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Research in Autism Spectrum Disorders xxx (2006) xxx–xxx
http://ees.elsevier.com/RASD/default.asp

Examining sensory quadrants in autism

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Received 4 September 2006; accepted 12 September 2006

Abstract

The purpose of this study was to examine sensory quadrants in autism based on Dunn's Theory of Sensory Processing. The data for this study was collected as part of a cross-sectional study that examined sensory processing (using the Sensory Profile) in 103 persons with autism, 3–43 years of age, compared to 103 age- and gender-matched community controls. Sensory quadrants (Low Registration, Sensation Seeking, Sensation Sensitivity, and Sensation Avoidance) on the Sensory Profile are different in persons with autism as compared to community controls, with persons with autism engaging in the behaviors more frequently than the controls. This study provides further evidence of sensory differences in autism.
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Keywords: Autism; Sensory quadrants; Sensory Profile; Low Registration; Sensation Seeking; Sensation Sensitivity; Sensation Avoidance

1. Introduction

To be able to process sensory information is an important part of our daily function. Our understanding of life as humans is rooted in our sensory experiences. Data suggests that

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1750-9467/$ – see front matter. Published by Elsevier Ltd.
doi:10.1016/j.rasd.2006.09.002

there are individual differences in sensory processing. Thus, how we experience life and how we interpret our world could conceivably vary depending on our individual and unique way of processing of sensory information.

Dunn (2001) outlined the Dunn's Model of Sensory Processing that focuses on the impact of sensory processing in daily life. The basic concept of this Model is that a person's way of responding to sensory events is a combination of their sensory threshold (high or low) and their responding strategy (passive or active). Using this Model, Dunn (2001) delineates sensory processing into four quadrants: Low Registration, Sensation Seeking, Sensation Sensitivity, and Sensation Avoidance. Low Registration is a combination of high thresholds and passive responding. Sensation Seeking is a combination of high thresholds and active responding. Sensation Sensitivity is a combination of low thresholds and passive responding. Sensation Avoidance is a combination of low thresholds and active responding (Dunn, 2001).

For person's with significant sensory processing differences, the world may be viewed very differently, and in some cases, sensory experiences could be different to the point of being altered or confusing. Anecdotal reports suggests that for person's with autism sensory processing is very different and can, in some cases, be overwhelming. Some researchers have suggested that there is a link between the sensory processing problems that a person with autism experiences and the difficulties in managing daily life (Cook & Dunn, 1998; Dunn, 1997, 1999, 2001; Kern et al., 2006).

Since the nature or the frequency of abnormal sensory responses is not included in the diagnostic criteria for autism or pervasive developmental disorder (PDD), it has been disregarded in some research (Tadevosyan-Leyfer et al., 2003). As such, there has been a paucity of research in sensory processing in autism, and as a result, there is not a clear understanding of the sensory pathology.

Some studies have reported significant differences in both high and low thresholds on autism as compared to controls (Baranek, Foster, & Berkson, 1997a, 1997b; Kern et al., 2006; Rosenhall, Nordin, Sandstrom, Ahlsen, & Gillberg, 1999). A better understanding of sensory processing in autism, including threshold differences, will improve on our understanding of what persons with autism experience everyday and how their sensory experience may shape their behavior and their response to their world.

This analysis examined sensory quadrants, based on Dunn's Theory of Sensory Processing, in 103 persons with autism, 3–43 years of age, compared to 103 age- and gender-matched controls using the Sensory Profile.

2. Methods

2.1. Subject selection and participation

The data for this study was collected as part of a cross-sectional study of 103 persons with a diagnosis of autism, 3–43 years of age, as compared to 103 gender- and age-matched community controls (see Table 1 for demographic information). The participants were recruited across seven age categories (3–7; 8–12; 13–17; 18–22; 23–27; 28–32; and 33+) in order to ensure a full range of ages and a balance of participants in the seven categories.

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Table 1
Demographics

Setting	Age mean (*SD*)	Age range	CARS mean (*SD*)	CARS range
ATC-Dallas ($n = 39$)	22.9 (12.0)	5–43	43.1 (9.1)	26.5–58.5
ATC-San Antonio ($n = 28$)	27.3 (8.6)	10–37	46.3 (7.2)	33.5–58
Autism Societies ($n = 36$)	11.1 (7.8)	3–31	36.7 (7.0)	20.5–50.5
All settings ($n = 103$)	19.9 (11.4)	3–43	41.7 (8.8)	20.5–58.5
Gender				
Females ($n = 25$)	21.5 (10.6)	4–37	41.8 (8.9)	26.5–58.5
Males ($n = 78$)	19.4 (11.7)	3–43	41.7 (8.8)	20.5–58

Each category had no less than 12 participants. Other data from this study is reported in Kern et al. (2006).

The persons in the group with autism had been given a diagnosis of autism during childhood. The diagnosis was confirmed at the time of the study by one of the investigators (JKK, CRG, AAA, or JAM) based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV; American Psychiatric Association, 1994) criteria and clinical judgment. Each of these investigators (JKK, CRG, AAA, or JAM) has had at least 8 years of experience as a professional in the field. To determine the severity of the autistic symptoms, the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1994) was completed on all participants in the autism group (see Table 1 for CARS information). The only exclusion criteria were the presence of blindness or deafness.

Thirty-nine (39) of the 103 participants with autism were residents of the Autism Treatment Center (ATC) in Dallas; 28 of the participants were from the ATC in San Antonio; and 36 were from the local autism societies (see Table 1 for demographic information). For the autism group, informed consent was signed by the parent, legal guardian, or caseworker.

The controls had no history of mental illness, learning, neurological, or developmental disorders (as reported by the parent or participant on a survey and history). No formal psychiatric assessment was conducted on the control participants. Participants for the control group were identified from the Dallas Metroplex and Collin County area. For the control group, informed consent was signed by the participant (if 18 years of age or older), or by the parent (if less than 18 years of age).

2.2. Measures

The Sensory Profile (Dunn, 1999) and the Childhood Autism Rating Scale (CARS; Schopler et al., 1994) were completed for each of the 103 participants in the autism group. At the ATC, the Sensory Profile was completed by a teacher, a job coach, a facilitator, group home manager, or a therapist who was very familiar with the subject, seeing him or her at least 5 days per week. For the participants with autism from the local autism societies, the Sensory Profile was completed by a family member (typically a parent).

The CARS was completed by the same person that completed the Sensory Profile with the assistance of one of the investigators: JKK (39 participants from the ATC in Dallas and 31 participants from the general population in the Dallas Metroplex, Fort Worth, and Collin

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County area); AAA (28 participants from the ATC in San Antonio where he is the director); or JAM (5 participants from her practice).

2.2.1. Sensory Profile

The Sensory Profile is a 125-question caregiver-completed profile that reports the frequency of the person's response to various sensory experiences (Dunn, 1999). Caregivers are asked to check the box that best describes the frequency with which the subject engages in the listed behaviors. Choices are: never (five points); seldom (four points); occasionally (three points); frequently (two points); and always (one point). It is important to note that, on the Sensory Profile, lower scores indicate greater symptoms. The Sensory Profile includes high and low threshold items. High threshold items measure an individual's lack of response or need for more intense stimuli. Low threshold items measure a person's notice of or annoyance with sensory stimuli.

The Cronbach's Alpha for the internal consistency for the various sections ranged from .47 to .91 (Dunn, 1999). Construct validity was rated as high when compared to the functional tasks measured by the School Function Assessment (Coster, Deeney, Haltiwanger, & Haley, 1998). Internal validity correlations ranged from .25 to .76, suggesting that the sections of the Sensory Profile use relatively unique constructs and support the factor structure. Construct validity was obtained by comparing the results of the Sensory Profile to electrodermal response rating (EDR) that captures the physiological response to sensation. The EDR and the Sensory Profile showed a correlation ($p < .05$) (Dunn, 1999). The Sensory Profile is recommended by occupation therapists that work with children with autism spectrum disorder because the Sensory Profile accurately reflects the person's sensory processing and measures threshold (personal communication, Sandy Buttine, OT, Kidnetics, 08/01/2002).

2.2.2. Autism rating

The CARS is a fifteen-item behavioral rating scale developed to identify autism as well as quantitatively describe the severity of the disorder. The CARS is a well-established measure. The items are: (I) Relating to People; (II) Imitation; (III) Emotional Response; (IV) Body Use; (V) Object Use; (VI) Adaptation to Change; (VII) Visual Response; (VIII) Listening Response; (IX) Taste, Smell, and Touch Response and Use; (X) Fear or Nervousness; (XI) Verbal Communication; (XII) Nonverbal Communication; (XIII) Activity Level; (XIV) Level and Consistency of Intellectual Response; (XV) General Impressions. Each item is scored from 1 (no pathology), to 4 (severe pathology) in .5 intervals. A total score of 15–29.5 is considered nonautistic; a score of 30–36.5 is considered mild to moderate autism; a score from 37 to 60 is considered moderate to severe autism.

The CARS shows excellent internal consistency reliability with an alpha coefficient of .94, an inter-rater reliability correlation coefficient of .71, and a test-retest correlation coefficient of .88 (Schopler et al., 1994). CARS scores have high criterion-related validity when compared to clinical ratings during the same diagnostic sessions, with a correlation of .84 ($p < .001$) (Schopler et al., 1994).

The authors acknowledge that the CARS was designed for children; however, the items used by the CARS to rate autism address features that are seen in adolescents and adults as

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well. The CARS has been used in previous studies to rate autism in adolescents and adults (Elia et al., 2000; Njardvik, Matson, & Cherry, 1999).

2.3. Statistical analyses

An analysis of covariance (ANCOVA) was used to compare the two groups on the items delineated by Dunn (1999, 2001) on the Sensory Profile for calculating quadrant scores for Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoidance. Age (3–43) and diagnostic group by age interaction were included in the model. Diagnostic Groups were compared for Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoidance quadrants individually.

3. Results

Using analysis of covariance, all measures showed a group effect and some showed a group by age interaction. No significant gender effects were noted.

3.1. Low Registration

Low Registration showed a significant group effect ($f = 139.7$, $df = 1, 200$, $p < .0001$), with persons with autism (mean = 3.8, $SD = .7$) engaging in the behaviors more frequently than controls (mean = 4.7, $SD = .3$). A significant main effect for age was found ($f = 8.8$, $df = 1, 200$, $p = .0033$), and group by age interaction ($f = 8.0$, $df = 1, 200$, $p = .0052$). Fig. 1 shows the estimated difference between persons with autism and controls by age. It can be seen that older persons with autism were closer to the normal controls than younger persons with autism.

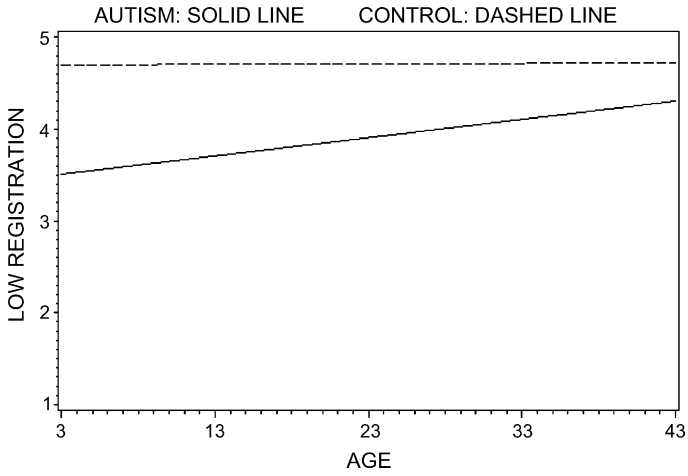

Fig. 1. Low Registration.

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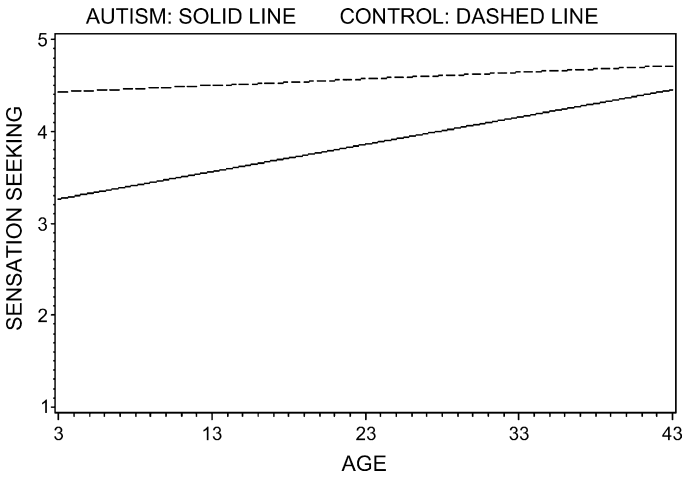

Fig. 2. Sensation Seeking.

3.2. Sensation Seeking

Sensation Seeking showed a significant group effect ($f = 129.8$, $df = 1, 194$, $p < .0001$), with persons with autism (mean = 3.7, $SD = .7$) engaging in the behaviors more frequently than the controls (mean = 4.5, $SD = .4$). There was a significant main effect for age ($f = 31.3$, $df = 1, 194$, $p < .0001$), and group by age interaction ($f = 11.7$, $df = 1, 194$, $p = .0008$). Fig. 2 shows a pattern similar to that for Low Registration where the gap between persons with autism and controls is narrower for older than younger persons.

3.3. Sensation Sensitivity

Sensation Sensitivity showed a significant group effect ($f = 138.9$, $df = 1, 195$, $p < .0001$). The estimated group effects (by age) are shown in the graph below (Fig. 3) with persons with autism (mean = 3.8, $SD = .6$) engaging in the behaviors more frequently than the controls (mean = 4.6, $SD = .3$). There was a significant main effect for age ($f = 17.2$, $df = 1, 195$, $p < .0001$), and group by age interaction ($f = 14.8$, $df = 1, 195$, $p = .0002$). Fig. 3 shows a similar pattern to that seen for Low Registration and Sensation Seeking.

3.4. Sensation Avoidance

Sensation Avoidance showed a significant group effect ($f = 162.5$, $df = 1, 192$, $p < .0001$), with persons with autism (mean = 3.6, $SD = .5$), engaging in the behaviors more frequently than controls (mean = 4.4, $SD = .4$). There was not a significant main effect for age ($f = 1.1$, $df = 1, 192$, $p = .2904$). However, there was a group by age interaction ($f = 4.4$, $df = 1, 192$, $p = .0381$) (Fig. 4).

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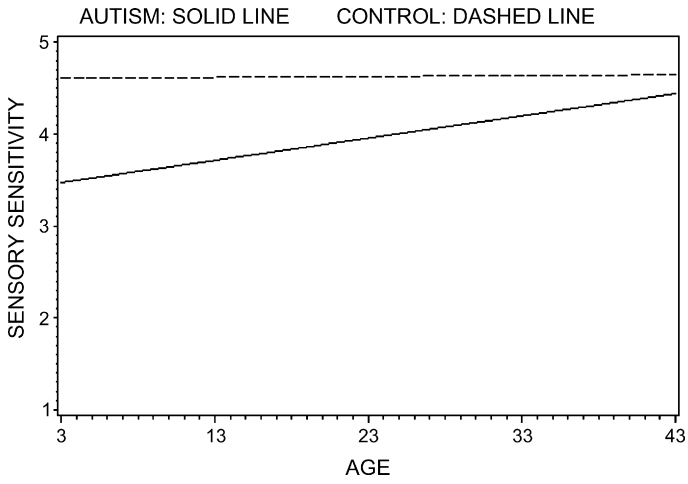

Fig. 3. Sensation Sensitivity.

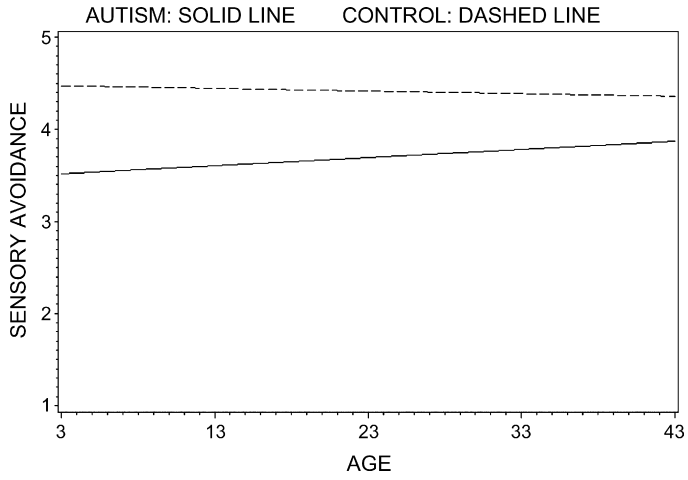

Fig. 4. Sensation Avoidance.

4. Discussion

Sensory quadrants (Low Registration, Sensation Seeking, Sensation Sensitivity, and Sensation Avoidance) on the Sensory Profile were different in persons with autism as compared to community controls with persons with autism engaging in the behaviors more frequently than the controls. There was a group by age interaction for Low Registration, Sensation Seeking, Sensation Sensitivity, and Sensation Avoidance, such that the older persons with autism were closer to the normal controls than younger persons with autism. An age effect was seen in the Low Registration, Sensation Seeking, and Sensation Sensitivity and the figures show that the older persons with autism displayed the behaviors

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at a lesser frequency than the younger persons with autism, perhaps suggesting some type of neurological normalization. Sensation Avoidance did not show age effects.

The figures show that the gap between persons with autism and controls is narrower for the older persons with autism than the younger persons with autism; however, the data and figures also show that the gap remains. Although a longitudinal study would be needed to accurately examine this issue, the present study suggests that sensory differences in autism are not completely ameliorated.

As mentioned in the introduction, some researchers have suggested that there is a link between the sensory processing problems in autism and the difficulties they experience in managing daily life (Cook & Dunn, 1998; Dunn, 1997, 1999, 2001; Kern et al., 2006). There is evidence that sensory processing differences may play a role in certain behaviors, such as self-injury and stereotypic behavior. Tordjman et al. (1999), for example, found that there is a significant relationship between certain self-injurious behaviors and the apparent reduced pain reactivity in children with autism ($N = 80$). Baranek et al. (1997a) found that children with autism with higher levels of tactile defensiveness ($N = 28$) were also more likely to show rigid, inflexible behaviors and repetitive verbalizations.

There is a clear need for more research in the area of sensory processing and autism. Empirical research is needed to examine therapies used to help children with sensory differences. Little is known about what therapies are the most effective and why (Schaaf & Miller, 2005). Studies are needed to examine the relationship between sensory processing abnormalities and problems in autism, such as negative behaviors, difficulty with socialization, eating problems, and insistence on sameness. It is important to try to understand sensory differences in autism because it can enable us to better understand the needs of persons with autism, and in turn, influence treatment protocols.

Acknowledgements

This research was funded in part by a grant from the Hogg Foundation # 4456. The authors wish to acknowledge the help of Anna Hundley, the Executive Director of the Autism Treatment Center, Dallas and San Antonio, Texas and Anne Russell-Bramlett of East Side Speech and Language Clinic in Plano, Texas. The authors wish to acknowledge the help of the Autism Society of Collin County.

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