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Sensory Responsiveness in Siblings of Children with Autism Spectrum Disorders

Claudia L. Hilton, PhD, OTR, FAOTA,

University of Texas Medical Branch, Department of Occupational Therapy and Division of Rehabilitation Science, 301 University Blvd., Galveston, TX, USA

Alison Babb-Keeble, MSOT, OTR/L,

Play2Learn, Chesterfield, MO, USA

Erin Eitzmann Westover, OTD, OTR/L,

Central Kansas Cooperative in Education, Salina, KS, USA

Yi Zhang, MS,

Washington University School of Medicine, Department of Psychiatry, St. Louis, Missouri, USA

Claire Adams, OTR, MSOT,

San Diego Unified School District, San Diego, California, USA

Diane M. Collins, PhD, OT,

University of Texas Medical Branch, Department of Occupational Therapy and Division of Rehabilitation Science, Galveston, TX, USA

Amol Karmarkar, PhD, OTR,

University of Texas Medical Branch, Division of Rehabilitation Science, Galveston, TX, USA

Timothy A. Reistetter, PhD, OTR, FAOTA, and

University of Texas Medical Branch, Department of Occupational Therapy and Division of Rehabilitation Science, 301 University Blvd., Galveston, TX, USA

John N. Constantino, MD

Correspondence: Please address correspondence to: Claudia L. Hilton, OTR, PhD, MBA, FAOTA, corresponding author, University of Texas Medical Branch, Occupational Therapy & Rehabilitation Sciences, School of Health Professions, 301 University Blvd., Galveston, TX 77555-1142, Fax 409-747-1615, clhilton@utmb.edu.

Authors are: Claudia L. Hilton, PhD, OTR, MBA, FAOTA, University of Texas Medical Branch, Alison Babb-Keeble, OTR, MSOT, Erin Eitzmann Westover, OTD, OTR/L, Yi Zhang, MS, Washington University School of Medicine, Claire Adams, MSOT, OTR, San Diego Unified School District, Diane M. Collins, PhD, OT, University of Texas Medical Branch, Amol Karmarkar, PhD, MPH, OTR, University of Texas Medical Branch, Timothy A. Reistetter, PhD, OTR, FAOTA, University of Texas Medical Branch, and John N. Constantino, MD, Washington University School of Medicine.

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Washington University School of Medicine, Department of Psychiatry, St. Louis, Missouri, USA

Abstract

This study examined sensory responsiveness in unaffected siblings of children with autism spectrum disorder (ASD) and associations between sensory responsiveness and social severity. Sensory Profile Caregiver Questionnaires and Social Responsiveness Scales were completed by parents of 185 children between age 4 and 10.95 years. Significant differences were found between participants with ASD and controls, and between participants with ASD and unaffected siblings for all sensory quadrants and domains, but not between controls and unaffected siblings. Social responsiveness scores were significantly correlated with scores from most sensory profile categories. Sensory responsiveness as an endophenotype of ASD is not indicated from these findings; however, studies with larger numbers of unaffected siblings and controls are needed to confirm the null hypothesis.

Keywords

endophenotype; autism; family; sensory responsiveness; genetics

Although autism spectrum disorder (ASD) is known to be heritable, the patterns of endophenotypic trait occurrences are not well understood. Endophenotypic traits are those inherited traits associated with a particular diagnosis that manifest in family members who do not have the diagnosis (Gottesman & Gould, 2003). Endophenotypes may be neurophysiological, biochemical, endocrinological, neuroanatomical, cognitive, or neuropsychological and have emerged as an important concept to help clarify genetic underpinnings of complex neuropsychiatric conditions and to provide insight into underlying etiologies.

Sibling recurrence of ASD has been seen in 1.5 to 19.4% of families in recent studies (Constantino et al., 2010; Ozonoff et al., 2011). An aggregation of sub-clinical autistic social impairment in studies of unaffected family members of children with ASD suggests the possibility that social impairment constitutes an autism endophenotype (Constantino et al., 2006; Cornew, Dobkins, Akshoomoff, McCleery & Carver, 2012; Dawson et al., 2002; Dawson et al., 2005; Pickles et al., 2000; Pickles, St. Clair & Cont-Ramsden, 2013; Piven, Palmer, Jacohbi, Childress, and Arndt, 1997; Spencer et al., 2011). Reduced GABA/Cr (Creatine) matter was found in unaffected ASD siblings, consistent with that of the children with ASD (Rojas, Singel, Steinmetz, Hepburn and Brown, 2014). Whole brain functional hypoconnectivity was also identified as an endophenotype of autism in a recent study of adolescents (Moseley et al., 2015). Other studies have identified visual motion perception (Koh, Milne & Dobkins, 2010), atypical frontal activation during visual attention (Belmonte, Gomot & Baron-Cohen, 2010), accelerated head growth in male infants (Constantino et al., 2010), and immunological functions (Saresella et al., 2009) as potential autism endophenotypes. One study found a range of autistic traits among siblings of children with ASD that clustered into two groups, a high-scoring group with autistic traits similar to those of individuals diagnosed with ASD and a low-scoring group with autistic traits similar to the

controls (Ruzich et al., 2015). In another study, no evidence was found to indicate that motor impairment is an autism endophenotype among unaffected siblings (Hilton et al., 2012).

A greater understanding of endophenotypes will provide a better understanding of the genetic contribution of specific traits and will increase our awareness of potential needs of family members of individuals with ASD. Because previous studies have found children with ASD to have a high incidence of atypical sensory responsiveness, we conducted an exploration of how such differences are distributed in ASD-affected families through the use of sibling designs. The intent of this study was to begin the examination of the genetic patterns of sensory responsiveness in children with ASD.

Children with ASD have been shown to demonstrate unusual sensory responses to stimuli more frequently than do typically developing peers or those with other developmental disorders (Baranek, David, Poe, Stone, & Watson, 2006; Lane et al., 2010; Wiggins, Robins, Bakeman, & Adamson, 2009). In a study comparing children with and without ASD, atypical sensory responsiveness patterns greater than one standard deviation from the mean were found in up to 95% in children with ASD, compared to 12 to 25% of children without ASD in the various sensory domains (Tomchek & Dunn, 2007). Our prior investigation examined the relationship between autistic severity and atypical sensory responsiveness in a group of children with ASD and found moderate to strong correlations between the two (Hilton et al., 2007), suggesting that sensory responsiveness follows patterns similar to autistic severity.

Dunn (1997) proposed a model of sensory processing that describes the interaction between a person's neurological threshold for sensory input and the person's response to that input. The model describes a continuum of possibilities for interpreting a person's behavior. Individuals who have high thresholds to sensory input need a large amount of input to evoke a response, while those with low thresholds respond to small amounts of sensory input. An individual may act passively in accordance with his or her threshold or respond actively to counteract his or her threshold. A person with a high threshold who passively responds is considered to have *low registration*. This individual might not even notice normal sensory input that easily evokes a response from others. A person with a high threshold and an active response would be categorized as *sensation seeking*. He or she might seek out sensory experiences because a large amount of sensory input is enjoyable. *Sensory sensitivity* is used to describe individuals with a low threshold and a passive response mechanism. They perceive sensory stimuli very easily and become distracted or irritated by movements, sounds and smells. In comparison, individuals who are *sensation avoiding* have low thresholds and respond actively to find ways that limit their sensory exposures (Dunn, 1997, 2001; Dunn, Saiter, & Rinner, 2002).

Atypical sensory responsiveness can create problems for children at home and at school. At home, atypical sensory responsiveness may interfere with family routines and activities of daily living (ADL). Reynolds and Lane (2008) found that tactile sensitivity, in particular, affected children's tolerance of ADLs, such as eating, grooming, dressing, tooth-brushing, and bathing. At school, Miller, Anzalone, Lane, Cermak, and Osten (2007) described children with sensory seeking behaviors often being labeled as troublemakers in their

elementary classrooms because they have disruptive behaviors due to difficulty regulating their responses to stimuli or are constantly seeking more. Children who are sensation avoidant may be labeled as withdrawn and asocial, but are really attempting to avoid noxious sensory stimuli in their environments. Those who have low registration may appear lazy or apathetic when they simply need more sensory input to evoke the same level of responsiveness as others (Dunn, 1997). These issues can lead to a decrease in participation in many childhood activities that are important for the child's optimal development (Baranek, 2002). Pfeiffer and colleagues (2005) found strong correlations between anxiety disorders and hyper-responsiveness, as well as between low registration and depression in adolescents with autism. Mood disorders, also examined in the same study, were found to severely limit participation and enjoyment of activities.

De la Marche, Steyaert and Noens (2012) examined sensory responsiveness in unaffected siblings of adolescents with ASD. Their sample consisted of 80 adolescents with ASD and 56 unaffected siblings from 87 families, along with 33 control adolescents. They used the Adolescent/Adult Sensory Profile (AASP; Brown & Dunn, 2002), a 60-item self-report questionnaire standardized on individuals between ages 11 and 65 years and examined differences in the sensory quadrant scores. They found significant differences between the adolescents with ASD and their unaffected siblings in all four sensory processing quadrants. Significant differences were also found between the unaffected siblings and the control group for *sensation seeking*, but not for the other quadrant scores. They found that the participants with ASD and the siblings identified lower frequencies of seeking sensations than the control group. Examples of items in this category are "I enjoy being close to people who wear perfume or cologne," and "I like to go barefoot." These findings suggested the possibility of some degree of heritability in the sensory responsiveness among siblings from the families affected with ASD.

To our knowledge, no prior studies of atypical sensory responsiveness in ASD have examined sensory issues in unaffected young siblings from a sample as large as this one. Questions addressed in our study were: a) Do unaffected siblings of children with ASD exhibit atypical sensory responsiveness? and b) Is sensory responsiveness related to social responsiveness in unaffected siblings of children with ASD? We employed a standardized measure of sensory responsiveness to examine quantitative variation in unaffected siblings of children with an ASD diagnosis.

Methodology

Participants

Participants were recruited from two larger studies and consisted of children with a diagnosis of ASD, siblings without ASD, and a control group of unaffected children who have no ASD in the family. Participants who qualified for this study were between age 4 and 10.95 years of age. Diagnostic categories were based on physician diagnosis per parent report and confirmed by the DSM-IV-TR criteria (APA, 2000) on all participants. Inclusion criteria consisted of a full-term birth, no history of cerebral palsy, epilepsy, or any other diagnosed major neurological condition, and no current uncorrected hearing or sight problems. Hearing and vision abilities were from parent report and confirmed by

observation. A voluntary convenience sample of participants were recruited through group e-mail lists, newsletters for parents of children with ASD, and flyers about the study posted at sites of service providers for children with ASD. Additional efforts were made through announcements and flyers at parent support group meetings and through parent and professional contacts known by the investigators. The research was approved by the Washington University Human Research Protection Office. All participants and their parents gave informed consent or assent prior to their participation in the research.

Measures

The Sensory Profile Caregiver Questionnaire (SPCQ; Dunn, 1999) was completed by a parent of each child between ages 4 and 10.95 years. This questionnaire has normative data for children between ages 3 and 10.99 years. It describes the child's responses to sensory events in daily life and measures the degree to which children exhibit problems in sensory processing, modulation, behavioral and emotional responses and responsiveness to sensory events. The assessment consists of 125 statements ranked on a Likert scale of frequency, (1) always to (5) never, which are classified in comparison to how a typically developing child responds to the same sensory input. From the total scores for each of these quadrants, cut scores were developed to reflect the normal distribution of the behaviors from data collected on 1,263 children (Dunn, 2006). Children are categorized by ordinal rank, binned by cutoffs at 2 standard deviations (SD) below the mean, 1 SD below the mean, the mean, 1 SD above the mean, and 2 SD above the mean and labeled: much less than others, less than others, similar to others, more than others, and much more than others. The Sensory Profile caregiver questionnaire has shown internal consistency with the School Function Assessment of .47–.91 (SFA; Dunn, 1999). Convergent and discriminant validity were demonstrated by comparing similar behaviors on the SFA and SPCQ (Coster, Deeney, Haltiwanger & Haley, 1998). The SPCQ produces several groups of outputs, including total and categorical sensory domain scores: *visual*, *tactile* (touch), *vestibular* (movement), *gustatory/olfactory* (taste/smell), and *auditory* (hearing) processing, and sensory quadrant scores: *low registration*, *sensation seeking*, *sensory sensitivity*, and *sensation avoiding*. Sensory quadrant scores examine the patterns of atypical responses to various types of sensory input according to Dunn's model, such as "Holds hands over ears to protect ears from sounds," in the sensory sensitive quadrant and "Routinely smells nonfood objects," in the sensation seeking quadrant. Means and standard deviations from the normative data set were requested from the Sensory Profile author (Dunn) and were used to generate Z-scores so that we could use continuous data for our statistical analyses. Severity gradations were addressed in this study using quantitative measurements of severity rather than inference from diagnostic distinctions within ASD. The Social Responsiveness Scale, 2nd Edition (SRS-2; Constantino & Gruber, 2012) is a quantitative trait measure of symptoms associated with autism and was completed on each child by a parent. The SRS-2 added a broader age span, new standard scores and new DSM-5-compatible subscale scores to the original SRS (Constantino & Gruber, 2005). Both assessments use observations of children in their naturalistic social settings to generate a total score for autistic social impairment, empirically validated through factor, cluster, and latent class analyses (Constantino et al., 2004). The SRS exhibits non-significant correlations with IQ and substantial agreement with the Autism Diagnostic Interview-Revised (Constantino et al., 2004). Parent-report scores on the SRS

were found to be highly heritable (Constantino & Todd, 2005), continuously distributed in clinical and non-clinical populations, and distinguish children with ASD from those with other psychiatric conditions (Constantino et al., 2007). Higher scores indicate greater social impairment severity.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 20 (IBM Corporation, Armonk, NY). We used nonparametric statistical analyses to examine differences between the groups. First we used a Kruskal Wallis analysis of variance by ranks (ANOVA) to examine the difference between the SRS-2 score, age, ethnicity and gender with a post-hoc Bonferroni t-test. We then used a Kruskal Wallis ANOVA to examine the differences between the sensory response scores. To quantify the size of the variances, we examined the effect sizes in the children with ASD and the unaffected siblings and compared them to the control participants. Because of multiple comparisons, we used a Bonferroni correction to reduce the chances for a Type 1 error. We used a post-hoc Mann Whitney U test with a Bonferroni correction to locate significant differences. Correlations between the severity and the sensory Z scores were examined using the Spearman's rank correlation coefficient test.

Results

A total of 185 children between ages 4 and 10.95 years participated in this study, 113 with ASD, 33 unaffected siblings, and 39 controls. As expected, SRS T-scores were significantly higher (more impaired) in the ASD group compared to the controls ($p < .001$) and were significantly higher in the ASD group than the unaffected siblings ($p < .001$). SRS T-scores were also higher, but not significantly, in the unaffected siblings compared to the control group ($p = .09$). Age was not significantly different among groups. Ethnicity was significantly different because all participants in the control group were Caucasian. Gender was significantly different between the unaffected siblings and the other two groups because females were much more strongly represented in the unaffected sibling group. ANCOVA was used to control for this difference, resulting in the same outcomes as from the ANOVA, with no significant effect of gender. See Tables 1 and 2 for details.

Sensory Responsiveness Differences between Children Affected and Unaffected with ASD

The ASD affected participants had a wide range of sensory scores, while many of the unaffected siblings and controls had a preponderance of scores in the most typical end of the range. This contributed to reduced correlations between sensory and social responsiveness scores among these groups. Kruskal Wallis analysis of variance by ranks comparing the Z score results presented significantly more atypical sensory Z scores for the children with ASD compared to the controls and unaffected siblings for all quadrants. Post-hoc tests located significant differences for unaffected siblings of children with ASD only with participants who had an ASD diagnosis. Controls were also significantly different from the ASD group. No significant differences were found between unaffected siblings and controls. (See Table 2 for details regarding relationships between unaffected siblings and other groups.)

Similarly, Kruskal Wallis analysis of variance by ranks comparing the effect size results indicated significantly more atypical sensory scores among the children with ASD compared to the controls and unaffected siblings for all quadrants. Post-hoc testing identified significant differences for unaffected siblings only with participants who had an ASD diagnosis. No significant differences were found between unaffected siblings and controls. See Figures 1 and 2 for details regarding effect size relationships between unaffected siblings and other groups.

Correlations between Sensory and Social Responsiveness

Correlations between the Sensory Profile Z scores and the SRS-2 T-scores were negative and weak to moderately strong for the ASD affected participants and the controls. For the unaffected siblings, these correlations were weaker. Unaffected siblings had the lowest correlations between sensory and social responsiveness scores. The ASD affected group had one sensory quadrant more negatively correlated than $-.50$: *sensory sensitivity* ($r = -.501$), and all four quadrants were negatively correlated more than $-.40$. For the sensory domains, the ASD affected group had one domain more negatively correlated than $-.50$: *touch* ($r = -.569$) and an additional one more negatively correlated than $-.40$: *auditory* ($r = -.451$). The controls had two more negatively correlated than $-.50$: *low registration* ($r = -.622$) and *sensation avoiding* ($r = -.512$). For the sensory domains, they had two more negatively correlated than $-.50$: *touch* ($r = -.519$) and *taste/smell* ($r = -.538$) and an additional one more negatively correlated than $-.40$: *auditory* ($r = -.414$). The unaffected siblings had no sensory quadrants or domains more negatively correlated than $-.50$. Two additional quadrants: *low registration* ($r = -.471$) and *sensation avoiding* ($r = -.498$), and one additional domain: *auditory* ($r = -.438$) were more negatively correlated than $-.40$. Repetitive behaviors was the most frequently correlated SRS-2 score with the sensory quadrants and sensory domains. *Social cognition* was also frequently correlated with the sensory scores. The sensory quadrant scores were more frequently correlated with the social scores than the sensory domain scores. *Low registration*, *sensory sensitivity* and *sensation avoiding* were more strongly correlated than *sensation seeking* with the SRS-2 scores. *Touch* was more correlated with the SRS-2 scores than the other domains. See Table 3 for details. [Insert Table 3 here]

Discussion

Results of this study revealed significantly more atypical sensory responses among the children with ASD compared to the unaffected controls and unaffected siblings of children with ASD for all of the quadrants. Atypical sensory responsiveness has been well documented in children with ASD and this study supports those findings. No significant differences were found between unaffected siblings and controls. However, the small numbers of participants in these two groups underpower it to be able to assert a null hypothesis.

Similar to findings from De la Marche and associates (2012), this study found significant differences for all sensory quadrants scores between individuals with ASD and unaffected controls. However, in the De la Marche study, significant differences were seen between

controls and unaffected siblings in *sensation seeking*, while significant differences for this study were not seen in any category. Possibilities for differences between the two studies are that this study examined a younger age range of children with ASD. Because of the older age group, the De la Marche study used the AASP to examine sensory responsiveness, the version developed for individuals between ages 11 and 65 years. The AASP is a self-report questionnaire, while the SPCQ, the younger version that was used with this study, utilizes parent report. Questions are similar, but not the same between the AASP and the SPCQ (used for the younger children). It is possible that the items self-rated for *sensation seeking* are less evident to the individuals doing the self-report than to parents who rate the younger children in the SPCQ that was used in this study. It is also possible that lower *sensation seeking* than typically developing individuals is more common among unaffected adolescent siblings than among younger unaffected siblings. A further possibility also exists that the differences between items in the two versions of the Sensory Profile are different enough that the quadrant scores may not be consistent. Sensory responsiveness is a very broad construct, including sensory patterns of responsiveness over a wide range of sensory mechanisms. This study examined parents' reports of general patterns of behavior rather than specific observed or physiological responses. It is possible that unaffected siblings do experience sensory responses differently from controls, but using this type of assessment in this relatively small group of participants is not sensitive enough to detect such differences.

Findings of generally moderate to strong correlations between many of the Sensory Profile Z scores and the SRS-2 T-scores of the ASD affected participants and the unaffected controls were consistent with previous research (Hilton et al., 2007). Findings also suggest that the sensory quadrants are more closely associated with social responsiveness than the sensory domains. The reason for this is probably that the quadrants are general patterns of behavior, in contrast to the domains, which are specific to each sensory system. This suggests that the quadrants would have a larger impact on general behaviors than the domains. Touch and taste/smell were the domains most frequently associated with social responsiveness, suggesting the possibility that they may bear some responsibility in social responsiveness problems and may be important targets for intervention for these problems. *Repetitive behaviors* were more frequently associated with sensory responsiveness than the other social responsiveness categories. This suggests a relationship between the two and the potential for interventions addressing sensory problems to have an impact on reducing repetitive behaviors.

Previous research has suggested the possibility that social impairment constitutes an autism endophenotype. Finding the correlation between social responsiveness and sensory responsiveness could lead to the possibility that sensory responsiveness is also an autism endophenotype. This study does not seem to support that conclusion. However, these findings are inconclusive because of the limitations of the study and more research is indicated to clarify this relationship. Results of this study were limited by several factors. The numbers of unaffected siblings and controls were not adequate to clearly determine the presence or absence of sensory responsiveness as an endophenotype. No African Americans were recruited to participate in the control group so we were not able to compare control data for that race/ethnicity. Girls were over-represented in the unaffected sibling group. IQ was not available for the participants. In addition, use of questionnaire assessments involves a risk of

misinterpretation of the questions. Using parent report may not be the most accurate way to quantify sensory responses. Even self-report does not always produce reliability between subjects' personal experiences of their own sensory responses. Further research is needed to examine observed behaviors and physiological indicators of sensory responsiveness of individuals with ASD and their siblings to provide more objective examination of their sensory responses.

Although this study has provided new information about sensory differences between siblings in families affected with ASD, the development of a sensory responsiveness assessment that is more consistent across the entire age span of childhood and adulthood would help to strengthen the understanding of these relationships in future studies. In addition, examining differences in sensory responsiveness among unaffected siblings from multiple incidence families (multiplex) compared to those families with only one child affected with ASD (simplex) would benefit our understanding of the heritability of these response patterns.

Conclusion

Understanding the sensory characteristics of unaffected siblings in ASD-affected families is necessary to fully understand the genetics and underlying issues associated with ASD. The results of these analyses examining parent report of children less than 11 years of age do not support the notion that unaffected siblings of children with ASD exhibit atypical sensory traits as an endophenotype, although this study is underpowered to be able to assert the null hypothesis. More physiological examination of responses in a larger group of individuals and comparison between simplex and multiplex unaffected siblings are needed to further clarify the heritability of autistic traits.

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Fig 1.
Comparison of Z Scores of Sensory Quadrants

Fig 2.
Comparison of Z Scores of Sensory Domains

Table 1

Characteristics of Participants

	ASD (n=114)	Unaffected Siblings (n=32)	Control Subjects (n=39)	<i>p</i>
Ethnicity				
Caucasian	97	21	39	.00 **
Other	17	11	0	
Mean Age (years) (range)	8.11 (4.01 – 10.95)	7.29 (4.30 – 10.78)	8.18 (4.59 – 10.90)	ns
Gender				
Male	96	15	31	.00 **
Female	18	17	8	
SRS-2 T-Score Mean	77.81	46.93	44.36	.00 **

SRS-2 = Social Responsiveness Scale, 2nd Ed.,

*
 $p < 0.05$;

**
 $p < 0.01$;

ns = not significant.

Table 2

Characteristics of Participants Post Hoc Analysis of Variance

	Comparison Groups		Mean Difference between Comparison Groups	Standard Error	p
	Affected	Unaffected Sibling			
SRS-2		Control	30.88 [*]	1.96	.000 [*]
		Affected	33.45 [*]	1.77	.000 [*]
	Unaffected Sibling		-30.88 [*]	1.96	.000 [*]
	Control		2.57	2.32	.209
	Control	Affected	-33.45 [*]	1.77	.000 [*]
		Unaffected Sibling	-2.57	2.32	.209
Age	Affected	Unaffected Sibling	.82	.37	.058
		Control	-.06	.34	.695
	Unaffected Sibling		-.82	.37	.058
	Control		-.88	.44	.087
	Control	Affected	.06	.34	.695
		Unaffected Sibling	.88	.44	.087
Ethnicity	Affected	Unaffected Sibling	-.16	.08	.055
		Control	.08	.07	.235
	Unaffected Sibling		.16	.08	.055
	Control		.24 [*]	.09	.014 [*]
	Control	Affected	-.08	.07	.235
		Unaffected Sibling	-.24 [*]	.09	.014 [*]
Gender	Affected	Unaffected Sibling	-.37 [*]	.08	.000 [*]
		Control	-.07	.07	.304
	Unaffected Sibling		.37 [*]	.08	.000 [*]
	Control		.30 [*]	.09	.009 [*]
	Control	Affected	.07	.07	.304
		Unaffected Sibling	-.30 [*]	.09	.009 [*]

SRS-2 = Social Responsiveness Scale, 2nd Ed.,

* = significant difference at .016 with Bonferroni correction

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Table 3
Relationships between Sensory Profile Z-scores & SRS-2 T-scores for Children with ASD, Unaffected Siblings and Controls (N = 181)

SRS-		Social Motivation	Social Communication	Social Awareness	Social Cognition	Repetitive Behaviors	SCI	Total SRS-2
2 Sensory Profile								
Low Registration	ASD	-.362**	-.340**	-.296**	-.351**	-.456**	-.396**	-.411**
	Sib	-.099	-.458*	-.378	-.522**	-.271	-.427*	-.471**
	CG	-.406*	-.575**	-.334*	-.545**	-.657**	-.564**	-.622**
Sensation Seeking	ASD	-.320**	-.319**	-.384**	-.393**	-.407**	-.401**	-.443**
	Sib	-.050	-.282	-.177	-.299	-.214	-.281	-.306
	CG	-.240	-.319*	-.357*	-.208	-.493**	-.318*	-.357*
Sensory Sensitivity	ASD	-.491**	-.365**	-.405**	-.529**	-.451**	-.517**	-.501**
	Sib	-.022	-.313	-.341	-.432*	-.226	-.320	-.360
	CG	-.360*	-.366*	-.225	-.291	-.576**	-.349*	-.430**
Sensation Avoiding	ASD	-.559**	-.416**	-.364**	-.519**	-.483**	-.537**	-.480**
	Sib	-.257	-.480**	-.235	-.481*	-.367*	-.454*	-.498**
	CG	-.346*	-.362*	-.437**	-.302	-.537**	-.458**	-.512**
Auditory	ASD	-.421**	-.407**	-.366**	-.473**	-.473**	-.484**	-.451**
	Sib	-.105	-.381*	-.271	-.467**	-.352	-.385*	-.438*
	CG	-.303	-.388*	-.126	-.291	-.632**	-.322*	-.414**
Visual	ASD	-.413**	-.304**	-.232*	-.376**	-.362**	-.379**	-.336**
	Sib	-.100	-.254	-.072	-.330	-.142	-.186	-.207
	CG	-.253	-.278	-.518**	-.123	-.326*	-.379*	-.396*
Vestibular	ASD	-.332**	-.267**	-.304**	-.321**	-.404**	-.354**	-.373**
	Sib	-.032	-.102	-.032	-.168	-.082	-.101	-.101
	CG	-.262	-.326*	-.254	-.208	-.477	-.305	-.354*

SRS-	Social Motivation	Social Communication	Social Awareness	Social Cognition	Repetitive Behaviors	SCI	Total SRS-2
2 Sensory Profile							
Touch	ASD	-.535 **	-.485 **	-.499 **	-.562 **	-.539 **	-.569 **
	Sib	-.273	-.206	-.314	-.346	-.166	-.298
	CG	-.446 **	-.495 *	-.343 *	-.354 *	-.492 **	-.519 **
Taste/Smell	ASD	-.220 *	-.134	-.229 *	-.309 **	-.245 **	-.320 **
	Sib	-.090	-.148	-.163	-.241	-.046	-.152
	CG	-.365 *	-.405	-.334 *	-.466 **	-.480 **	-.538 **

*
 $p < .05$ **
 $p < .01$

Affected (ASD) N = 114, Unaffected Siblings (Sib) N = 32, Control (CG) N = 39. ASD = autism spectrum disorder, SRS-2 = Social Responsiveness Scale, 2nd Ed., SCI = Social Communication and Interaction and is the composite score for Social Motivation, Social Communication, Social Awareness and Social Cognition. Total SRS-2 is the composite score for all SRS-2 subscales.