DOI:
10.1007/s10803-016-2881-7

Document Version
Peer reviewed version

DSM-5 Sensory Behaviours in children with and without an autism spectrum disorder.

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Abstract

Atypical responses to sensory stimuli are a new criterion in DSM-5 for the diagnosis of an autism spectrum disorder (ASD) but are also reported in other developmental disorders. Using the Short Sensory profile (SSP) and Autism Diagnostic Interview–Revised (ADI-R) we compared atypical sensory behaviour (hyper- or hypo-reactivity to sensory input or unusual sensory interests) in children aged 10-14 years with (*N* = 116) or without an ASD but with special educational needs (SEN; *N* = 72). Atypical sensory behaviour was reported in 92% of ASD and 67% of SEN children. Greater sensory dysfunction was associated with increased autism severity (specifically restricted and repetitive behaviours) and behaviour problems (specifically emotional subscore) on teacher and parent Strengths and Difficulties Questionnaires but not with IQ.

Keywords: Autism spectrum disorder, Sensory Reactivity, Sensory Interests, DSM-5, diagnostic criteria, Behaviour

Abstract Word count 120/120

DSM-5 Sensory Behaviours in children with and without an autism spectrum disorder.

Kanner's (1943) original description of autism referred to negative reactions to sensory stimuli, "loud noises or moving objects, which are therefore reacted to with horror or panic" (p.245) while noting that the child "can happily make as great a noise as any that he dreads and move objects to his heart's desire" (p.245). Asperger (1941) also described children as demonstrating hypersensitivity in some circumstances but in other situations either ignoring (appearing hyposensitive) or seeking out particular stimuli. The Third Diagnostic and Statistical Manual of Mental Disorders (DSM-III) (American Psychiatric Association (APA), 1980) included atypical sensory responsiveness as an associated feature of infantile autism under diagnostic criterion E: "Bizarre responses to various aspects of the environment" (APA 1980, p.90). However, the subsequent two editions of the DSM did not include specific reference to sensory responsiveness in the diagnostic criteria (DSM-IV, APA, 1994; DSM-IV-TR, APA, 2000). Since then, atypical responses to sensory stimuli have been reported as occurring in 65- 95% of individuals with ASD (Lane et al. 2014; Leekam et al. 2007; Tomchek and Dunn 2007; Zachor and Ben-Itzach 2014). Different types of response to the sensory environment in ASD have been described; hyper-responsivity, hypo-responsivity and over focussed sensory interests (described in the literature as sensory seeking) (Ausderau et al. 2014). Single or mixed sensory modality responsivity and association with core features of ASD and comorbidities have been explored. A meta-analysis of sensory behaviours in individuals with ASD showed significant variation between studies with three important moderators identified; chronological age, severity of autism and type of control group (whether comparison groups were matched for chronological or mental age or other developmental disorder) (Ben-Sasson et al. 2009). Altered sensory responsivity is

reported as being associated with restricted repetitive behaviours (Chen et al. 2009; Foss-Feig et al. 2016) and need for sameness (Wigham et al. 2015). Foss Feig et al. (2012) considered sensory subtypes in a study of 5-8 year olds with ASD (without a comparison group) using both parent questionnaire and direct observation of sensory behaviour. They found that tactile hypo-responsiveness and sensory seeking correlated strongly with increased social and communication impairment on the Autism Diagnostic Interview-Revised (ADI-R) (LeCouteur et al. 2003) and Autism Diagnostic Observation Schedule–Generic (ADOS-G) (Lord et al. 2000), and to a lesser degree, repetitive behaviours. Tactile hyper-responsiveness did not significantly correlate with any of the core features of ASD (Foss Feig et al. 2012). Lane et al. (2010; 2014) described four distinct sensory subtypes showing different associations with age and IQ (e.g., taste/smell versus postural inattentiveness) but noted that the sensory phenotypes were not explained by gender or autism severity (Lane et al. 2014). Altered sensory responsiveness has been linked to anxiety (e.g., Lane et al. 2012; Ben Sasson et al. 2008; Wigham et al. 2015) and depression (Bitsika et al. 2016) and may also have a significant impact on adaptive function (e.g. Ben Sasson et al. 2009; Lane et al. 2010; Tomchek and Dunn 2007; Zachor and Ben Itzchak 2014).

The latest version of the DSM has again included atypical sensory responsiveness (hyper- or hypo- reactivity to sensory input) or unusual interest in sensory aspects of the environment as one of four possible elements of which two must be met in Criterion B: Restricted, repetitive patterns of behaviour, interests, or activities. Combined with persistent deficits in social communication and social interaction across multiple contexts, these two domains define autism spectrum disorder (DSM-5; APA 2013).

However, atypical responses to sensory stimuli are also reported in people with intellectual disability and other neurodevelopmental disorders (Watling et al. 2001; Green et al.

2003; Tomchek and Dunn 2007; Lane et al. 2012), leading to the suggestion that sensory symptoms are a non-specific indicator, along with abnormalities in motor skills or self-regulation, of brain network vulnerability in developmental psychopathology (Levit-Binum et al. 2013). While sensory behaviours are reported as occurring more frequently in ASD than in comparator groups (Watling et al. 2001; Tomchek and Dunn 2007), it is not clear what proportion of individuals with conditions other than ASD have hyper- or hypo-reactivity or sensory interests and whether these involve the same sensory modalities, single or multiple. We therefore contrasted the proportion of individuals with hyper-or hypo-reactivity or sensory interest to environmental sensory input, consistent with DSM-5 criteria, in two groups of children from the Special Needs and Autism Project (SNAP; Baird et al. 2006). Children with ASD and children with other forms of special educational needs (SEN) without ASD were compared using relevant items from the ADI-R (Lord et al. 1994) and the Short Sensory Profile (SSP) (Dunn, 1999). We also explored whether atypical sensory behaviours in ASD were associated with autism symptom severity, IQ or co-occurring emotional and behavioural problems. We hypothesised that children with ASD would show a high frequency of atypical responses to the sensory environment. These atypical responses would be more frequent and more severe than in children with other neurodevelopmental problems and associated with autism severity and behaviour problems.

Methods

The study was approved by the South East Multicentre Research Ethics Committee (REC) (00/01/50). Parents gave informed consent for participation.

Participants

The sampling methodology of the SNAP study has been described previously (Baird et al. 2006) and is illustrated in Figure 1. In brief, this was a study of the prevalence of ASD within a total population cohort of 56,946 children born between July 1st 1990 and December 31st 1991who were assessed when aged 9-14 years. All those with a current clinical diagnosis of ASD (*N*=255) or considered 'at risk' of ASD by virtue of having a Statement of SEN[1] (*N*=1,515) were screened using the Social Communication Questionnaire (SCQ) (Rutter et al. 2003). Based on SCQ score, a subsample stratified by four levels of SCQ score[2] representing low (<8), moderately low (8-14), moderately high (15-21) and high (>21) scores (by coincidence also *N* = 255), received a face to face comprehensive diagnostic assessment by trained researchers which included the ADOS-G (Lord et al. 2000) and the ADI-R (Lord et al. 1994), and measures of intellectual ability (IQ).and behaviour. All information was used by the senior authors to derive a clinical consensus diagnosis of ASD (childhood autism and other ASDs; Baird et al. 2006) based on ICD-10 (World Health Organization (WHO), 1993) research criteria. The total number of ICD-10 autism symptoms was recorded. A panel of international experts reviewed a proportion of cases and agreement on diagnosis was high (see Baird et al. 2006 for details). Cases not meeting criteria for a diagnosis of ASD were categorized as SEN. These children had educational needs and a variety of other developmental/medical diagnoses.

<Insert Figure 1 about here>

Measures

ADI-R. The ADI-R has three items relevant to sensory responsivity; 'unusual sensory interests', 'undue sensitivity to noise', and 'abnormal idiosyncratic response to specific sensory stimuli'. Scored as current or having ever been present; 0 (nil), 1 (present but with little or no impact, 2 (definite with impact), and 3 (for two items) indicating severe impact.

The Sensory Profile (SPr) (Dunn 1999). Parents completed the SSP (Dunn, 1999), a commonly used questionnaire measure of abnormal responses to sensory stimuli, reported to have good discriminate validity for children (McIntosh et al. 1999a). The parent or carer rates the child's typical responses to sensory stimuli across 38 items on a five point scale from 'never = 5' responds in this manner to 'always = 1'. The time period is not specified but the present tense phrasing implies current behaviour. The total score indicates overall sensory dysfunction (lower scores reflecting greater sensory dysfunction), and seven subscales reflect dysfunction in the following domains; tactile sensitivity, taste/smell sensitivity, movement sensitivity, under-responsive/seeks sensation, auditory filtering, low energy/weak, and visual/auditory sensitivity. Missing values were prorated as an average for the subscale if less than 10% of items were missing for that subscale and no more than 10% of items missing across all subscales. Cut-off scores for typical performance, probable difference and definite difference can be calculated for the total as well as each subscale. Construct validity and cut-off scores have been derived from a North American sample exploring the relationship of the SSP to physiological responses in skin conductance in typical children and a clinical sample of children identified with sensory modulation difficulties (McIntosh et al 1999a; 1999b)

To conform to DSM-5 criteria, hyper-reactivity was defined as scoring within the definite difference range on SSP domains (tactile sensitivity, taste/smell sensitivity, movement sensitivity

or visual/auditory sensitivity) or a score of 2 or 3 on the ADI-R items describing undue sensitivity to noise or idiosyncratic negative responses to sensory stimuli (using current codes). Hypo-reactivity was defined as definite difference in the auditory filtering domain of the SSP and an 'always' or 'frequently' response to 'Doesn't seem to notice when face or hands are messy', or 'Leaves clothing twisted on body' items (both from the under-responsive/seeks sensation domain) of the SSP. Sensory interests were defined as a score of 1 or 2 on the ADI-R item 'unusual sensory interests' (current code used).

IQ was measured using the Wechsler Intelligence Scale for Children (WISC-III, Wechsler 1991; the current version at the time of the study) or Raven's Standard (SPM) or Coloured Progressive Matrices (CPM) (Raven et al. 1990) depending on the child's ability. Where WISC full scale IQs were not available, imputed full-scale IQs were obtained using the regression relationship of full scale IQ to SPM/CPM IQ (N = 12). For the five cases where no direct cognitive testing was possible, all had Vineland Adaptive Behaviour composite scores (Sparrow et al. 1984) below 20 and these cases were assigned an IQ score of 19 to reflect their profound level of intellectual disability.

Severity of ASD was measured by ADI-R (4-5 and current) and ADOS total scores, as well as an overall ICD-10 symptom count based on all available information (with symptom counts ranging 0-12). For each of these measures, total scores as well as domain scores for social impairment, communication impairment, and restrictive, repetitive and stereotyped behaviours (RRSB) were calculated. Behaviour problems were measured by the parent and teacher versions of the Strengths and Difficulties Questionnaire (SDQ) (Goodman 1997), which asks parents/teachers to rate 25 behaviours as not true (0), somewhat true (1) or certainly true (2). These ratings can be used to generate a total difficulties score, as well as subscales for emotional

symptoms, conduct problem, hyperactivity, peer problems, and prosocial behaviours. The SDQ is widely used as a brief screening instrument for psychiatric problems and its psychometric properties have been established in several samples, including the UK (e.g. Goodman et al., 2000).

Data Analysis

Chi-squared analyses and Fisher's exact tests were used to compare the proportions of children, with and without ASD, with a hypersensitivity or a hyposensitivity or a sensory interest consistent with DSM-5 criteria. Within the ASD group, linear regression was used to examine the relationship between sensory dysfunction (indicated by lower SSP total scores) and other child characteristics, IQ, age, autism symptoms (domain scores from the ICD-10 symptom count, ADOS and ADI-R), and behaviour and emotions (SDQ subscale scores). Analyses were carried out using Stata 11 (StataCorp, 2009).

Results

From a sample of 255 children, a total of 210 SSPs were returned. Of these, 173 were fully completed and prorated scores were calculated for a further 15 resulting in a total of 188 SSPs available for analysis (see Figure 1). Of the 188, 116 children received a consensus diagnosis of ASD. The diagnoses of the remaining 72 children (categorised as SEN) included: 39 intellectual disability, 11 hyperkinetic or conduct disorder, 10 language impairment, 4 hearing impairment, 5 physical disability or medical condition, 2 chromosome disorders and 1 with no current clinical

diagnosis. Sample characteristics, mean SSP total and domain scores are presented in Table 1. The SEN group was slightly older than the ASD group (t (186) = 8.85, $p < .001$) but the groups did not differ in terms of IQ (t (186) = 0.92, $p = 0.36$).

<Table 1 about here>

The proportions of SEN and ASD children reported to have sensory behaviours on the ADI-R, and those scoring within the definite difference range for each of the SSP domains are shown in Table 2. Ninety-two percent (107) of the ASD group compared with 67% (48) of the SEN group had either a hypersensitivity, hyposensitivity or a sensory interest (χ^2 (1, N = 188) = 20.1, $p < .001$).

<Table 2 about here>

Compared to the SEN group more children with ASD scored within the definite difference range on at least one hyper-reactive domain on the SSP (χ^2 (1, N = 188) = 29.7, $p <$ .001) and also for two hyper-reactive domains (χ^2 (1, N = 188) = 27.1, $p < .001$). Hyper-reactivity to the sensory environment was more common among the ASD group compared to the SEN group for tactile, taste/smell and visual/auditory sensitivity (all $p < .05$); for movement sensitivity, the difference in rates did not quite reach significance (χ^2 (1, N=188) = 3.84, $p = .05$). Definite/marked oversensitivity to noise (ADI item, current coding of 2 or 3) was also more common in the ASD group, compared to the SEN group (Fisher's exact: N = 188, $p < .001$). However rates of idiosyncratic negative responses to specific sensory stimuli causing intrusion (ADI item coding of 2 or 3) did not differ significantly (Fisher's exact: N = 188, p =.295).

Regarding hyposensitivity, a greater proportion of the ASD group compared to the SEN group, scored within the definite difference on the SSP auditory filtering subscale (70% versus 49%, χ^2 (1, N = 188) = 8.46, $p < .05$). The SEN and ASD groups showed similar proportions of

children who always/frequently '[doesn't] seem to notice when face or hands are messy' (χ^2 (1, N = 188) = .92, p = .34, see Table 3). However, the proportion of children who always/frequently 'leaves clothing twisted on body' was significantly higher in the ASD group (χ^2 (1, N = 188) = 13.3, p < .001).

More children in the ASD than SEN group were reported to have unusual sensory interests both by current (χ^2 (1, N = 188) = 23.2, p < .001) and historical (χ^2 (1, N=188) = 36.4, p < .001) ADI-R score (coding 1 or 2).

<Table 3 about here>

Within the ASD group, a lower SSP total (indicating greater sensory dysfunction) was associated with higher SDQ total score, accounted for by the emotional subscale on parent report (β = -2.54, t (101) = -2.96, p = .004) and with repetitive, restricted and stereotyped behaviour as recorded on the ICD-10 symptom count (β = -5.49, t (101) = -2.18, p = .03);but not with ICD-10 social or communication impairment scores (p = .36 and p = .46, respectively) (See Table 4). Sensory dysfunction was not associated with IQ, age, or the remaining SDQ subscales (all p > .12). Repeated regressions using the different measures of autism severity, ADI-R and ADOS scores, yielded the same results, i.e. autism severity and SDQ total were associated with sensory behaviours, while IQ was not. A similar pattern was found when the regression analysis was repeated using teacher SDQ totals in place of parent SDQ totals.

<Table 4 about here>

Discussion

In this well characterised cohort, sensory interests or hyper or hypo reactivity to sensory input were reported in the majority (92%) of children with ASD but were also reported in 67% with

SEN but without ASD. A definite difference in total SSP score was found in 66% of the ASD group and 32% of the SEN group. Both groups showed a higher frequency than a group of typically developing children without functional/clinical impairments (albeit aged 3-6 years) who were reported as having a probable (13%) or definite (3%) difference in total SSP scores (Dunn and Tomchek, 2007). Multiple hyper-sensitivities (i.e. tactile, taste/ smell, and noise) were much more common in ASD than in the SEN group, as was severity of hypersensitivity and impact particularly from noise as shown on ADI score. Sensory interests were more common in the ASD than SEN group.

Our findings support the inclusion of atypical sensory responsivity to the environment in the DSM-5 diagnostic criteria but emphasise that such behaviours are not unique to ASD; one feature does not make a diagnosis, other features remain essential. The findings are also supportive of the hypothesis that sensory symptoms are a non-specific indicator of brain functional network difference in developmental psychopathology (Levit-Binum et al. 2013).

The association of atypical sensory behaviours with restricted, repetitive and stereotyped behaviours, but not IQ, are consistent with those of Boyd et al. (2010), Mandy et al. (2012), Dar et al. (2012) and Wigham et al. (2015) but inconsistent with Lane et al (2014) who found hyper-sensitivity and generalised reactivity to differ by age and IQ but not ASD severity (as measured by the ADOS whereas we included history from the ADI-R and ADOS). We did not explore sensory subtypes but other studies have found individual sensory subtypes e.g. tactile responsiveness patterns in ASD, to be only weakly (or not at all) correlated with repetitive behaviours and extent of social impairment (Foss-Feig et al. 2012). Some aspects of atypical sensory behaviours, e.g. sensory interests, in ASD may be an expression of positive absorption in a detail of the environment similar to other restricted and repetitive behaviours.

Our finding of an association between atypical sensory behaviours and increased emotional symptoms in ASD is consistent with the literature showing a potential link between sensory symptoms and anxiety (Lane et al. 2012) and depression (Bitsika et al. 2016) although the direction of effect is not known. Further research is required for a better understanding of the inter-relationship between autism, comorbidities and sensory symptoms and, how these may change over time (Chen et al. 2009; McCormick et al. 2015). Anecdotally, many sensory symptoms persist into adult life and continue to have a significant impact on individuals.

Assessing sensory behaviours is limited by the current methods available, usually through questionnaires completed by parent or carers or individuals themselves rather than objective measures (Tavassoli et al. 2016). The SSP has been widely used clinically and in research studies but for some items the face validity as a 'sensory' behaviour is unclear e.g. 'Has a weak grasp'. Some clinically important items are not recorded in the SSP, for example lack of response to pain and lack of awareness of temperature, which are hypo-responsivities frequently commented on by parents. Thus, for this study we used complete SSP domains for hypersensitivity but for hyposensitivity, one domain and two items met face validity as representing under-responsiveness to sensory stimuli. This aspect of behaviour may therefore have been underestimated. Strengths of the study are a well characterised sample, the use of a recognised sensory questionnaire and a comparison group who have special educational needs and are a group in which ASD is often considered as a differential diagnosis.

In summary, the inclusion of hyper-or hypo responsivity or sensory interests within the ASD diagnostic criteria of DSM-5 is supported. However, comparison of children with ASD to those with SEN affirms the finding that young people with other developmental disorders may

also demonstrate altered sensory responsivity. In ASD altered sensory function was associated with emotional problems and the restricted repetitive behaviours. It remains to be seen if the profile of sensory responsivities differs between neurodevelopmental disorders, how these may differentially impact on function and participation and how these may change over time.

Acknowledgments

We are grateful to the children and families and the clinical teams in South Thames, whose participation and collaboration made the study possible

Compliance with Ethical Standards

Funding: This study was funded by the Wellcome Trust and the Department of Health. (Grant number 039/0026).

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

The study was approved by the South East Multicentre Research Ethics Committee (REC) (00/01/50).

Informed consent was obtained from all parents for their and their child's participation in the study.

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Footnotes

[1] A Statement of Special Educational Needs is a legal document issued by the local educational authority when children require significant additional support in school due to any learning and/or behavioural problems.

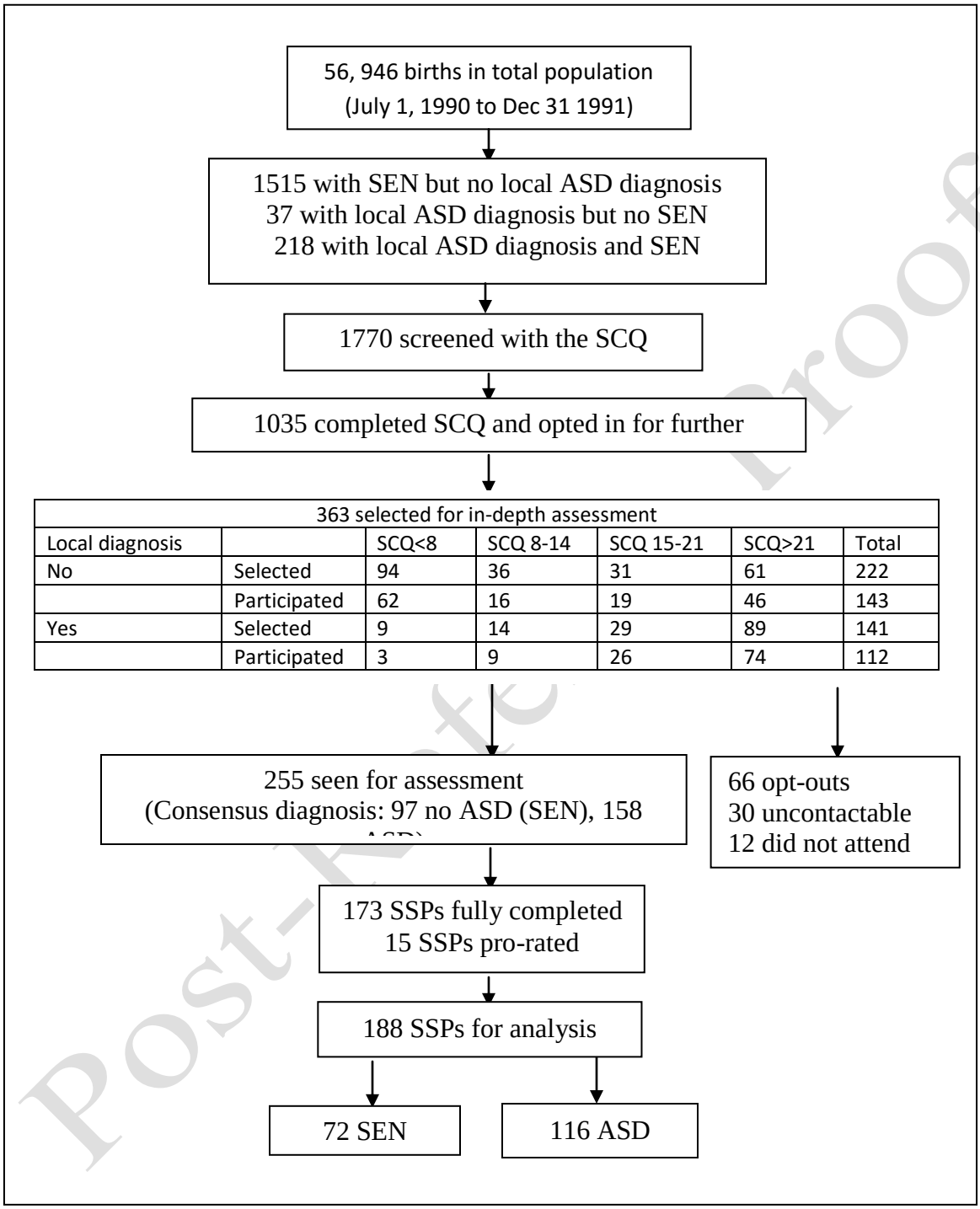
[2] The cut-offs of 15 and 22 are recommended by Rutter et al. (2003), and an additional cut-point of <8 was applied, based on the distribution of SCQ scores within the sample.

[3]As these children scored at floor on the Vineland Adaptive Behaviour Scale (composite standard score <20), these cases were assigned a proxy IQ score of one point below this, consistent with previous papers.

Figures

Figure 1 SNAP Sampling Methodology

Figure 1: SNAP Sampling Methodology



363 selected for in-depth assessment						
Local diagnosis		SCQ<8	SCQ 8-14	SCQ 15-21	SCQ>21	Total
No	Selected	94	36	31	61	222
	Participated	62	16	19	46	143
Yes	Selected	9	14	29	89	141
	Participated	3	9	26	74	112

ASD = Autism Spectrum Disorder; SCQ = Social Communication Questionnaire; SEN = Special Educational Needs; SSP = Short Sensory Profile

Table 1: Sample characteristics and mean SSP scores

	SEN (N=72)	ASD (N=116)	T-test/ Chi-square/Fisher's Exact
Sample characteristics			
Age in years (SD, range)	12.7 (0.87, 10.1-14)	11.6 (0.87, 10-13.8)	p <.001
IQ (SD, range)	77.0 (20.5, 31-131)	73.9 (23.0, 19-136)	p = .359
Ethnicity	94% white	95% white	p =.909
Parental education	39% with A-levels	47% with A-levels	p = .287
Gender	82% male	87% male	p =.337
ADI-R 4-5 total (SD)	12.0 (8.87)	43.2 (11.0)	p <.001
ADOS-G total (SD)	3.99 (2.92)	12.5 (6.39)	p <.001
ICD-10 symptom count (SD)	1.38 (1.17)	7.97 (2.47)	p <.001
SSP scores			
SSP total (mean (SD))	153.7 (24.1)	131.0 (24.3)	p < .001
SSP domain scores (mean (SD)):			p < .001
tactile sensitivity	30.4 (4.45)	26.4 (5.68)	
taste sensitivity	16.8 (4.58)	13.5 (5.51)	p < .001
movement sensitivity	13.0 (2.64)	11.89 (3.30)	p < .014
underresponsive/ seeks sensation	26.2 (7.54)	21.4 (6.20)	p < .001

auditory filtering	20.2 (5.25)	16.8 (4.85)	$p < .001$
low energy/weak	25.6 (5.98)	23.4 (7.12)	$p = .029$
visual/auditory	21.4 (3.71)	17.6 (5.22)	$p < .001$

A-Levels = Advanced Level General Certificate of Education equivalent to Secondary or High School leaving qualification

ADI-R = Autism Diagnostic Interview-Revised

ADOS-G = Autism Diagnostic Observation Scale- Generic

SSP = Short Sensory Profile

Table 2: Frequency and percentage of definite sensory symptoms among the SEN and ASD groups

		SEN (N=72)	ASD (N=116)	Chi-Sqaure/Fisher's Exact
ADI-R items				
Sensory interests (current):	1 or 2 shown regularly–score 1 (n (%))	11 (15%)	49 (42%)	$p < .001$
		2 (3%)	13 (11%)	$p = .051$
	marked with impact–score 2 (n (%))	13 (18%)	62 (53%)	$p < .001$
	any–score 1 or 2 (n (%))			
Sensory interests (ever):	1 or 2 shown regularly score 1 (n (%))	11 (15%)	49 (42%)	$p < .001$
	marked with impact–score 2 (n (%))	3 (4%)	26 (23%)	$p = .001$
	any–score 1 or 2 (n (%))	14 (20%)	75 (65%)	$p < .001$
Sensitivity to noise (current):	slight–score 1 (n (%))	9 (13%)	31 (27%)	$p = .027$
	Definite–score 2 (n (%))	2 (3%)	28 (24%)	$p < .001$
	marked with impact–score 3 (n (%))	1 (1%)	6 (5%)	$p = .254$
	Any–score 1-3 (n (%))	12 (17%)	65 (56%)	$P < .001$

Sensitivity to noise (ever):	slight-score 1 (n (%))	8 (11%)	32 (28%)	$p = .008$
	Definite score 2 (n (%))	7 (10%)	40 (34%)	$p < .001$
	marked with impact-score 3 (n (%))	1 (1%)	12 (10%)	$p = .020$
	Any-score 1-3 (n (%))	16 (23%)	84 (72%)	$p < .001$
Abnormal idiosyncratic negative response to specific sensory stimuli (current):	mild reaction – score 1 (n (%))	5 (7%)	23 (20%)	$p = .020$
	causes some intrusion – score 2 (n (%))	4 (6%)	11 (9%)	$p = .415$
		0 (-)	2 (2%)	$p = .525$
	substantial intrusion – score 3 (n (%))	9 (13%)	36 (31%)	$p = .005$
	any –score 1-3 (n (%))			
Abnormal idiosyncratic negative response to specific sensory stimuli (ever):	mild reaction- score 1 (n (%))	7 (10%)	26 (22%)	$p = .030$
	causes some intrusion – score 2 (n (%))	4 (6%)	14 (12%)	$p = .202$
		0 (-)	3 (3%)	$p = .287$
	substantial intrusion – score 3 (n (%))	11 (15%)	43 (37%)	$p = .001$
	any – score 1-3 (n (%))			
SSP domains				
SSP total	definite difference (n (%))	23 (32%)	76 (66%)	$p < .001$
Taste/smell sensitivity	definite difference (n (%))	9 (13%)[†]	41 (35%)[†]	$p = .001$

Movement sensitivity	definite difference (n (%))	12 (17%)	34 (29%)	$p = .050$
Under-responsive/Seeks sensation	definite difference (n (%))	23 (32%)	72 (76%)	$p < .001$
Auditory Filtering	definite difference (n (%))	35 (49%)	81 (70%)	$p = .004$
Low Energy/Weak	definite difference (n (%))	20 (28%)	42 (36%)	$p = .232$
Visual/auditory sensitivity	definite difference (n (%))	3 (4%)	37 (32%)	$p = < .001$

Table 3: Frequency and percentage of children who always or frequently displayed behaviours on the Short Sensory Profile

	SEN (N=72)	ASD (N=116)	Chi-Squarre/ Fisher's Exact
Tactile Sensitivity:			
1. Expresses distress during grooming	5 (7%)	39 (34%)	p <.001
2. Prefers long-sleeved clothing even when it is warm or short sleeves when it is cold	8 (11%)	20 (17%)	p = .296
3. Avoids going barefoot, especially in grass or sand	4 (6%)	18 (16%)	p = .060
4. Reacts emotionally or aggressively to touch	5 (7%)	15 (13%)	p = .231
5. Withdraws from splashing water	4 (6%)	18 (16%)	p = .060
6. Has difficulty standing in line or close to other people	7 (10%)	41 (35%)	p <.001
7. Rubs or scratches out a spot that has been touched	5 (7%)	12 (10%)	p = .602
Taste/Smell Sensitivity:			
8. Avoids certain tastes or food smells that are typically part of children's diets	7 (10%)	40 (34%)	p <.001
9. Will only eat certain tastes	9 (13%)	37 (32%)	p = .003
10. Limits self to particular food textures/temperatures	7 (10%)	34 (29%)	p = .002

11. Picky eater, especially regarding food textures	14 (19%)	41 (35%)	p = .020
Movement Sensitivity:			
12. Becomes anxious or distressed when feet leave the ground	1 (1%)	9 (8%)	p = .092
13. Fears falling or heights	4 (6%)	22 (19%)	p = .009
14. Dislikes activities where head is upside down	12 (17%)	24 (21%)	p = .496
Underresponsive/ Seeks Sensation			
15. Enjoys strange noises/seeks to make noise for noise's sake	11 (15%)	45 (39%)	p = .001
16. Seeks all kinds of movement and this interferes with daily routines	24 (33%)	58 (50%)	p = .025
17. Becomes overly excitable during movement activity	13 (18%)	39 (34%)	p = .020
18. Touches people and objects	15 (21%)	46 (40%)	p = .007
19. Doesn't seem to notice when face or hands are messy	20 (28%)	40 (34%)	p = .338
20. Jumps from one activity to another so that it interferes with play	15(21%)	39 (34%)	p = .060
21. Leaves clothing twisted on body	10 (14%)	46 (40%)	p <.001
Auditory Filtering:			
22.Is distracted or has trouble functioning if there is a lot of noise around	32 (44%)	75 (67%)	p = .007
23. Appears to not hear what you say	21 (29%)	63 (54%)	p = .001

24. Can't work with background noise	6 (8%)	25 (22%)	p = .025
25. Has trouble completing tasks when the radio is on	12 (17%)	33 (28%)	p = .066
26. Doesn't respond when name is called but you know the child's hearing is ok	10 (14%)	39 (34%)	p = .003
27. Has difficulty paying attention	30 (42%)	70 (60%)	p = .013
Low Energy/Weak			
28. Seems to have weak muscles	7 (10%)	25 (22%)	p = .045
29. Tires easily, especially when standing or holding particular body position	12 (17%)	25 (22%)	p = .413
30. Has weak grip	7 (10%)	17 (15%)	p = .375
31. Can't lift heavy objects	8 (11%)	25 (22%)	p = .078
32. Props to support self	8 (11%)	16 (14%)	p = .592
33. Poor endurance/tires easily	10 (14%)	27 (24%)	p = .089
Visual Auditory Sensitivity			
34. Responds negatively to unexpected or loud noises	3 (4%)	43 (37%)	p <.001
35. Holds hands over ears to protect ears from sound	7 (10%)	47 (41%)	p <.001
36. Is bothered by bright lights after others have adapted to the light	2 (3%)	19 (16%)	p = .004
37. Watches everyone when they move around the room	16 (22%)	24 (21%)	p = .803

38. Covers eyes or squints to protect eyes from light	3 (4%)	21 (18%)	$p = .006$

Table 4 Multiple regression results for Short Sensory Profile Total Scores and features of Autism and behavioural factors as report on the parent SDQ

Full Scales F(6,108)=6.50, *p<.001* R^2 = .224,	Coefficient	t	95% CI	*p*
IQ	.150	1.58	-.038, .337	.117
ADOS age years	-.235	-0.10	-4.92, 4.45	.921
ICD 10 total	-.066	-0.06	-2.34, 2.20	.954
ADI-R total	-.709	-3.42	-1.12, -.298	.001
ADOS G total	.370	0.90	-.448, 1.19	.372
SDQ total	-1.58	-3.79	-2.40, -.752	<.001
Subscales F(10,101)=3.41, *p < .001* R^2 = .253				
ICD 10_social	2.20	0.91	-2.57, 6.96	.362
ICD 10 communication	-1.87	-0.74	-6.83, 3.10	.458
ICD 10 repetitive	-5.50	-2.18	-10.5, -.510	.031
SDQ emotional	-2.54	-2.96	-4.24, -.834	.004
SDQ conduct	-1.18	-1.21	-3/12, .750	.228
SDQ peer relations	-1.70	-1.45	-4.03, .621	.149
SDQ hyperactivity	-.038	-0.04	-2.09, 2.01	.971
SDQ pro-social	-.043	-0.05	-1.87, 1.79	.963

CI = Confidence Interval; Rfsiq – Raven's Full Scale IQ: ADOS = Autistic Diagnostic Observation Scale-Generic; ICD = SDQ = Strengths and Difficulties Questionnaire