaluated the content of the verbal responses of these 10 children using the criteria described by Baron-Cohen et al (1986). In the present study, a response was considered "folk psychological" if it included at least one of the following:

(a) a mental state term such as want, likes, believes, knows. For example: *It doesn't want to stand up!*

(b) an attribution of agency and/or animacy. For example: *These dogs [blocks] are silly. They're being bad.*

In contrast, responses were considered "folk physical" if they included one of the following:

(a) *because* clause. For example, [The block falls] *because it has a weight in it*.

(b) causal phrase. For example: *It's broken!* [the blocks].

Phrases that included the term *Why, How come* , or implied either of these (e.g., "What's wrong with it?") were included in the "Why" category. And, only explicit requests for help (e.g., *Please help me!*) were included in the "Help" category. Comments that were not obviously 'folk physical' or 'folk psychological' and were not explicit requests for Help or requests for information (e.g., Why?) were considered "Descriptive". Examples include: *They're not standing up in their yards; This keeps falling; It's stuck.*

There was a main effect for explanation type (X^2 (9) = 43.99, p < .001, Kruskall-Wallis Test). A Mann-Whitney non-parametric test was used for pairwise comparisons. As can be seen in Table 2, there were two significant differences in the types of questions and verbal explanations given by typically-developing children and children with autism, regardless of diagnosis. Although groups did not differ in terms of describing the state of affairs [Z = -.18, p = .43, one-tailed] or offering mentalistic/psychological explanations [Z = -.33, p = .37, one-tailed], there was marginal tendency for children with autism to ask more "Why" questions than typically-developing controls [Z = -1.34, p = .09, one-tailed] and a significant tendency by the children with autism to make explicit requests for help [Z = -2.10, p < .05, one-tailed] and to offer physical explanations for the problem [Z = -1.72, p < .05, one-tailed]. Finally, an evaluation of the total number of descriptions and questions revealed that children with autism asked more questions about the problem than typically-developing control children [Z = -1.73, p < .05, one-tailed]. The autistic group's proclivity to ask more questions was not correlated with this group's verbal mental age (Spearman's r = .14, p = .34, one-tailed), non-verbal mental age (Spearman's r = .14, p = .34, one-tailed) or with chronological age (Spearman's r = .11, p = .38, one-tailed) [Inter-rater reliability for verbal measures is summarized in Table 2].

Discussion

The children with autism tested in this paradigm have an intact explanatory drive. Although the children with autism did not differ from the control group in any of non-verbal measures that involved visual and/or tactile inspection of the sham block, there were significant group differences in a number of verbal measures. Overall, children with autism asked more question and offered more explanations of the problem than the typically-developing control subjects. Specifically, the children with autism asked for help more often and offered more physical explanations than typically-developing control subjects. This difference cannot be explained by group differences in verbal ability because the VMA of the autism group was lower than that of the control group. If VMA determined verbal explanations in the present study, then the typically-developing group should have offered significantly more explanations for the problem than the autism group. But, as noted, that was not the case. Furthermore, while therapeutic interventions may explain why the children with autism sought the help of the experimenter more often than the control children, such interventions cannot explain the high frequency of physical explanations.

This pattern of performance is consistent with studies demonstrating that individuals with autism are over-represented in certain branches of the natural sciences such as physics, engineering, and mathematics (e.g., Baron-Cohen, 2003; Baron-Cohen, Bolton, Wheelwright, Scahill, Short, Mead, and Smith, 1998; Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999) as well as family history reports suggesting that the “obsessions” of individuals diagnosed with Asperger’s Syndrome (DSM-IV-R, 2004) or High Functioning Autism do not cluster randomly, rather they occur most often in the domain of ‘folk physics’ where the focus is how things and objects work and significantly less often in the domain of ‘folk psychology’ whose focus is on how people work (Baron-Cohen, 2003; Baron-Cohen & Wheelwright, 1999). Baron-Cohen and his colleagues note that these 'obsessions' do not result from anxiety, but rather from a curiosity to understand a given problem, as was the case in the present study.

The present study is the first experimental investigation that demonstrates that, at the very least, that individuals with autism have a preserved explanatory drive and can conceptualize unobservable, hypothetical constructs such as 'cause' despite their inability to reason about psychological unobservables (Povinelli, 2000). But our data suggests another possibility: children with autism may possess an exceptional explanatory drive. This latter hypothesis is derived from the fact that in the present study, children with autism were in some measures more inquisitive—offering more verbal explanations for the problem—and more persistent—exploring the problem with equal intensity in both the manipulation and questioning periods—than typically-developing controls tested in a similar paradigm. Importantly, the reverse was never true. Whenever there was a group difference, it always favored the autism group. This pattern of performance demonstrates that the explanatory drive is present in young individuals with autism and does not emerge later in development. A late-emerging explanatory drive would suggest either educational training or the product of compensatory mechanisms arising from folk psychological (theory of mind), among other cognitive, deficits. Moreover, this is the first study we are aware of that demonstrates that the explanatory drive is not unique to high-functioning individuals with autism. The fact that children representing the full spectrum of

Autism evidenced a preserved, and in some instances an exceptional, explanatory drive suggests that this is a stable feature of Autism Spectrum Disorders and not an exclusive characteristic of individuals with Asperger's Syndrome or High Functioning Autism. Importantly, the exceptional performance of the children with autism in the verbal measures cannot be explained entirely by VMA. Because while visual and tactile inspection correlated with the autistic group's non-verbal MA ($r = .65$), verbal explanations were not correlated with the autistic group's verbal MA ($r = .14$).

Is the explanatory drive in autism restricted to the physical (non-social) domain? Various case histories suggest that among individuals with Asperger's Syndrome (AS), folk psychology deficits may be dissociated from deficits in folk physics. In one study, the mean performance of three individuals diagnosed with Asperger's Syndrome and with an MA greater than 130 on a test of "Folk Physics" was two standard deviations above the mean performance of age-matched control subjects and one standard deviation below the mean performance of these same control subjects in a test of "Folk Psychology." There were no significant differences between the performance of the three AS individuals and the control group in a gender recognition task (Baron-Cohen et al., 1999).

How does one consolidate the performance of individuals with autism in the physical domain and in the psychological/social domain with their preserved explanatory drive? After all, if individuals with autism have a desire to understand and explain events shouldn't they do so in the social domain and not just the physical domain? That is, shouldn't they be as sensitive to social rules and conventions as they are to physical forces? While the present study cannot directly answer this question, the results reported here and elsewhere (e.g., Subiaul, 2004) demonstrate that individuals with autism are not blind to the fact that individuals are important sources of information as evidenced by the autistic group's willingness to ask for help from an investigator. Moreover, case studies suggest that individuals with autism seek to explain social phenomenon as much as physical systems. For instance, Baron-Cohen et al. (1999) note that DB, a renown Mathematics Professor diagnosed with Asperger's Syndrome, has attempted to formulate rules governing social behavior, much like is done in mathematics and physics. GC, another case documented by Baron-Cohen and colleagues (1999) described the difference between his mind and those of most peoples the following way: "My mind is like a digital computer: it is either on or off. Information is either true or false. Other people's minds are like analog computers, with smoothly varying voltages, and manifesting fuzzy logic." In fact, all three cases documented by Baron-Cohen and his associates evidence having spent a significant amount of time attempting to understand and explain inter-personal relationships; at times attempting to reduce behaviors to formal laws and principles, much like the Behaviorists did in the middle part of the twentieth century (e.g., Skinner 1965).

Conclusions

Children with autism evidence from an early age a desire to understand and explain their world much like typically-developing children. However, the present study suggests that children with autism are prone to ask more questions and offer more causes for a given problem than age-matched control subjects tested in a similar paradigm. The seemingly superior drive to verbally explain and understand phenomena may explain, in part, why some segments of the autistic population excel in certain scientific fields. But it doesn't explain why the explanatory drive does not extend beyond the physical domain. The failure of autistic individuals to successfully explain (and understand) social phenomena rests in part on a number of factors that characterize Autism Spectrum Disorders. Among these are linguistic and affective impairments (APA, 2000) as well as specific reasoning deficits (Minshew et al., 1994, 2003). In this view, children with autism have a drive to understand and explore all types of problems but when they seek out explanations in the social domain they are hampered by the linguistic and affective impairments of autism and are, consequently, overwhelmed by the "fuzzy logic" governing social dynamics.

While beyond the scope of the present study, future research should explore the development of the explanatory drive in children with autism and directly test the possibility that individuals with autism do not explore social problems the same way typically-developing children do. One might predict, for example, that children with autism may approach social problems as if it were a physical problem. And while children with autism may give as many explanations for the atypical social behavior, they may offer more causal than psychological explanations (e.g., Baron-Cohen, Leslie, and Frith, 1986) and consequently, engaged a greater number of causal rather than social/psychological interventions. These and other studies will bring us closer to answering whether the explanatory drive, like folk physics and folk psychology, is domain-specific or whether it is a broadly distributed, domain-general characteristic of the human mind.

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Table 1. Number (and Percentages) of Children Who Visually or Tactilely Examined the Bottom of the Sham Block.

GROUP	*n*	VISUAL	TACTILE	BOTH	EITHER
AUTISM	**14**	**11 (79%)**	**4 (29%)**	**4 (29%)**	**11 (79%)**
Asperger	1	1 (100%)	1 (100%)	1 (100%)	1 (100%)
Autism	9	5 (67%)	3 (33%)	3 (33%)	5 (67%)
PDD-NOS	4	4 (100%)	0 (0%)	0 (0%)	4 (100%)
CONTROL	**14**	**11 (79%)**	**5 (36%)**	**5 (36%)**	**11 (79%)**

Table 2. Inter-rater reliabilities for non-verbal and verbal measures.

INTER-RATER RELIABILITY

	% Agreement	Kappa Value
Non-Verbal Explanations		
Tactile Exploration	98	0.96
Visual Exploration	96	0.91
Verbal Explanations		
"Describe"	100	1.00
"Help"	90	0.79
"Why"	100	1.00
"Physical"	90	0.79
"Psychological"	100	1.00

Table 2. Number (and Percentage) of Children who Generated Various Kinds of Questions and Verbal Explanations Regarding the Sham Block.

GROUP	*n*	DESCRIBE	HELP	WHY	PSYCH	PHYSICAL
AUTISM	**11**	**10 (91%)**	**7 (64%)**	**3 (27%)**	**3 (27%)**	**7 (64%)**
Asperger	*1*	*1 (100%)*	*1 (100%)*	*1 (100%)*	*0 (0%)*	*1 (100%)*
Autism	*7*	*7 (100%)*	*4 (50%)*	*2 (29%)*	*2 (25%)*	*5 (75%)*
PDD-NOS	*3*	*2 (67%)*	*3 (100%)*	*0 (0%)*	*1 (33%)*	*1 (33%)*
CONTROL	**14**	**13 (93%)**	**0 (0%)**	**1 (7%)**	**3 (21%)**	**3 (21%)**