

Brief Reports

Brief Report: Macrographia in High-Functioning Adults with Autism Spectrum Disorder

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The initial description of Asperger syndrome commented on the poor handwriting and motor coordination difficulties of individuals with this condition. Early descriptions of autism do not remark upon such difficulties. Recent evidence, however, suggests that individuals with both conditions have a similar motor control impairment. Handwriting has not been formally assessed in this context. Our study compared handwriting size between individuals with autism spectrum disorder and age- and IQ-matched control subjects. Macrographia was observed among subjects with autism spectrum disorder which remained statistically significant when covaried with educational level. This finding may correlate with the anatomical abnormalities present in the cerebellum of individuals with autism spectrum disorder.

KEY WORDS: Autism; Asperger syndrome; motor control; handwriting.

INTRODUCTION

Initially described by Kanner (1943), autism is defined in the DSM-IV as a behavioral disorder with impairments in socialization, communication, and imagination, with stereotyped repetitive interests (American Psychiatric Association [APA], 1994). Asperger syndrome is a closely related disorder which is characterized by relatively preserved linguistic functioning as

compared to autism (APA, 1994). Motor incoordination and poor handwriting were noted in the original description of Asperger syndrome (1944; translated in Frith, 1991), but have not been the subject of further study.

Extensive literature exists on micrographia and its relationship to lesions in the dominant parietal lobe (Scolding & Lees, 1994), the nondominant anterior cerebral artery distribution (Klatka, Depper, & Marini, 1998), in focal lesions involving the various combinations of the thalamus, internal capsule, midbrain, and basal ganglia (Kim, Im, Kwon, Kang, & Lee, 1998; Lewitt, 1983; Martinez-Vila, Artieda, & Obeso, 1988; Noda, Itoh, & Goda, 1994; Pick, 1903; Pullicino, Lichter, & Benedict, 1994; Yamamoto, Takase, Fukusako, Nogaki, & Morimatsu, 1990; Yoshida, Yamadori, & Mori, 1989), and its long established part of the syndrome of Parkinson disease (Parkinson, 1817). Micrographia has also been studied as a manifestation of motor programming and performance disorders (Margolis & Wing, 1983). However, little literature exists on the topic of macrographia. Macrographia has been observed among patients with cerebellar lesions (Haymaker, 1956) as well as in patients with basal ganglia dysfunction such

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as Huntington disease (Phillips, Bradshaw, Chiu, & Bradshaw, 1994). Both cerebellar (Schmahmann, 1994) and basal ganglia (Damasio & Maurer, 1978) lesions have both been hypothesized to be important to some of the clinical features of autism and both regions are known to be important in motor control.

Some recent studies have suggested that motor impairments do exist in autism and Asperger syndrome (Ghaziuddin, Butler, Tsai, Ghaziuddin, 1994; Manjiviona & Prior, 1995). Our hypothesis is that individuals with autism spectrum disorder will exhibit larger handwriting than nonautistic individuals. Therefore, the purpose of this investigation is to offer a statistical comparison between the handwriting size of individuals with autism spectrum disorder (a general term for the closely related disorders: autism, Asperger syndrome, and pervasive developmental disorder not otherwise specified) and age- and IQ-matched control subjects. Whereas all subjects with autism spectrum disorder met the diagnostic criteria for autism through their reported behavior during childhood, most subjects had demonstrated significant improvement in function over time, such that the distinction between the various forms of autism spectrum disorder was not as clear. Therefore the more general term autism spectrum disorder is used to describe these patients.

Ten high-functioning adults with autism spectrum disorder (seven male, three female; nine diagnosed with the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) (interviews performed by D.Q.B., validated administrator for this test), and one by medical records and personal history (including recall of ADI-R items)), and 13 nonautistic adults (eight male, five female) were subjects of a neuropsychological study. The groups were matched for age, verbal scale, and performance scale Wechsler Adult Intelligence Scale Revised (WAIS-R) IQ scores. Requirements for enrollment included age of 18 or older, full-scale IQ of 85 or higher, and ability to complete the study (Table I).

Handwriting samples from the neuropsychological study were used as data for the comparison of handwriting in this study (Fig. 1). Responses for all individuals on the neuropsychological test were written on identical one quarter inch ruled tablets of writing paper, allowing direct comparison between subjects. These tests involved written recall of verbally presented materials. Few words were recalled and written by all subjects within the same context. From these few words, letters of various types were randomly selected. Two letters written in upper case by all subjects were selected ("C" in "California", and "S" in "Saturday" were selected). Four letters written in lower case by all sub-

jects were selected. Of these four letters, two lower case letters that are commonly as tall as upper case letters were selected ("t" and "f") as well as two lower case letters that are not as tall ("o" and "a") (Fig. 2).

Vertical extent of each of these letters was measured for each subject and compared across diagnostic groups (autism spectrum disorder versus control).

No significant differences existed between groups in age (Table I). However, significant differences did exist in years of educational level achieved (autism spectrum disorder: 13.7 ± 1.8 years, nonautistic: 15.8 ± 2.5); independent samples pooled variances *t* test, $t(21) = -2.295$, $p = .032$.

Observation of the subjects handwriting revealed an obvious tendency for larger handwriting among individuals with autism spectrum disorder (Fig. 1). An independent samples *t* test of average letter height between diagnostic groups revealed a significant difference (autism spectrum disorder: 6.8 ± 1.9 mm, nonautistic: 4.7 ± 1.0 mm, $t(21) = 3.515$, $p = .002$). Independent samples *t* tests also revealed a significant difference for each individual letter analyzed separately (Fig. 2).

Due to the significant difference in educational level between groups, an ANCOVA (analysis of covariance) was performed between diagnostic groups with educational level as the covariant. The difference in average letter height remained significant with this analysis, $F(1) = 8.499$, $p = .009$.

Asperger (1944; translated in Frith, 1991) remarked upon poor handwriting and motor incoordination in the initial description of Asperger syndrome. Rumsey and Hamburger (1988) did not find impaired motor skills among high-functioning autistic (HFA) individuals. However, other studies have shown similar impairment in motor coordination in both individuals with autism and Asperger syndrome on screens of gross and fine motor tasks (Ghaziuddin *et al.*, 1994; Manjiviona & Prior, 1995).

Our study demonstrates larger handwriting among subjects with autism spectrum disorder as compared to age- and IQ-matched control subjects. This difference was significant not only for average letter height but also for height of each individual letter tested, suggesting a high degree of consistency for this finding. Furthermore, this overall difference remained significant when covaried with educational level, suggesting that the finding is not the result of a lower educational level present among subjects with autism spectrum disorder when they are matched for age and IQ with nonautistic controls. We speculate that this finding relates to the motor coordination impairments of indi-

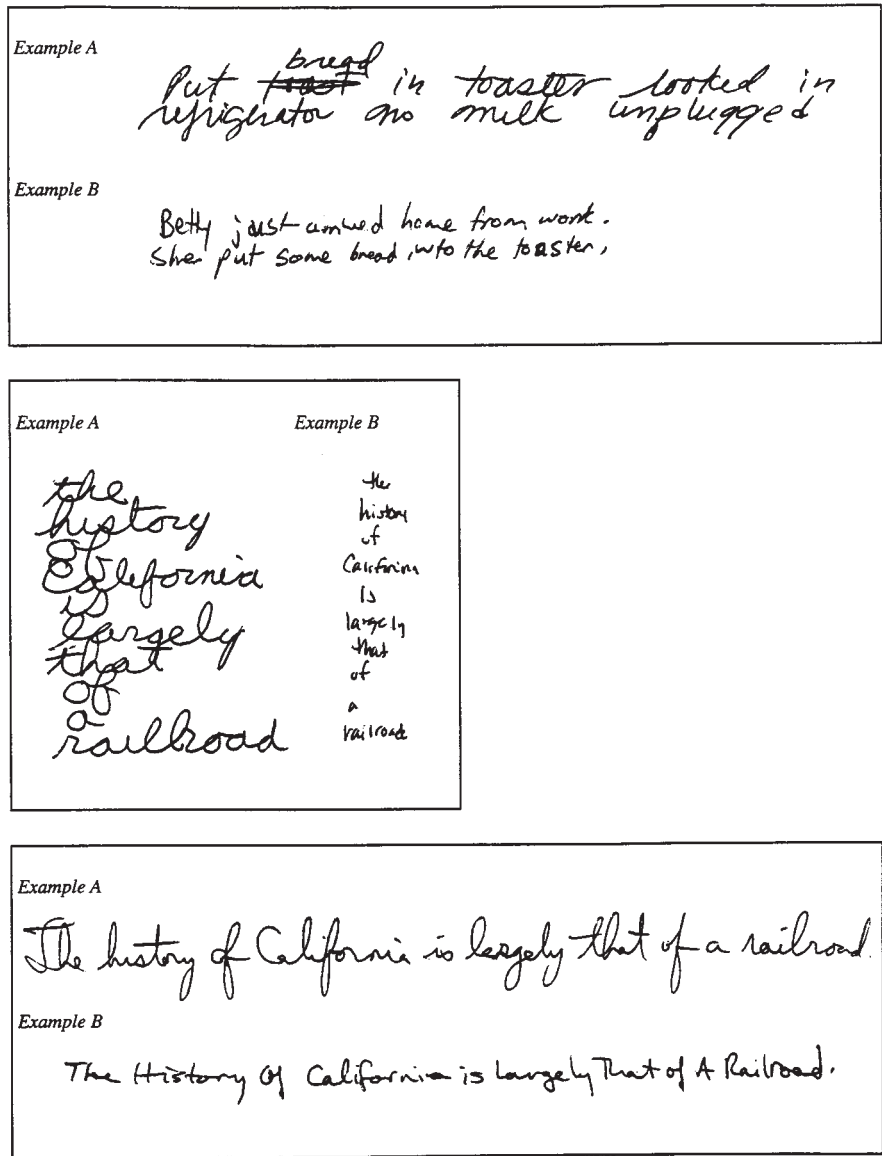


Fig. 1. Representative samples of handwriting of high-functioning subjects with autism spectrum disorder (A) and nonautistic control subjects (B) including the index letters used for measurement ("C" in "California" and the first "t" in "toast[er]"). (These samples are reproduced here at 60% of their original size.)

viduals with autism and Asperger syndrome (Ghaziuddin *et al.*, 1994; Manjiviona & Prior, 1995). Whereas the macrographia detected in autism spectrum disorder in our study does not directly indicate "poor" handwriting as described by Asperger (1944; Frith, 1991), we suspect that the findings correlate. Subjectively, the most difficult handwriting to read on the neuropsychological test responses tended to be that of a few particular subjects with autism spectrum disorder. Future investigations are required to better understand hand-

writing and motor control issues in these two closely related diagnostic groups within autism spectrum disorder (Asperger syndrome and HFA).

Whereas few studies have examined macrographia, it has been observed among patients with cerebellar lesions (Haymaker, 1956) and patients with basal ganglia dysfunction such as Huntington disease (Phillips *et al.*, 1994). It has also been observed in certain situations in aphasic patients (Fradis & Leischner, 1985). However, our subjects demonstrated normal ver-

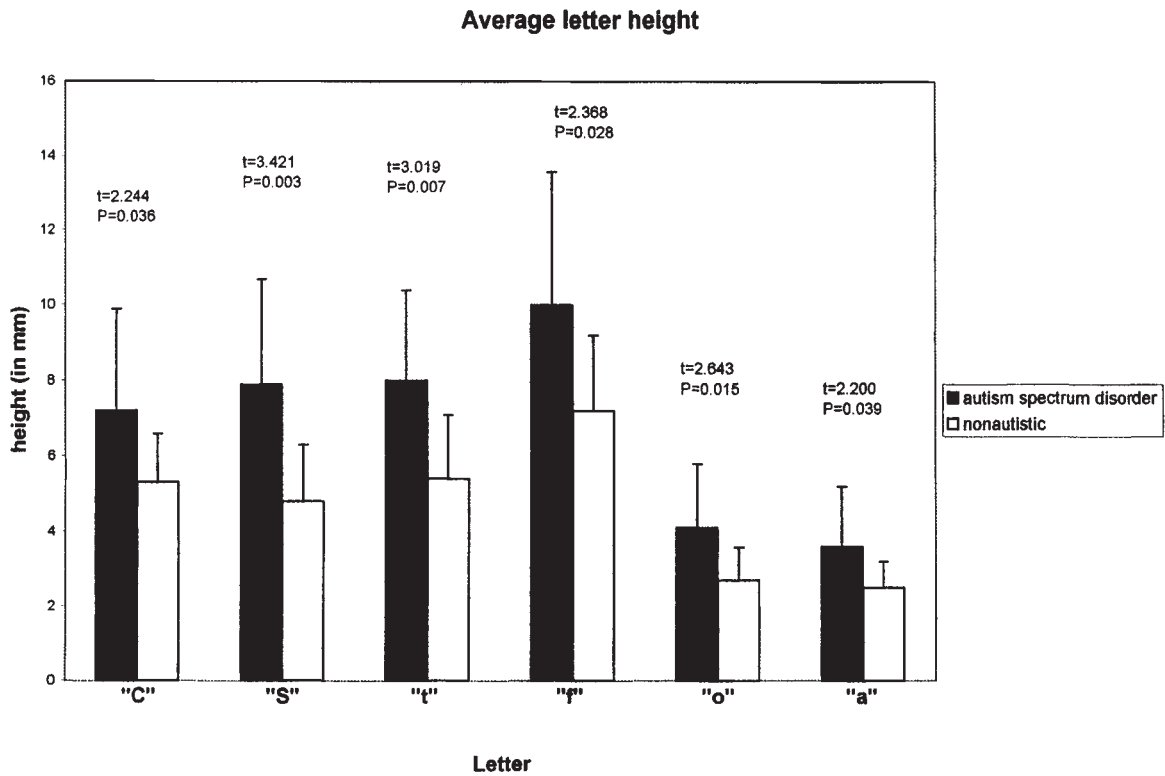


Fig. 2. A. Comparison of vertical extent of each measured letter between groups (autism spectrum disorder vs. nonautistic). Results of independent samples *t* tests are shown on graph (*df* = 21 for each *t* test). B. Comparison of total letter height between groups.

Table I. Characteristics of Autism Spectrum Disorder and Control Subjects

	Autism spectrum disorder	Control	Significance
Age (years)	30.8 ± 9.3	30.6 ± 12.8	ns
WAIS-R IQ full scale	109.7 ± 16.2	117.3 ± 11.2	ns
WAIS-R IQ performance scale	105.6 ± 14.3	111.5 ± 10.8	ns
WAIS-R IQ verbal scale	112.5 ± 18.3	118.6 ± 13.8	ns
Right-handed	9	13	
Left-handed	1	0	
Education (years)	13.7 ± 1.8	15.8 ± 2.5	<i>p</i> = .032

bal performance. Cerebellar (Schmahmann, 1994) and basal ganglia (Damasio & Maurer, 1978) lesions have both been hypothesized to be important to some of the clinical features of autism and may be related to the motor findings observed in this study. Changes in pathology, primarily to the lateral and inferior cerebellar hemispheres, deep cerebellar nuclei, and inferior

olives, have been reported in autism (Bauman & Kemper, 1994). To date, no pathological changes have been reported in the basal ganglia in autism. Further study is required to investigate the role of the cerebellar abnormalities seen with autism spectrum disorder in macrographia and other motor control issues.

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