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Sensory processing in adults with autism spectrum disorders

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ABSTRACT Unusual sensory processing has been widely reported in autism spectrum disorders (ASDs); however, the majority of research in this area has focused on children. The present study assessed sensory processing in adults with ASD using the Adult/Adolescent Sensory Profile (AASP), a 60-item self-report questionnaire assessing levels of sensory processing in everyday life. Results demonstrated that sensory abnormalities were prevalent in ASD, with 94.4 percent of the ASD sample reporting extreme levels of sensory processing on at least one sensory quadrant of the AASP. Furthermore, analysis of the patterns of sensory processing impairments revealed striking within-group variability in the ASD group, suggesting that individuals with ASD could experience very different, yet similarly severe, sensory processing abnormalities. These results suggest that unusual sensory processing in ASD extends across the lifespan and have implications regarding both the treatment and the diagnosis of ASD in adulthood.

KEYWORDS *autism; sensory processing; Sensory Profile*

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Unusual sensory responses are present in the majority of children with autism spectrum disorders (ASDs) (O'Neill and Jones, 1997) and have been identified since the earliest descriptions of ASD (Asperger, 1944/1991; Kanner, 1943). These sensory abnormalities have been described in relation to sound, vision, touch, taste and smell (O' Neill and Jones, 1997) and include hypersensitivity (acute, heightened or excessive sensitivity), hyposensitivity (below normal sensitivity) and general sensory overload. In addition, these responses have been reported from as early as 6 to 12 months of age (Freeman, 1993) and are therefore one of the earliest indicators of ASD in early childhood (O'Neill and Jones, 1997).

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Evidence for sensory abnormalities in ASD stems from several sources; anecdotal accounts of adults with high-functioning ASD, for example, have provided an insight into the effects of heightened sensory processing on everyday life:

> The clamor of many voices, the different smells – perfume, cigars, damp wool caps or gloves – people moving about at different speeds, going in different directions, the constant noise and confusion, the constant touching, were overwhelming. (Grandin and Scariano, 1986, p. 129)

> I began to lose sense of what was around me. The shop was a mess of confused colour and noise. (Williams, 1992, p. 108)

Likewise, retrospective analyses of the home videos of children with ASD (e.g. Baranek, 1999) have found unusual sensory responses to be one of the defining features of children with ASD. Psychological research has also provided evidence for unusual sensory processing in ASD (e.g. Baranek et al., 2006; Dahlgren and Gillberg, 1989), with recent estimates suggesting that sensory abnormalities are present in 30–100 percent of individuals with the disorder (Dawson and Watling, 2000).

Unusual sensory responses were once included as part of the diagnostic criteria for ASD (American Psychiatric Association, 1980) but were omitted from later revisions due to a number of factors. For example, unusual sensory responses are present in a number of other clinical conditions, including William's syndrome (Gothelf et al., 2006), schizophrenia (Brown et al., 2002), fragile X syndrome (Rogers et al., 2003) and attention deficit hyperactivity disorder (ADHD) (Dunn and Bennett, 2002), and are therefore not unique to ASD. Furthermore, there is concern over the lack of systematic empirical research into sensory behaviours in ASD (Filipek et al., 1999) and confusion over the description and classification of sensory symptoms (Ornitz, 1989).

The most widely used tool to investigate sensory processing is the Sensory Profile (SP) questionnaire (Dunn, 1999). Using the SP, several studies have found evidence of unusual sensory processing in ASD (Kern et al., 2006; 2007a; Watling et al., 2001). Research has also demonstrated that children with ASD can be differentiated from children with ADHD (Ermer and Dunn, 1998), children with learning disabilities (O'Brien et al., in press) and typically developing children (Kientz and Dunn, 1997) on the basis of scores on this instrument. However, the majority of studies assessing sensory processing in ASD using the SP have focused on children.

In one of the few examinations of sensory processing in adults with ASD, Kern et al. (2006; 2007a) administered the SP to a group of adults and children with and without ASD and found that individuals with ASD displayed significantly different patterns of sensory responding compared

to controls in relation to oral, visual, touch, auditory and multisensory processing. In addition, these unusual sensory responses were found to dissipate across the lifespan. However, although this study assessed sensory processing across different ages (3–56 years), the majority of questionnaires were completed by family members/carers, who may underestimate the impact of unusual sensory responses in adults with ASD, in particular those at the higher end of the spectrum.

To date, no published study has empirically examined self-reported sensory processing in a group of adults with ASD compared to an age, gender and IQ matched comparison group. The aim of the current study was therefore to examine self-reported sensory processing in ASD in order to ascertain whether sensory abnormalities persisted into adulthood. It was hypothesized that, in line with previous research (Kern et al., 2006; 2007b), individuals with ASD would report unusual levels of sensory processing, relative to the comparison group. A further aim was to examine sensory processing at both a group and an individual level, to ascertain the patterns and profiles of sensory processing in ASD in more depth; of particular interest is the extent to which age, IQ and levels of autistic traits correlate with sensory processing.

Method

Participants

In total, 36 adults participated in this study; 18 adults with ASD (10 males, eight females; age range 18 to 65) and 18 comparison participants (10 males, eight females; age range 19 to 64). All experimental participants had received a formal diagnosis of ASD from a psychologist or psychiatrist experienced in the field of autism. All but two of the participants were diagnosed with Asperger syndrome (the other two had received a diagnosis of high-functioning autism) and all participants had been diagnosed in adulthood. A review of records confirmed that participants were diagnosed according to DSM-IV/ICD-10 criteria, excluding the requirement of unimpaired language development, as this information was often unavailable. However, none of the participants appeared to have any current abnormalities in structural or semantic aspects of their language. To support their diagnoses, the Autism-Spectrum Quotient (AQ) questionnaire was administered (Baron-Cohen et al., 2001). The adults with ASD (mean 35.28, SD 5.78) scored significantly higher than the comparison group (mean 12.53, SD 3.50) on this measure ($t(34) = 13.32$, $p < 0.001$). In addition, all but one of the ASD participants scored above the suggested cutoff of 26 on this measure, while none of the comparison participants did. Experimental

participants were recruited from the National Autistic Society (UK), as well as various social groups for adults with ASD.

The comparison group were group matched with the ASD group on the basis of age, gender and IQ (verbal, performance and full scale) (see Table 1) and were recruited from various further/higher education colleges and local social groups. Ethical approval was obtained from the Goldsmiths, University of London, Psychology Department Ethics Committee.

Materials

Wechsler Abbreviated Scale of Intelligence (WASI: Wechsler, 1999a). The WASI was used to provide a measure of verbal, performance and full-scale IQ, for group matching purposes. The WASI is a widely used measure in both clinical and non-clinical samples when there is no need to provide a full cognitive profile. In addition, the WASI correlates highly (verbal IQ = 0.88, performance IQ = 0.84, full-scale IQ = 0.92) with the Wechsler Adult Intelligence Scale (WAIS-III: Wechsler, 1999b). The WASI was selected for the current study due to its speed of administration.

Autism-Spectrum Quotient (AQ: Baron-Cohen et al., 2001). The AQ is a 50-item self-report questionnaire assessing levels of autistic traits in adults with normal intelligence. Participants rate their behaviours in five different areas (attention switching, attention to detail, communication, imagination and social skill) on a four-point scale (strongly agree, agree, disagree, strongly disagree). A score of 32 or above is indicative of clinically significant levels of autistic traits, although a score of 26 or above has recently been proposed as a useful cutoff for a clinic referred sample (Woodbury-Smith et al., 2005). The AQ has good test–retest reliability and 83 percent discriminative validity (Woodbury-Smith et al., 2005) (in line with the number of participants scoring above 26 in the current sample).

Table 1 **Demographic data for ASD and comparison participants**

Measures	*ASD group*		*Comparison group*		*Group differences*	
	Mean	*SD*	*Mean*	*SD*	*t*	*p*
Age	41.78	15.24	39.50	13.27	.63	.635
Verbal IQ	116.22	11.09	111.78	11.17	1.20	.240
Performance IQ	115.83	11.77	114.83	11.02	.26	.794
Full scale IQ	118.17	10.74	114.89	11.75	.87	.388

Adult/Adolescent Sensory Profile (AASP: Brown and Dunn, 2002). The AASP is a 60-item self-report questionnaire assessing levels of sensory processing in everyday life across several sensory modalities (taste/smell, movement, visual, touch, activity and auditory). The questionnaire takes approximately 10–15 minutes to complete and participants are instructed to indicate the frequency of responses to various sensory experiences on a five-point scale (1 = almost never, 2 = seldom, 3 = occasionally, 4 = frequently, 5 = almost always).

The AASP is based on Dunn's (1997) model of sensory processing and the interacting principles of neurological thresholds (which can be high or low) and behavioural responses (which can be passive or active). Neurological thresholds refer to the amount of stimuli needed for a neuronal system to respond to sensory input, whilst behavioural responses concern the way in which a person responds to their sensory thresholds. The interactions between these continuums form four orthogonal quadrants:

1 *Low registration*: refers to high neurological thresholds and passive behavioural responses, i.e. responding slowly or not noticing sensory stimuli. Sample item: 'I don't smell things that other people say they smell.'
2 *Sensation seeking*: refers to high neurological thresholds and active behavioural responses, i.e. actively pursuing sensory stimulation. Sample item: 'I like to go to places that have bright lights and that are colourful.'
3 *Sensory sensitivity*: refers to low neurological thresholds and passive behavioural responses, i.e. experiencing discomfort in response to sensory stimuli. Sample item: 'I am distracted if there is a lot of noise around.'
4 *Sensation avoiding*: refers to low neurological thresholds and active behavioural responses, i.e. engaging in behaviours designed to reduce exposure to sensory stimuli. Sample item: 'I stay away from noisy settings.'

Reliability statistics for the quadrants of the AASP range between 0.639 and 0.775 (alpha coefficients) and validity statistics range between 3.58 and 4.51 (standard errors of measurements) (see Brown and Dunn, 2002, for further information).

The AASP is based on the Sensory Profile (SP: Dunn, 1999), which is a 125-item measure for use with children aged 3–10 years. However, there are several important differences between the SP and the AASP:

1 The AASP is a self-report questionnaire, whereas the SP is completed by a caregiver.
2 On the SP a score of 5 indicates that the child displays less of the particular attribute, whereas on the AASP a score of 5 indicates that the adult displays more of the attribute.

3 The AASP has four quadrants (low registration, sensation seeking, sensory sensitivity, sensation avoiding), whereas the SP has nine factors (sensory seeking, emotionally reactive, low endurance/tone, oral sensory sensitivity, inattention/distractibility, poor registration, sensory sensitivity, sedentary, fine motor/perceptual).
4 The AASP examines sensory processing across six modalities (taste/smell, movement, visual, touch, activity and auditory), whereas the SP examines these six modalities as well as two further modalities (body position and emotional/social).

However, despite these differences, the AASP follows the same principles as the SP in examining sensory processing in everyday life across a number of sensory modalities.

Procedure

These data were collected as part of a larger study investigating the relationship between sensory processing and memory in adults with ASD. All participants were tested individually, either in Goldsmiths, University of London, or in their own homes. The WASI was administered before the questionnaire measures, all following standard instructions from the test manuals. The WASI took approximately 30–45 minutes to administer, whilst the two self-report questionnaires were completed by participants in approximately 15–20 minutes.

Results

Overall sensory processing

Using multivariate analysis of variance (MANOVA) with scores on the four sensory quadrants (low registration, sensory seeking, sensory sensitivity and sensory avoidance) entered as dependent variables and group membership as the independent variable, results demonstrated a significant difference in overall scores on the AASP between the ASD and comparison groups, $F(1, 34) = 20.80$, $p < 0.001$.

Analysis of sensory quadrants

Following the significant MANOVA, independent samples t-tests were used to compare the quadrant scores of the adults with and without ASD. Results demonstrated significant group differences in relation to all four sensory quadrants. Specifically, the ASD group displayed higher scores on the low registration, sensory sensitivity and sensation avoidance quadrants, but scored lower than the control group on the sensation seeking quadrant (see Table 2).

Table 2 **Quadrant scores for the ASD and comparison groups**

Factor	*ASD group*		*Comparison group*		*Group differences*	
	Mean	*SD*	*Mean*	*SD*	*t*	*p*
Low registration	42.56	9.28	31.22	5.00	4.56	.001
Sensation seeking	39.44	8.15	48.33	5.91	–3.74	.001
Sensory sensitivity	45.00	10.05	33.83	7.17	3.84	.001
Sensation avoidance	46.17	11.87	31.67	5.03	4.77	.001

Multiple case series analysis

A multiple case series analysis was used to examine the profile and pattern of scores across quadrants on an individual basis. In this analysis, the number of participants whose scores fell outside the normal distribution of the comparison group (in the extreme 5%) were examined (as in Hill and Bird, 2006); considering that the majority of participants in the ASD group scored above the comparison group on the low registration, sensory sensitivity and sensation avoidance quadrants, the extreme 5 percent on these quadrants represented the highest 5 percent of scores in the comparison group. Conversely, as the majority of ASD participants scored below the comparison group on the sensation seeking quadrant, the extreme 5 percent on this quadrant represented the lowest 5 percent of scores in the comparison group.

Results demonstrated that the majority of outlying scores (77.78%) fell in the sensory avoidance quadrant. In addition, all but one of the ASD participants (94.44%) were found to display extreme levels of sensory dysfunction on at least one of the quadrants, indicating that unusual sensory processing is prevalent in adults with ASD. Further analysis of individual scores across quadrants indicated that different participants scored in the extreme 5 percent of the comparison group on differing quadrants. Therefore, although extreme levels of sensory processing are prevalent in ASD, they manifest themselves differently between individuals (see Table 3).

Correlational analyses

In order to further examine the patterns of sensory processing in adults with ASD, correlational analysis was used to assess the relationship between sensory processing, IQ and age. As a relatively high number of within-group correlations were conducted in this analysis, a significance level of $p < 0.01$ (two-tailed) was set to avoid type I errors.

Sensory processing and age. No significant correlations were observed with respect to age and levels of sensory processing in the ASD or comparison groups (r-values ranged between –0.086 and –0.170 in the ASD

Table 3 **Multiple case series analysis illustrating the number of outlying scores in the ASD group for each sensory quadrant**

Participant	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoidance	% of quadrants
4					*50%*
5					*0%*
8					*50%*
11					*100%*
12					*25%*
13					*75%*
16					*50%*
17					*100%*
18					*25%*
19					*50%*
20					*75%*
21					*25%*
22					*75%*
24					*25%*
26					*50%*
29					*50%*
33					*50%*
36					*100%*
No of outliers (%)	*11/18 (61.11%)*	*8/18 (44.44%)*	*6/18 (33.33%)*	*14/18 (77.78%)*	

group and between 0.119 and –0.179 in the comparison group, $p > 0.05$), suggesting that levels of unusual sensory processing do not dissipate across the lifespan.

Sensory processing and IQ. Pearson correlations revealed significant negative within-group correlations regarding performance IQ and three of

the four sensory quadrants on the AASP (low registration, sensory sensitivity and sensation avoidance) in the ASD group but not the comparison group. Specifically, higher scores on the three sensory quadrants were associated with lower levels of performance IQ. A similar, although weaker, relationship was observed regarding full-scale IQ and scores on the low registration quadrant. In contrast, there were no significant correlations between sensory processing and IQ in the comparison group (see Table 4).

Sensory processing and autistic traits. No significant correlations were observed regarding levels of autistic traits and levels of sensory processing in either the ASD or comparison groups ($p > 0.05$). This is consistent with previous research that found sensory processing to correlate with autistic traits in childhood, but not adulthood (Kern et al., 2006).

Discussion

This study compared levels of sensory processing in adults with ASD with an age and IQ matched comparison group using a self-report measure of everyday sensory processing, the AASP. Results demonstrated that adults with ASD reported abnormal levels of responding to sensory stimuli, relative to the comparison group. Furthermore, sensory abnormalities were found to be prevalent, with all but one participant in the ASD group (94.44%) reporting extreme levels of sensory processing on at least one sensory quadrant. Analysis of scores on an individual basis also revealed striking within-group variability in the ASD group, suggesting that sensory abnormalities may manifest themselves differently across the autism spectrum. Overall, these results suggest a distinctive pattern of sensory processing in adults with ASD and have implications regarding both the diagnosis and the treatment of ASD in adulthood.

Table 4 **Correlations between IQ and quadrant scores in the ASD and comparison groups.**

	ASD group			*Comparison group*		
	VIQ	*PIQ*	*FSIQ*	*VIQ*	*PIQ*	*FSIQ*
Low registration	–.274	–.698*	–.588*	.205	.075	.180
Sensation seeking	–.351	–.024	–.260	–.042	.039	.001
Sensory sensitivity	.050	–.660*	–.357	–.097	–.442	–.235
Sensation avoidance	–.068	–.683*	–.447	–.137	–.128	–.142

* = $p < .01$ (two-tailed)

The finding that adults with ASD reported abnormal levels of sensory responding, relative to comparison participants, is consistent with a growing body of literature suggesting the presence of sensory processing abnormalities in individuals with ASD (Kern et al., 2006; 2007a; Kientz and Dunn, 1997; O'Brien et al., in press). Although the majority of this research has focused on children, these results (as do those of Leekam et al., 2007) suggest that sensory processing abnormalities persist across the lifespan in ASD. These findings are also consistent with autobiographical accounts of adults with ASD that highlight the impact of sensory processing on everyday functioning in both childhood and adulthood (e.g. Grandin and Scariano, 1986; Williams, 1992).

These results do, however, contrast with those of Kern et al. (2007a), who reported that levels of abnormal sensory processing in ASD tend to dissipate with increasing age. However, in Kern et al.'s study, the majority (62%) of the questionnaires were completed by caregivers who may underestimate the extent of the sensory processing abnormalities in adults with ASD. Furthermore, some of the items in the SP may not be applicable to adults, especially high-functioning adults, with ASD, for example, 'Has trouble staying between the lines when colouring or when writing' and 'Dislikes activities where head is upside down, for example, somersaults'. These two methodological differences may therefore account for the apparent discrepancies between the results of the present study and those of Kern et al. It is also likely that the presentation of sensory processing abnormalities manifests itself differently with increasing age and the AASP may be more appropriate to detect these patterns of unusual sensory processing in adulthood than the SP.

These results also contrast with Kern et al.'s (2007a) findings regarding the quadrant scores of individuals with ASD; in the current study, adults with ASD were more sensitive to sensory stimulation and were more likely to avoid sensory input. They also registered information less and engaged in fewer sensation seeking behaviours than the comparison group. In contrast, Kern et al. found that although their sample also registered information less, had heightened sensitivity and avoided sensory stimulation, they tended to engage in more sensation seeking behaviours than controls. However, this effect was found to dissipate with increasing age. Although this result has not always been consistently replicated (Ermer and Dunn, 1998, for example, found evidence of lower sensation seeking behaviours in ASD, in line with the current study), it is possible that, with maturation, individuals with ASD develop strategies to cope with their unusual sensory responding.

However, it is important to note that Kern et al.'s (2007a) study comprised a sample of individuals with a diagnosis of autism, whereas the current study focused more on individuals at the higher end of the spectrum, the majority of whom had a diagnosis of Asperger syndrome. Indeed, Dunn

et al. (2002) found that children with Asperger syndrome displayed lower sensory seeking behaviours than controls, in line with the current findings. It is therefore important to ascertain whether there are any differences in the presentation of sensory processing symptoms between individuals with classic autism and those with high-functioning autism or Asperger syndrome and, indeed, whether there are any subgroups on the autistic spectrum that present with different sensory symptoms.

Further analysis of sensory quadrant scores revealed significant positive within-group correlations regarding three of the four sensory quadrant scores (low registration, sensory sensitivity and sensory avoidance) and non-verbal IQ scores in the ASD group but not the comparison group (a similar, although weaker, relationship was also found between the low registration quadrant and full-scale IQ scores). High levels of non-verbal IQ may therefore serve as a protective factor against sensory processing abnormalities in ASD such that adults with high non-verbal IQ scores may be more adept in implementing strategies to reduce the effects of heightened sensory processing. Alternatively, extreme levels of sensory processing may consume the limited attentional resources of those with lower non-verbal IQ in the ASD group; indeed, attentional abilities are thought to be closely related to sensory abnormalities in ASD (Liss et al., 2006). These may therefore be important factors to consider when designing sensory interventions for adults with ASD. However, it is important to stress that these results are correlational and further investigation is needed to explore these preliminary findings and interpretations in more depth.

Overall, this research has several important implications. First, if sensory abnormalities are prevalent in adults with ASD, this suggests that the reinstatement of unusual sensory processing in the diagnostic criteria for ASD should be seriously considered; indeed, several researchers have campaigned for this symptom to be reinstated in the diagnostic criteria for ASD since its withdrawal (e.g. Gillberg and Coleman, 1992). Although research into children with ASD has suggested that abnormal sensory responses are commonplace in ASD, the finding that these responses are also present in adulthood would further highlight the need for this symptom to be more widely recognized. Second, this research has important implications regarding sensory interventions for individuals with ASD. Several sensory therapies have been advocated for children with ASD, although the evidence for the efficacy of these treatments is mixed (see Dawson and Watling, 2000). It is therefore important to evaluate sensory interventions for adults with ASD (particularly those at the higher end of the autistic spectrum) to identify the effects of these treatments on everyday functioning.

Although this research has provided evidence of unusual sensory processing in ASD, further research in this area is warranted. First, it is important

that these results are replicated in a larger sample to ascertain the population prevalence of sensory abnormalities in ASD in adulthood. Second, it is also of interest to examine how sensory responding changes across the lifespan. Although Pohl et al. (2001) found sensory responding to be relatively consistent across the lifespan (changing only after the age of 65), it is nonetheless important to examine the consistency of sensory symptoms in adults with ASD. Additionally, further research is needed to better understand the cognitive, behavioural and neurological effects and consequences for such unusual sensory processing.

It is also important to note that the current study used a self-report questionnaire to examine levels of sensory processing, which is subject to both individual and group biases. Although the current group of adults were very high functioning and were able to offer insight into their sensory processing difficulties, this measure would perhaps not be suitable for adults at the lower end of the spectrum. It is therefore important for objective measures of sensory processing to be developed, in order to empirically assess sensory processing abnormalities in ASD (cf. Bennetto et al., 2007; Blakemore et al., 2006). These measures could then be used to verify self-reported levels of sensory processing in ASD.

Finally, previous research has demonstrated that unusual sensory responses are not unique to ASD and have been observed in several other neurodevelopmental disorders. It is therefore important to examine the patterns of sensory processing in other disorders to determine the extent to which these adults can be differentiated from adults with ASD on the basis of sensory processing.

To conclude, this research has provided evidence of self-reported sensory processing abnormalities in adults with ASD compared to an age, gender and IQ matched comparison group. Furthermore, analysis of the data at an individual level revealed substantial within-group variability in the ASD group, highlighting how individuals with ASD can experience very different, although similarly severe, sensory processing impairments. Further research is necessary to identify whether these unusual responses are unique to ASD and to examine the profile of sensory responses in more depth. This has important implications with respect to the diagnosis and treatment of ASD in adulthood.

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