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ORIGINAL PAPER

Activity Participation and Sensory Features Among Children with Autism Spectrum Disorders

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Abstract Sensory features are highly prevalent among children with autism spectrum disorders (ASD) and have been shown to cluster into four patterns of response, including hyperresponsiveness, hyporesponsiveness, enhanced perception, and sensory interests, repetitions and seeking behaviors. Given the lack of large-scale research on the differential effects of sensory response patterns on children's participation in specific activities, this study investigated the extent to which sensory response patterns impacted six dimensions of children's activity participation as measured by the Home and Community Activities Scale among a large, national sample of school aged children with ASD (n = 674). Using mixed model regression, results showed that sensory response patterns differentially impacted dimensions of activity participation, and associations were moderated by a number of child characteristics.

Keywords Sensory processing · Autism · Participation

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Introduction

Children with autism spectrum disorders (ASD) have been shown to participate in activities less frequently and with less variety as compared to children with typical development as well as other developmental disabilities (Hilton et al. 2008; LeVesser and Berg 2011; Marquenie et al. 2011; Orsmond et al. 2004; Potvin et al. 2012). Participation in everyday activities provides children with learning opportunities across contexts as well as provides avenues to practice and develop skills (Dunst et al. 2006; Humphry and Wakeford 2006). The limited activity participation among children with ASD likely has cascading effects on overall development, with fewer opportunities to practice and develop skills compounding and perpetuating their limitations.

Research has uncovered a number of child factors that contribute to decreased activity participation among children with ASD. For example, participation in social activities is inversely related to language ability and adaptive functioning in ASD (Orsmond et al. 2013; Shattuck et al. 2011). Further, cognition has been found negatively related to activity participation in children with developmental disabilities (Rosenberg et al. 2013; Wuang and Su 2012; Zingerevich and Patricia 2009) as well as in typical development (Rosenberg et al. 2011). In addition to such child characteristics, emerging evidence points to how sensory features, or unusual responses to sensory stimuli, contribute to the participation of children with ASD across a range of contexts (e.g., Hilton et al. 2007; Hochhauser and Engel-Yeger 2010; Reynolds et al. 2011). However, given the ubiquity and variability of sensory features across individuals with ASD, a large-scale investigation on the impact sensory features have on activity participation is needed. Such knowledge would increase our understanding

of the impact of sensory response patterns on specific activities, potentially contributing to the design of intervention approaches aimed at increased activity participation.

Research suggests that sensory features cluster into four patterns of response in ASD, which include hyperresponsiveness (HYPER), hyporesponsiveness (HYPO), enhanced perception (EP) and sensory interests, repetitions and seeking behaviors (SIRS) (Ausderau et al. 2014b). HYPER is a sensitive or avoidant response to sensory stimuli (e.g., react negatively to touch) (Baranek et al. 2007; Schoen et al. 2008). HYPO is a lack of or delayed response to sensory stimuli (e.g., slow reaction to pain) (Ben-Sasson et al. 2009; Watson et al. 2011). SIRS is characterized by a fascination with or craving of sensory stimulation which is intense and may be repetitive in nature (e.g., fascination with lights) (Ben-Sasson et al. 2007; Liss et al. 2006). EP is characterized by superior acuity in the awareness of specific sensory stimuli and focus on specific elements of stimuli (e.g., superior ability to recognize auditory stimuli) (Mottron et al. 2009).

The behavioral presentation of sensory features is variable across individuals and sensory response patterns often co-occur in ASD (Ausderau et al. 2014a; Baranek et al. 2006; Ben-Sasson et al. 2009; Lane et al. 2014), which complicates their measurement. Sensory features in ASD are frequently measured using parent-report instruments (e.g., Sensory Profile, Dunn 1999; Short Sensory Profile, McIntosh et al. 1999; Sensory Processing Measure, Parham, Ecker, Miller Kuhaneck, Henry, and Glennon 2007) to capture the variability of children's responses across contexts. Behavioral assessments have also been developed to more directly measure specific sensory response patterns (e.g., Sensory Over-Responsivity Scales Assessment, Schoen et al. 2008; Sensory Processing Assessment, Baranek 1999). It may be that different activities elicit specific sensory responses from children with ASD. For example, a child may demonstrate aversion (i.e., HYPER) during a painting activity, while not responding to his or her name (i.e., HYPO) during a social activity.

Sensory features in ASD have been linked with decreased activity participation in qualitative reports and studies using small samples using parent report measures (e.g., Bagby et al. 2012; Dickie et al. 2009; Schaaf et al. 2011), with findings consistently pointing to the negative impact of sensory sensitivities and sensory seeking. Research suggests that increased sensory sensitivities contribute to a lack of activity participation in the community (e.g., visiting restaurants or parks) (Hochhauser and Engel-Yeger 2010; Larson 2006; LeVesser and Berg 2011), with caregivers of children with ASD reporting that they often restrict activities to the home environment (Schaaf et al. 2011). The lack of community participation may be due to the unpredictability of sensory stimuli in such environments, and adults with ASD have reported that they preferred expected and predictable sensory input due to sensory sensitivities (Ashburner et al. 2013). Additionally, other studies found that sensory sensitivities and sensory seeking is associated with decreased social, school, and activity competence among school-aged children with ASD (Ashburner et al. 2008; Reynolds et al. 2011). Although the aforementioned studies provide evidence of the ways in which children's sensory features impact participation, the extent to which specific sensory response patterns differentially impact activities remains unknown.

Study Aims

This study investigated the extent to which sensory response patterns (HYPER, HYPO, EP, SIRS) impacted the frequency of activity participation among school aged children with ASD. We also examined the moderating role of child factors (i.e., autism severity, chronological age, developmental age) on the associations between sensory response patterns and activity participation. We hypothesized that increased HYPER, HYPO, and SIRS would negatively impact children's activity participation. Additionally, we hypothesized that chronological age and developmental age would be positively related to activity participation, whereas autism severity would be negatively related to activity participation. As previous research has not examined the impact of EP on children's activity participation, we explored this relationship.

Methods

Procedure

Participants for this study (n = 674) were a subset of those recruited for a NICHD federally funded longitudinal study (n = 1307) using online survey methods. Participants were recruited through various autism advocacy organizations in the United States. The primary source of recruitment was the Interactive Autism Network (IAN), an online research registry for caregivers of children with ASD. Participants were also recruited through a university research registry and autism organizations (e.g., advocacy and parent groups), primarily via online methods such as listservs and Facebook. The larger study was longitudinal and collected data at two time points approximately 1 year apart using Qualtrics online survey software (Qualtrics Labs 2011). Data for the current analysis were drawn from the second time point, with the exception of the measure of autism severity (see "Measures" section). This study was approved by the University's Institutional Review Board.

Participants

The current study included survey responses from 674 caregivers of school-aged children with ASD ages 5–12 years (mean 106.18 mos.; SD 25.92 mos.). Diagnoses of ASD were reported by parents; IAN authenticated the parent-report ASD diagnosis for a subset of individuals in their registry and showed a high level of corroboration (98 %) between parent reported and professional documentation of a diagnosis (Daniels et al. 2012). Exclusionary criteria were as follows: co-morbid conditions of ASD, such as Fragile X Syndrome; significant visual or hearing impairments; other developmental disabilities due to a genetic disorder or syndrome; physical impairments; psychiatric conditions such as schizophrenia; or seizure activity within the last 12 months. Consistent with study aims, the inclusion and exclusion criteria were developed to examine the effect of sensory response patterns on activity participation, which led to excluding children with primary sensory impairments and co-occurring conditions. Children with ASD often have multiple diagnoses that may have additional impact on their activity participation (Levy et al. 2010), and should be a focus in future research. Demographic information on the sample is shown in Table 1.

Table 1 Sample demographics

Demographic variable	N (%)
Child gender	
Male	561 (83.2)
Female	113 (16.8)
Child race/ethnicity	
Caucasian	578 (85.8)
African-American	16 (2.4)
Hispanic	51 (7.6)
Asian	7 (1.0)
Other	87 (12.9)
Diagnostic category	
Autism/autistic disorder	342 (50.7)
Asperger's syndrome	150 (22.3)
PDD-NOS	121 (18.0)
Multiple ASD diagnoses	61 (9.0)
Respondent	
Mother	646 (95.8)
Father	23 (3.4)
Grandmother	2 (.3)
Other primary	3 (.4)
Annual income	
<$20,000	41 (6.1)
$20,000–$39,999	99 (14.7)
$40,000–$59,999	98 (14.5)
$60,000–$79,999	106 (15.7)
$80,000–$99,999	85 (12.6)
$100,000 or more	175 (26.0)
Unknown	70 (10.4)
Autism severity mean (SD)	106.94 (27.53)
Developmental age mean (SD)	62.44 mos. (25.84)
Chronological age mean (SD)	106.18 mos. (25.92)

Measures

Home and Community Activities Scale (HCAS; Adapted from Dunst et al. 2000)

The HCAS is based on research by Dunst et al. (2000), in which 3300 children with or at-risk for developmental disabilities (DD) were surveyed to determine the settings of naturally occurring learning opportunities. The original version of the HCAS included a likert response scale ('Not at All' to 'Always') of how each activity was a setting in which a child learned or displayed a desired behavior. The current study used an adapted response scale, which measured the frequency of participation across 83 activities on a scale from never (0), monthly (1), weekly (2), to daily (3). An exploratory factor analytic study (Little et al. 2014) demonstrated that the HCAS measured six factors of activity participation, including: (1) Parent–Child Household Activities; (2) Community Activities; (3) Outdoor Activities; (4) Neighborhood-Social Activities; (5) Routine Errands; and (6) Faith-based Activities (see Table 2).

Sensory Experiences Questionnaire Version 3.0 (SEQ 3.0; Baranek 2009)

The SEQ 3.0 is a 105-item caregiver report tool that characterizes sensory features in children ages 2–12 years with ASD and/or DD. Ninety-seven items on the SEQ 3.0 measure the frequency of child responses to various sensory stimuli in the context of functional activities and daily routines using a 5-point Likert scale (i.e., 1 = almost never to 5 = almost always). Previous studies have shown good reliability and validity for earlier versions of the SEQ (1.0, 2.1) (Baranek et al. 2006; Boyd et al. 2010; Little et al. 2011; Watson et al. 2011). A confirmatory factor analysis on the SEQ 3.0 with a large national ASD sample (N = 1307) indicated good model fit [Chi square = 16, 724.18 (3984)**, RMSEA = .051; SRMR = .07] for 4 sensory response patterns (i.e., HYPER, HYPO, EP, SIRS) controlling for modality and social context (Ausderau et al. 2014b).

Social Responsiveness Scale (SRS; Constantino and Gruber 2005a, b)

The SRS is a 64-item caregiver report quantitative measure of autistic traits in children. The SRS has been found to

Table 2 Descriptive statistics and example items

Study variables	Mean (SD) range	Example items
Parent–child household activities	2.947 (.454)	Picking up toys
	1.50–3.857	Adult/child play times
Community activities	1.534 (.274)	Children's festivals
	1.00–3.19	Community celebrations
Routine errands	2.473 (.580)	Doing errands
	1.00–4.00	Going shopping
Neighborhood-social activities	1.911 (.477)	Swimming
	1.00–3.571	Having friends over to play
Outdoor activities	1.575 (.457)	Hiking
	1.00–3.400	Doing yard work
Faith-based activities	1.834 (.777)	Going to church
	1.00–3.75	Religious activities
Hyperresponsiveness*	−.181 (.951)	React sensitively to unexpected/loud sounds
	−2.394 to 2.620	Dislike being in water
Hyporesponsiveness*	−.249 (.934)	Slow to react to pain
	−1.842 to 3.453	Ignore or tune out loud noises
Enhanced perception*	−.134 (.903)	Notice minor changes in visual appearance of other people
	−2.313 to 2.691	Notices smells before other people do
Sensory interests, repetitions, and seeking*	−.286 (.961)	Seem fascinated with sounds
	−2.277 to 2.316	Stare at objects that spin or move

* Descriptives for sensory response pattern scores are based on factor scores

have a single factor structure (Constantino et al. 2004) and convergent validity with the Autism Diagnostic Interview-Revised (Lord et al. 1999). The SRS data used for the current study were drawn from the first point of data collection, approximately 1 year prior to the collection of other measures. The SRS has demonstrated excellent test–retest reliability (0.88 over 3 months; 0.83 over 27 months) (Constantino et al. 2003), providing strong evidence of the stability of the SRS score for use in the current study.

Vineland Adaptive Behavior Scales-II (VABS-2; Sparrow et al. 2005)

The VABS-II assesses the adaptive behavior of individuals from birth to adulthood, and measures daily living skills, socialization, and motor skills. The current study used the caregiver/parent rating form of the VABS-II *Developmental age* was derived from the average age equivalent across each of the domains (i.e., communication, daily living skills, socialization) with the exclusion of the motor subscale.

Covariates

In order to address the moderating role of child factors on the associations between sensory response patterns and activity participation, the following were included as covariates in the analysis: *autism severity*, *chronological age*, and *developmental age*. The SRS total raw score was used as a continuous variable to measure *autism severity*. *Chronological Age* was calculated from the child's date of birth to the time of testing. For *developmental age,* we used the Adaptive Functioning Age Equivalent score from the VABS-II score. Previous research in samples of children with disabilities suggests that the VABS-II Age Equivalent demonstrates high concurrent validity with other cognitive measures, such as the Bayley Scales of Infant Development-III (Scattone et al. 2011) as well as the Kaufman Assessment Battery for Children-II (Kaufman 2004) (Delaney et al. 2013). Moreover, the VABS-II Age Equivalent has been argued as sensitive for use in samples of children with ASD (e.g., Matson 2008). In addition, the use of the VABS-II Age Equivalent score is not dependent on a child's chronological age, allowing us to examine both the impact of a child's *developmental age* as well as *chronological age* on activity participation.

Data Analysis

SAS 9.2 (SAS Institute Inc 2008) was used to analyze data. We adopted a multivariate modeling strategy to test the relationships of sensory features to HCAS subscale scores

and whether these relationships varied across measures. Hierarchical linear regression (HLM), also referred to as mixed model regression, was used to test these patterns (Littell et al. 2006). We treated the six subscales of the HCAS as repeated measurements within child. Independent variables included sensory response patterns (HYPER, HYPO, EP, SIRS), covariates included autism severity, chronological age, and developmental age, and dependent variables were HCAS factors (Parent–Child Household Activities Community Activities, Routine Errands, Neighborhood Social Activities, Outdoor Activities, Faith-based Activities). Additionally, we included interactions of the sensory response pattern scores with the multivariate effect for HCAS scores. These interactions provided tests of whether the sensory response pattern scores had differential effects across the HCAS subscales.

The repeated measurement of each participant introduces within-subject dependence into the model. Subscale responses were nested within individuals resulting in a two level model with subscale at level one and child at level two (Raudenbush and Bryk 2002). The use of HLM enabled us to account this nesting (Burchinal and Applebaum 1991; Raudenbush and Bryk 2002). Specifically, we included random intercepts in the model to provide estimates of within subject covariance of HCAS scores. We used the Benjamini–Hochberg procedure (Benjamini and Hochberg 1995) to correct for multiple follow up comparisons.

Results

Descriptive Statistics

The means and standard deviations for sensory response pattern scores and HCAS dimensions are shown in Table 2 (see Table 1 for child characteristic descriptives). For sensory response pattern scores, higher scores indicate more sensory symptoms (poorer functioning). Similarly, higher scores on the autism severity measure indicate more symptoms (poorer functioning), whereas higher scores on the HCAS dimensions indicate more frequent participation (better functioning).

Solution for Fixed Effects

Tests of model effects are shown in Table 3 and reflect the final model with the removal of non-significant two and three way interactions. The reference category for the test of differences across subscales was the Parent–Child Household Activities score (unless otherwise specified below). Significant main effects were found for EP, autism severity, chronological age, and developmental age. The effect of HYPO, HYPER, and SIRS varied by HCAS factor. We then used follow up comparisons of each HCAS factor using the Benjamini-Hochberg procedure.

Table 3 Tests of model effects

Effect	DF	*F* value	Pr < *F*
Intercept	5,3350	836.34	<.0001
EP	1,666	9.14	0.0026
HYPO	1,666	1.08	0.3002
HYPER	1,666	5.48	0.0195
SIRS	1,666	0.45	0.5008
Autism severity	1,666	10.68	0.0011
Chronological age	1666	7.27	0.0072
Developmental age	1,666	31.63	<.0001
HYPO*HCAS	5,3350	2.48	0.0301
HYPER*HCAS	5,3350	4.89	0.0002
SIRS*HCAS	5,3350	1.02	0.403

Results of fixed effects and interaction terms of sensory response patterns and child characteristics on HCAS outcomes

Child Characteristics

Child characteristics that were found to impact activity participation included autism severity, chronological age, and developmental age. Autism severity had a significant, negative main effect on each of the six HCAS dimensions [$F(1666) = 10.98$, $p < .01$]. Chronological age demonstrated a positive main effect on activity participation, such that older children participate more frequently in activities [$F(1666) = 7.27$, $p < .01$]. Similarly, children with more advanced developmental ages participated more frequently in activities [$F(1666) = 31.63$, $p < .001$].

Enhanced Perception

EP positively impacted all dimensions of activity participation [$F(1666) = 9.14$, $p < .001$], regardless of child characteristics and other sensory response patterns. These findings suggest that EP supported participation across activity dimensions for children with ASD.

Hyperresponsiveness by HCAS Dimension

HYPER demonstrated a significant interaction with HCAS dimensions (see Table 3), controlling for child characteristics and other sensory response patterns, such that the effect of HYPER was dependent on the activity dimension. As compared to Parent–Child Activities, HYPER had a negative effect on Neighborhood-Social Activities [$t(1,3350) = -2.80$, $p < .01$). In additional follow-up comparisons, children with increased HYPER scores participated less frequently in Community Activities [$t(1,3350) = -3.06$, $p < .01$], Routine Errands [$t(1,3350) = -3.27$, $p < .01$], and

Neighborhood-Social Activities [$t(1,3350) = -4.27, p < .001$) as compared to Outdoor Activities.

Hyporesponsiveness by HCAS Dimension

Findings showed a significant interaction between HYPO and HCAS Dimension (see Table 3), such that the effect of HYPO was contingent on the activity dimension. As compared to Parent–Child Activities, children with increased HYPO participated more frequently in Community Activities [$t(13,350) = 3.07$, $p < .01$] and Neighborhood-Social Activities [$t(13,350) = 2.26$, $p < .05$].

Sensory Interests, Repetitions, and Seeking by HCAS Dimension

Follow-up comparison tests of the interaction between SIRS and HCAS dimensions demonstrated one significant difference. Children with increased SIRS scores engaged in more frequent Parent–Child Activities than Outdoor Activities ($t[53,350] = -2.08$, $p < .05$).

Discussion

This study investigated the impact of sensory response patterns on six dimensions of activity participation among a large sample of school-aged children with ASD. Novel findings suggest that child characteristics and sensory response patterns differentially impacted the frequency of child participation in different types of activities. Aligned with our hypotheses, autism severity was negatively related to activity participation whereas chronological age and developmental age were positively related to activity participation. Higher functioning and older, developmentally more mature children participated more frequently in activities. Older and higher functioning children may have increased opportunities to engage in activities that occur outside of the home and in the community, such as school or social functions. Moreover, children with increased autism severity likely experience fewer opportunities for participation, as their symptoms may be perceived to interfere with activities. This aligns with previous research that showed caregivers structure child's activity participation around their symptoms of autism (DeGrace 2004), which persists into adolescence (Orsmond and Kuo 2011). A further explanation may be that older, higher functioning children with ASD may have more opportunities to participate in activities, which allow them chances to practice skills. This is likely a transactional effect; children that are afforded opportunities to engage in activities build on skills that promote their participation.

Enhanced perception was found to *support* children's participation in activities across contexts; that is, children with higher scores in enhanced perception participated more frequently in all activities. Emerging evidence from research with adults with ASD suggests that enhanced perception occurs across modalities, including auditory (Bonnnel et al. 2003; Mottron et al. 2000), visual (Mottron et al. 2009), and tactile (Cascio et al. 2008; Tommerdahl et al. 2007) stimuli. Theorists have suggested that enhanced perception is associated with a cognitive style of processing (Baron-Cohen et al. 2009). Strengths in local processing may contribute to the ability (or super-ability) among individuals to recognize patterns and details (Mottron et al. 2006), which perhaps has some advantages in certain activities. Moreover, enhanced perception may be associated with hyper-attention to details (Baron-Cohen et al. 2009) or difficulty with disengagement of attention (e.g., Landry and Bryson 2004), which may contribute to successful completion of some cognitive tasks. It may be, then, that enhanced perception is somewhat protective or facilitatory of children's participation in some home and community activities. The ability to over-focus on the elements of activities, and the accompanying style of over-systemizing, may allow the child to have systematic ways of engagement in or completion of tasks. For example, certain activities may be reinforced by children's over focus on particular elements of the tasks, such as completing puzzles or art activities/drawing.

These findings align with one previous study on the hyper-attention to detail among children with ASD. Liss and colleagues (2006) found that individuals that demonstrated over-focused attention were reported to have higher adaptive skills as compared to other children with ASD, which may be related to the ability of children with enhanced perception to increasingly participate in home and community activities. Thus, our results are congruent with other literature suggesting that enhanced perception may reflect a unique processing style or an overfocus on detail that has advantages for perceiving and interpreting environmental stimuli in ways that contribute to increased frequency of participation in some activities; however, we acknowledge that the HCAS does not assess the quality of this activity participation.

As predicted, hyperresponsiveness demonstrated a significant, negative effect on activity participation. However, this effect varied based on activity dimensions. Increased hyperresponsiveness was inversely related to activity participation outside the home, specifically Neighborhood-Social Activities, Community Activities, and Routine Errands, as compared to Parent–Child Activities. It may be that the sensory stimuli in these settings are unpredictable and not easily controlled by caregivers, such as the sensory stimuli (e.g., noise) within the home, whereas Parent–Child Activities may be more routinized and controlled, mitigating the aversive effects of stimuli.

These results align with and extend findings from previous phenomenological accounts and small sample correlational research on ways in which hyperresponsiveness limits children's activity participation (Ashburner et al. 2008; Bagby et al. 2012; Brown and Dunn 2010; Dickie et al. 2009). For example, previous studies in ASD and other DD suggest that caregivers of children with more hyperresponsiveness experience difficulty in orchestrating activities for their child (Baranek et al. 2002; Larson 2010; Schaaf et al. 2011). Such studies, however, have not discriminated the types of activities that are difficult for families to pursue given their children's hyperresponsiveness. The stress experienced by families is perceived to outweigh the benefits of participation (DeGrace 2004), and necessitates caregiver 'back-up plans' to prevent meltdowns during community activities (Bagby et al. 2012). Therefore, it is likely that children's aversive responses to sensory elements of specific activities negatively reinforce caregivers' efforts to pursue those activities in the future. Moreover, children with limited chances to participate in activities may not develop the learning and coping strategies to counteract their aversions further perpetuating the cycle of limited participation (Baranek et al. 2002). Future research using longitudinal methods could further explore the likely transactions among child, parent and contextual variables over time.

We found that children with increased hyporesponsiveness participated more frequently in activities outside of the home (Community Activities, Neighborhood-Social Activities) versus those in the home. Although this finding was contrary to our hypotheses, it may be that children demonstrating significant hyporesponsiveness appear passive, not initiating activities independently (Baranek et al. 2006; Dunn 2007), and thus, may not resist accompanying the caregiver on community outings such as hiking, going to the zoo, or swimming. This finding extends our understanding of how hyporesponsiveness impacts children's participation across different activities; however, further investigation is needed.

Although we predicted that sensory interests, repetitions, and seeking behaviors would be negatively related to activity participation, findings showed that children with high levels of these behaviors participated more frequently in activities in the home versus those outdoors. Some research suggests that children may demonstrate sensory interests, repetitions, and seeking behavior in order to modulate anxiety associated with unpredictable sensory stimuli (Boyd et al. 2010; Wood and Gadow 2010), which could limit participation in activities outside the home. Others suggest that some children seek intensive stimuli to increase the salience of those stimuli (Dunn 2007), and have trouble disengaging from particularly stimulating activities (e.g., Landry and Bryson 2004), which perhaps limits their participation to more activities in the home environment. A further alternative explanation is that children with increased sensory interests, repetitions, and seeking behaviors participate less frequently in outdoor activities due to caregivers' safety concerns outside of the home. High levels of movement seeking among children with ASD are frequently reported (e.g., Ashburner et al. 2013; Tomchek and Dunn 2007), which may pose safety issues outside of the home.

Limitations and Future Directions

This analysis was cross sectional; therefore, the impact of sensory features on activity participation over time requires further study. Ideally, future studies could include observational measures to corroborate the caregiver report data analyzed in this study. The current study did not address the extent to which family and environmental influences on activity participation such as family socioeconomic status and location (i.e., urban, suburban, rural), which is clear need for future investigations. The interpretation that enhanced perception serves an adaptive function, unlike the largely negative impacts of the other sensory response patterns, requires further investigation especially given that research has shown links between enhanced perception and hyperresponsive sensory response patterns (Ausderau et al. 2014b; Baron-Cohen et al. 2009; Liss et al. 2006). Emerging research has identified sensory subtypes in ASD that may better address overlapping sensory response patterns within children (Ausderau et al. 2014a; Lane et al. 2014); thus, future studies are needed to illuminate the extent to which activity participation differs by subtype. Lastly, activity participation, as measured by the HCAS, addresses the frequency of participation across six dimensions, but does not measure the quality of participation, enjoyment of activities, nor level of engagement in solitary activities, which are potentially important variables for future study.

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