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Neural correlates of communication skill and symptom severity in autism: A voxel-based morphometry study

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ABSTRACT

Although many studies have compared the brains of normal controls and individuals with autism, especially older, higher-functioning individuals with autism, little is known of the neural correlates of the vast clinical heterogeneity characteristic of the disorder. In this study, we used voxel-based morphometry (VBM) to examine gray matter correlates of variation in communication skill and symptom severity within a heterogeneous group of 33 children with autism ranging in age from 3.4 to 11.4 years. Greater gray matter (GM) volume was associated with better communication skills in numerous frontal regions, especially in the left middle frontal gyrus. Further, greater GM volume in the right inferior frontal gyrus was associated with reduced severity of symptoms of autism. However, increased total GM volume was correlated with more severe symptoms of autism at a trend level, consistent with other studies, suggesting that while increased total GM volume is generally predictive of greater autistic severity, specific local increases in GM volume result in a reduction in symptoms. Our results suggest that communication and symptom severity have distinct neuroanatomic correlates and draw attention to the importance of studying the neuroanatomy of clinical heterogeneity within the autistic population.

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Autism is a pervasive neurodevelopmental disorder characterized by impairment in social interaction, deficits in communication skills, and repetitive or restrictive interests or behaviors (American Psychiatric Association, 2000). While all individuals with autism exhibit qualitative impairments in social interaction and communication, the degree and pattern of these impairments is extremely variable. Relatively little is known about the neural variation underlying symptom variability in autism and this is especially true for children with the more common, more severe form. In order to address this issue, two different types of symptom heterogeneity were investigated in young children with autism: communication skill and overall symptom severity.

All individuals with autism exhibit some form of impairment in both verbal and nonverbal communication, regardless of their level of overall functioning (Noens & van Berckelaer-Onnes, 2005). One-third (Bryson, 1996) to one-half (Lord & Paul, 1997) of all individuals with autism never acquire functional speech. Importantly, nonverbal individuals fail to compensate for this lack of speech with other forms of communication. Similarly, individuals with autism who acquire functional speech often exhibit a limited or inappropriate use of gestures or other forms of nonverbal communication. This universal impairment in verbal skills coupled with difficulty using other communication modalities has been commonly interpreted as a social-communication deficit (Noens & van Berckelaer-Onnes, 2005).

One of the most commonly observed specific communication deficits is the delay or absence of spoken language (De Fosse et al., 2004). It is often the first presenting symptom and is considered central to both diagnosis and prognosis (Herbert et al., 2002). Despite the significance of language abnormality in autism and the wide range of language abilities exhibited by individuals with autism, very few studies have actually examined morphologic variation in the structures specific to language and communication in the autistic brain.

Though there is limited neuroimaging research on linguistic abnormalities in autism, no studies have specifically focused on functional communication abnormalities. In normal right-handed people, structural magnetic resonance imaging (MRI) studies have shown that the language region in the inferior frontal cortex is larger in the left hemisphere than in the right (Escalante-Mead, Minshew, & Sweeney, 2003; Foundas, Eure, Luevano, & Weinberger, 1998). In contrast, reduced or reversed asymmetry has been reported in several disorders that involve deficits in communication including schizophrenia, dyslexia, and specific language impairment. Neuroimaging research on language impairment in autism has focused on both the planum temporale (PT) and Broca's area. In a study of high-functioning autistic adults, PT volume was found to be significantly smaller in the left hemisphere while the right PT volume was not different than controls (Rojas, Bawn, Benkers, Reite, & Rogers, 2002). Similarly, high-functioning boys (ages 7–11) with autism were found to have significant asymmetry reversal in frontal language-related cortex. Specifically, Broca's area was 27% larger on the right in autism and 17% larger on the left in controls (Herbert et al., 2002). Similarly, language-impaired children with autism show similar patterns of cortical language-related abnormalities as children with specific language impairment, suggesting that abnormal asymmetry in language-related areas may be more related to language impairment in general than to autism (De Fosse et al., 2004).

It has been suggested that speech, the discrimination of speech sounds, and other forms of communication share the same neural system (Bernardis & Gentilucci, 2006) and, as noted above, autistic individuals often have deficits in nonlinguistic communication. This is supported by the finding that language-related areas, such as Broca's area, are activated by imitation (Grezes, Armony, Rowe, & Passingham, 2003; Tanaka & Inui, 2002) and by observation of gestures (Grezes et al., 2003; MacSweeney et al., 2004). Hence, the present study utilized the Communication Domain of the Vineland Adaptive Behavior Scales (VABS-CD), a measure of overall communication ability that assesses both language-specific skills and more general communication skills such as the use of gestures (Tomblin, Records, & Zhang, 1996).

While several studies have compared "low-functioning" individuals with autism to those that are "high-functioning," based on overall intelligence, it is far less common to use symptom severity to differentiate individuals with autism. While symptom severity and level of functioning are often correlated, they are not evaluated or conceptualized the same way. Symptom severity is commonly obtained by the use of an autism-specific measure (i.e., Childhood Autism Rating Scale) and generally