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The Relationship Between Symptoms and Abilities in Autism

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Abstract

We assessed if autism symptoms relate to ability deficits and achievement discrepancies in 29 children aged 4 to 13 years with a diagnosis of Autistic Disorder. Symptoms, intelligence, language, motor coordination and social cognition were assessed. Children with autism underachieve on all ability measures. There were significant achievement discrepancies between Performance IQ and theory of mind, fine and gross motor coordination. The most common discrepancy was between Performance IQ scores and motor coordination scores, which was observed in 86% of children. Early developmental abnormalities related to most abilities, social interaction symptoms related to motor coordination and receptive language, and symptoms related to discrepancies between PIQ and social cognitive abilities.

Keywords: Autism, Intelligence, Empathy, Motor Coordination, Language

Autistic Disorder (AD) is defined by impairments in social reciprocity skills, communication, and behavior/interests relative to age and mental age (American Psychiatric Association, 1994). AD is also associated with deficits across several ability domains, including language (Howlin, 2003), motor coordination (Ghaziuddin & Butler, 1998) and social cognition (Baron-Cohen et al., 1985), and is often comorbid with Intellectual Disability (American Psychiatric Association, 1994). DSM-IV rules imply that delays in language and motor coordination are intrinsic to autism. Expressive Language Disorder, Mixed Receptive-Expressive Language Disorder, and Developmental Coordination Disorder are not diagnosed if criteria for a Pervasive Developmental Disorder (PDD) are met.

Whether ability deficits relate to autism symptoms is unknown. In general, correlations between abilities and symptoms are expected because AD children obtain lower scores on most ability measures than children with less severe PDDs (Dyck et al., 2001). However, children with different autism spectrum disorders differ in both the severity and the breadth of impairment (e.g., no communication impairment in Asperger's Disorder) (AsD), and the definition of AsD specifies "no clinically significant delay in cognitive development" and "no clinically significant general delay in language" (American Psychiatric Association, 1994, p. 77). These criteria mean that ability differences between children with different disorders need have nothing to do with the symptoms that define the disorders.

The idea that symptoms and ability deficits are related is also undermined by the observation that "the profile of cognitive skills is usually uneven" in AD children (American Psychiatric Association, 1994, p. 67). There are two problems that arise from an uneven cognitive profile, depending whether the unevenness is consistent (ability A always > B) or inconsistent (A is as likely > as < B). If consistent, achievement discrepancy rather than underachievement may be associated with autism; the size of a discrepancy, not the level of achievement, may relate to symptoms. If the unevenness is inconsistent, abilities would be independent of each other. It is hard to conceive how symptoms of a process that causes abilities to vary independently would themselves be correlated with one or more of those abilities.

It has been suggested that AD children have a consistently uneven cognitive profile in which performance IQ (PIQ) exceeds verbal IQ (VIQ) (Ehlers et al., 1997) and achievement on Block Design exceeds achievement on other scales (Happe, 1994a). However, the evidence is not compelling. Profiles which characterize AD *groups* do not characterize *individuals* with AD (Happe, 1994a), and the group profile is seldom useful in distinguishing AD from other disorders (Ehlers et al., 1997). However, these results may reflect methodological problems rather than the absence of a distinctive autism profile.

An important problem has been the narrow research focus. Typically, AD children are given an IQ test to assess whether some subscale scores are higher than others (Ehlers et al., 1997; Goldstein et al., 2001). This method ignores the fact that AD is associated with many deficits besides intelligence, and some of the other deficits are thought to explain autism symptoms. For example, deficits in theory of mind (Frith, 1996) and other social cognitive abilities (Baron-Cohen et al., 2001) have been used to explain the social and behavioral symptoms of autism. Research on an autism profile needs to assess the set of abilities in which AD children underachieve.

Research on cognitive deficits in AD always involves the measurement of intelligence and other cognitive functions, but results can seldom indicate whether performance on specific cognitive tests is better or worse than IQ. Cognitive tests seldom share a measurement scale with IQ tests or with each other. IQ scores are understandable because they are standard, aged-referenced scores with known population means and standard deviations. Unless other measures are also standardized and age normed, it is impossible to establish how performance on other tests compares to IQ. Profiling presupposes a shared measurement scale.

Our aim is to discover whether achievement and/or discrepant achievement on ability tests is related to symptoms of autism. PIQ was selected as the index variable for calculating discrepancy scores because of previous research suggesting that discrepancies between PIQ (especially Block Design) and other abilities are characteristic of autism (Ehlers et al., 1999). To ensure comprehensive assessment, we sample PIQ and VIQ, language (receptive and expressive), motor coordination (fine and gross), and social cognition (theory of mind, emotion recognition, and emotion understanding). To ensure a common measurement scale, we use data from a representative sample to create standard age-referenced scores (mean = 100, *sd* = 15) for each ability variable (Dyck et al., 2006) .

Method

Participants

Participants were 29 children (male = 22) aged 4 to 13 years (mean = 8.34 years, *sd* = 2.63) with a DSM-IV diagnosis of AD. Participants who obtained scores of 14 or higher (mean = 26.72) on the *Social Communication Questionnaire* (SCQ) (Rutter et al. 2001), were assessed with the *Autism Diagnostic Interview – Revised* (ADI) (Lord et al., 1999) to confirm that DSM-IV diagnostic criteria for AD were met. Children were required to have shown abnormality in at least one domain prior to age 36 months (ADI-A scale; sample mean = 3.83; range 1 – 5), to score > 9 on 'social' items (ADI-B; mean = 21.62; range 10 – 28), > 7 on 'communication' items (ADI-C; mean = 16; range 8 – 22), and > 2 on 'restrictive and repetitive behavior' items (ADI-D; mean = 6.52; range 3 – 12).

Measures

Intelligence was measured with 4 scales from the 3rd edition of the *Wechsler Intelligence Scale for Children* (Wechsler, 1991)—Vocabulary, Information, Block Design, and Picture Completion. Tests represent verbal and performance IQ and provide a good estimate of full-scale IQ. Each test is reliable and criterion and concurrent validity are established (Wechsler, 1991).

Language ability was estimated with 4 scales from the 3rd edition of the *Clinical Evaluation of Language Fundamentals* (Semel et al., 1995)—Concepts and Directions, Word Classes, Recalling Sentences, and Formulated Sentences. This test has been standardized across a wide age range. Specific scales are suitable across age ranges and sample receptive (Concepts and Directions, Word Classes) and expressive (Recalling Sentences, Formulated Sentences) language. These scales have acceptable internal consistency, test-retest reliability, and concurrent validity (Semel et al., 1995).

Motor coordination was assessed with the *McCarron Assessment of Neuromuscular Development* (McCarron, 1997). The test comprises 10 tasks: 5 assess fine motor skills (e.g., putting beads in a box) and 5 assess gross motor skills (e.g., heel to toe walking). These tasks have acceptable test-retest reliability, criterion validity, and concurrent validity (McCarron, 1997).

Social Cognition. Social cognitive ability was a combination of 3 1st-order, 1 2nd order, and an advanced theory of mind task, and 6 *Emotion Recognition Scales* (ERS)(Dyck et al., 2001, 2004b). First order tasks included the *Sally Ann* (Baron-Cohen et al., 1985), *Smarties* (Perner et al., 1989; Wimmer & Perner, 1983), and *Ella the Elephant* tasks (Harris et al., 1989). The 2nd order task was the *John and Mary icecream story* (Perner & Wimmer, 1985). We treated these tasks as items on a 4-point theory of mind scale. The *Strange Stories Test* is an ‘advanced’ theory of mind task and assesses the ability to provide context-appropriate mental state explanations for non-literal (irony, sarcasm, lies) statements (Happe, 1994b).

The ERS include 3 measures of emotion understanding ability (Emotion Vocabulary Test, Comprehension Test, Unexpected Outcomes Test) and 2 measures of emotion recognition ability (Fluid Emotions Test, Vocal Cues Test). The *Emotion Vocabulary Test* measures the ability to define emotion words (what does the word angry mean). The *Comprehension Test* measures the ability to understand the emotional consequences of exposure to an emotion-eliciting context (Susan is given a new bicycle for her birthday. What will Susan feel?). The *Unexpected Outcomes Test* measures the ability to explain incongruities between an emotion-eliciting context and the emotion elicited by the context. The *Fluid Emotions Test* (Dyck et al., 2004b) measures the ability to recognize static and changed/changing (morphed over 4 seconds) facial expresions of emotion (Matsumoto & Ekman, 1995). Two scales were used: initial Accuracy (the number of static emotion pictures correct); and Speed Given Accuracy. The latter scale is based on the speed of accurate responses to morphed emotion pictures. The *Vocal Cues*

Test measures the ability to recognize vocal intonations specific to different emotions. We used its *Unreal* scale in which emotions are expressed using non-semantic content: numerals, letters, nonsense syllables. The ERS have acceptable internal consistency. The social cognition measures used in this study are more strongly related to a child's parent-rated social and behavioral disturbances than are intelligence, motor coordination, language or executive functioning measures (Dyck et al., 2004a).

Autism symptoms were assessed with two parent report scales. The SCQ is a 40-item questionnaire designed to screen for the presence of a PDD. It has 3 scales assessing social interaction, communication, and stereotyped behavior. The SCQ has adequate sensitivity, specificity, positive and negative predictive value in discriminating PDDs from other diagnoses, and for discriminating autism from other PDDs (Berument et al., 1999).

The ADI is a semi-structured interview designed to be given to caregivers of persons who may have autism. The ADI is used to assess qualitative impairments in reciprocal social interaction, communication and language, and to assess restricted, repetitive behaviors and interests. The ADI has good inter-rater reliability, internal consistency, and stability, and is an effective tool in diagnosing autism (Lord et al., 1999).

Procedure

Children were tested individually at each child's home, school or a university, depending on parental preference. Testing was conducted in 3 sessions (2.5 hours, 2.5 hours, 1.25 hours) over 2 or 3 days.

Score Standardization

To ensure that measures had the same scale, we used data from a representative sample (Dyck et al., 2006) to create standard scores (mean = 100, *sd* = 15) for each variable. These scores were used to create composite indices, unweighted averages of tests that define each ability domain, as follows: *receptive language ability* was Concepts and Directions and Word Classes; *expressive language ability* was Formulating Sentences and Recalling Sentences; *perceptual organization* was Block Design and Picture Completion; *verbal comprehension* was

Vocabulary and Information; *emotion recognition ability* was Accuracy, Speed Given Accuracy, and Vocal Cues Test; *emotion understanding ability* was Comprehension Test, Emotion Vocabulary Test, and Unexpected Outcomes Test, *theory of mind ability* was the false belief tasks and Strange Stories Test; *fine motor coordination* was 5 fine motor tasks and *gross motor coordination* was 5 gross motor tasks.

Composite indices were restandardized (based on normative sample), with means = 100 and *sd*s = 15. This ensures that composites have the same distribution in the population, but in clinical samples it yields a larger range than does conventional scoring. To ensure that very low scores would not substantially reduce group means, we set a minimum of 10 for all composites. This restricts the range of scores and makes statistical tests more conservative.

We calculated discrepancy scores by subtracting each other composite score from PIQ.

Results

We conducted a series of one-sample t-tests to assess whether observed achievement scores were lower than the population mean of 100. Because each ability variable is age-referenced, this analysis is comparable to comparing the scores of each child with AD with those of same-aged typically developing children. Table 1 shows that children with AD underachieve in each ability domain.

We conducted another series of one-sample t-tests to assess whether discrepancy scores are significantly different from zero (the population mean). Table 2 shows that discrepancies between PIQ and theory of mind ability and between PIQ and both fine and gross motor coordination are significantly greater than zero.

Finally, we assessed how many individuals with AD are characterized by a cognitive profile in which PIQ equals or exceeds achievement on other ability scales. PIQ exceeds VIQ in 15 or 52% of cases, exceeds social cognitive ability and language ability in 19 or 66% of cases, exceeds theory of mind ability in 22 or 76% of cases, and exceeds motor coordination in 25 or 86% of cases.

We assessed whether ability or discrepancy scores are related to symptoms of AD with a series of correlation analyses. Table 3 shows that most composite ability measures are related to early abnormalities of development (ADI-A), but only the motor coordination scales and the receptive language measure are related to current symptoms, specifically to impairments in social interaction (ADI-B). In each case, the correlation is negative, indicating that lower achievement is associated with *greater* impairment. Table 4 shows that discrepancies between PIQ and each of the social cognition scales are related to two or more symptom scales. In each case, the correlation is negative, indicating that the more that PIQ exceeds a social cognitive ability, the *lower* the level of impairment. In order to assess whether variability in PIQ or social cognitive ability was the likely source of variability in discrepancy scores, we calculated correlations between composite PIQ, ER, EU, and TM scores and the respective discrepancy scores. In each case, PIQ was moderately to strongly and significantly related to the discrepancy score and the social cognition measure was not. Finally, we conducted partial correlation analyses between discrepancy scores and symptom (ADI) scores controlling for PIQ to confirm that achievement discrepancy, not just the association with PIQ, was associated with qualitative impairments. Partial correlations between emotion recognition ability and communication symptoms, theory of mind and repetitive movement symptoms remained significant, and that between emotion understanding and repetitive symptoms was marginally significant ($p = .052$)

Discussion

Children with autism underachieve in all ability domains. Consistent with the suggestion that AD children have disproportionate theory of mind deficits, our results show that the PIQ/theory of mind discrepancy is greater than zero and is evident in 75% of cases. Consistent with the DSM-IV view that motor coordination deficits are intrinsic to AD, our results show that AD children obtain their lowest scores on motor coordination measures, and the PIQ/motor coordination discrepancy is large and evident in 86% of cases. Finally, our results show that autism symptoms are related to achievement in receptive language, fine motor coordination, and gross motor coordination, and to achievement discrepancies between PIQ and social cognitive abilities.

AD children underachieve across a broad set of domains, but any given child need not underachieve in any ability domain. The performance of our sample was extremely variable, reflecting the fact that a few children performed markedly better than their peers. On each variable except gross motor coordination, at least one child obtained a score above the population mean of 100. At face value, if no ability domain is inevitably affected by the processes responsible for AD, it would be inappropriate to regard deficits in language or motor coordination as intrinsic to the disorder and to preclude children with AD from being given additional diagnoses of a communication or motor skills disorder when criteria for those disorders are met.

Although AD children may obtain average scores in any ability domain, it is rare for a child to score within the average range in all ability domains. In our sample, no child obtained scores above 80 on all measures, which suggests that underachievement in one or more domains is characteristic of AD. Underachievement appears most likely on motor coordination and theory of mind tasks. These tasks yield the lowest group means, are the tasks on which children are most likely to underachieve, on which significant discrepancies with PIQ scores are observed, and which are correlated with autism symptoms. Underachievement and/or discrepant achievement on motor coordination and theory of mind measures appears to characterize children with AD and relate to the severity of autism symptoms.

These results suggest that processes underlying motor coordination have been underestimated in explaining AD symptoms. Variations to the impairments responsible for motor coordination problems in children *without* AD may affect the quality of performances in children *with* AD. Among children with Developmental Coordination Disorder, the area of greatest impairment is the ability to integrate sensory information. In these children, the impairment is relatively specific to visual-spatial processing, kinesthetic perception, and cross-modal integration (Wilson & McKenzie, 1998). In children with AD, there is clear evidence of visual-motion integration problems (Gepner & Mestre, 2002; Milne et al., 2002), which are initially expressed as poor visual orientation responses (Baranek, 1999), and problems integrating visual, vestibular and somatosensory information (Molloy et al., 2003). Similarly, research on the 'weak central coherence' hypothesis shows that persons with AD are relatively superior on perceptual tasks that require local rather than contextual visual (Mottron et al., 2003) or auditory processing (Mottron et al., 2000), that are novel (Plaisted et al., 1998) or not influenced by prior knowledge (Ropar & Mitchell, 2002), and are noncategorical (Rinehart et al., 2000). In other words, as the integrative complexity of a task increases, performance decreases. Although the specific integrative abilities that are impaired in AD may be variable, profound impairments in some set of integrative abilities may characterize the disorder.

Clinical lore holds that AD is associated with discrepant achievement, especially between Block Design and other IQ tests. Our results confirm that AD is associated with discrepant achievement, but differ from clinical lore in three important ways. First, consistent with other research (Happe, 1994a), we observed that discrepant achievement characterizes the AD group rather than each child with AD. Second, discrepant achievement was not observed on tasks where it would traditionally be expected, but on motor coordination and social cognition tasks. Third, the extent to which the processes underlying PIQ are intact appears to determine how much a child is able to compensate for other impairments. The size of achievement discrepancies is inversely related to symptom severity: more uniformly low achievement, not discrepant achievement, signifies greater impairment. The implication of these results is that achievement discrepancies are not a sign of disorder.

It has been observed that "even when people with autism produce normal behavioral output, they tend to do so by abnormal physiological means" (Belmonte & Yurgelun-Todd, 2003, p. 652). Volkmar et al. (2004) suggest that these abnormal means reflect attempts to compensate for primary deficits. The bulk of evidence implies that processes of the kind that underlie PIQ abilities are what allow a person with autism to ameliorate the effects of primary impairments (Belmonte & Yurgelun-Todd, 2003; Heinze et al., 1994). But compensation is possible only when these processes have not been affected by intellectual disability. This means that among persons with AD, two distinct dimensions of qualitative impairment can be expected. The first is in the quality of social interaction, communication, and behavior/interest that define the disorder, and the second is in how compensatory processes affect performance among persons whose PIQ is largely intact. Individual differences in compensatory processes (which brain areas are acting synergistically; Volkmar et al., 2004) may mean that the quality of social performances will vary markedly even among individuals with similar PIQ.

AD symptoms are related to achievement on fine and gross motor coordination and receptive language measures, and to discrepancies between PIQ and theory of mind, emotion recognition, and emotion understanding scores. These results suggest that impairments in processes underlying motor coordination, possibly related to the ability to integrate sensory information, may be a core deficit in AD. These results also suggest that where processes that underlie achievement on PIQ measures are intact, people with AD are able to compensate for impairments in other processes. Future research will need to assess the sensory integration abilities of persons with AD, and to consider how PIQ can augment deficits in the ability to integrate sensory information.

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Table 1

Achievement on ability measures

	Mean	Std Dev	Range	t & sig.
ER	71.13	26.38	10 – 104	-5.89, p < .001
EU	70.92	23.34	19 – 104	-6.70, p < .001
TM	59.82	32.29	10 – 125	-6.69, p < .001
PIQ	69.27	35.46	10 – 130	-4.66, p < .001
VIQ	67.08	30.40	10 – 125	-5.82, p < .001
LE	66.01	34.19	10 – 122	-5.35, p < .001
LR	61.16	35.39	10 – 124	-5.90, p < .001
MCF	52.93	34.05	10 – 108	-7.44, p < .001
MCG	45.64	27.36	10 – 97	-10.69, p < .001

Abbreviations: ER = emotion recognition ability; EU = emotion understanding ability; TM = theory of mind ability; PIQ = performance IQ; VIQ = verbal IQ; LE = expressive language; LR = receptive language; MCF = fine motor coordination; MCG = gross motor coordination

Table 2

Discrepancies between performance IQ and other abilities

	Mean	Std Dev	t & sig
PIQ/ER	-1.85	30.76	-.32, ns
PIQ/EU	-1.64	25.45	-.34, ns
PIQ/TM	9.45	22.26	2.28, p < .05
PIQ/LE	3.25	25.73	.68, ns
PIQ/LR	8.10	24.54	1.77, p = .086
PIQ/MCF	16.34	25.28	3.48, p < .001
PIQ/MCG	23.63	25.99	4.89, p < .001
PIQ/VIQ	2.19	23.00	.51, ns

Abbreviations: ER = emotion recognition ability; EU = emotion understanding ability; TM = theory of mind ability; PIQ = performance IQ; VIQ = verbal IQ; LE = expressive language; LR = receptive language; MCF = fine motor coordination; MCG = gross motor coordination

Table 3

Correlations between symptom and ability scores

	ADI-A	ADI-B	ADI-C	ADI-D	SCQ
ER	**-.32***	-.11	.16	.07	.16
EU	-.17	-.14	-.02	.11	-.03
TM	**-.46****	-.19	-.02	.08	.11
PO	**-.42***	-.29	-.20	-.15	-.18
VC	-.29	-.19	-.00	.03	-.00
LE	-.24	-.20	-.04	.07	-.01
LR	**-.38***	**-.34***	-.16	-.02	-.10
MCF	-.27	**-.33***	-.08	.00	-.11
MCG	-.26	**-.36***	-.01	-.06	-.04

* significant at .05 level, one-tailed

** significant at .01 level, one-tailed

Abbreviations: ADI-A = early abnormality of development; ADI-B = social interaction; ADI-C = communication; ADI-D = restricted and repetitive behavior; SCQ = Social Communication Questionnaire; ER = emotion recognition ability; EU = emotion understanding ability; TM = theory of mind ability; PIQ = performance IQ; VIQ = verbal IQ; LE = expressive language; LR = receptive language; MCF = fine motor coordination; MCG = gross motor coordination

Table 4

Correlations between symptoms and achievement discrepancies

	ADI-A	ADI-B	ADI-C	ADI-D	SCQ
PIQ/ER	-.21	-.24	**-.37***	-.24	**-.35***
PIQ/EU	**-.43***	-.27	-.25	**-.31***	-.21
PIQ/TM	.00	-.18	-.28	**-.36***	**-.45****
PIQ/LE	-.25	-.12	-.21	-.30	-.23
PIQ/LR	-.05	.06	-.05	-.18	-.11
PIQ/MCF	-.22	.04	-.16	-.21	-.09
PIQ/MCG	-.30	-.02	-.25	-.13	-.20
PIQ/VIQ	-.25	-.20	-.29	-.27	-.27

* significant at .05 level, one-tailed

** significant at .01 level, one-tailed

Abbreviations: ADI-A = early abnormality of development; ADI-B = social interaction; ADI-C = communication; ADI-D = restricted and repetitive behavior; SCQ = Social Communication Questionnaire; ER = emotion recognition ability; EU = emotion understanding ability; TM = theory of mind ability; PIQ = performance IQ; VIQ = verbal IQ; LE = expressive language; LR = receptive language; MCF = fine motor coordination; MCG = gross motor coordination