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Sensory and Repetitive Behaviors among Children with Autism Spectrum Disorder at Home

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Abstract

Atypical sensory and repetitive behaviors are defining features of autism spectrum disorder (ASD) and are thought to be influenced by environmental factors; however, there is a lack of naturalistic research exploring contexts surrounding these behaviors. The current study involved video recording observations of 32 children with ASD (2 – 12 years of age) engaging in sensory and repetitive behaviors during home activities. Behavioral coding was used to determine what activity contexts, sensory modalities, and stimulus characteristics were associated with specific behavior types: hyperresponsive, hyporesponsive, sensory seeking, and repetitive/stereotypic. Results indicated that hyperresponsive behaviors were most associated with activities of daily living and family-initiated stimuli, whereas sensory seeking behaviors were associated with free play activities and child-initiated stimuli. Behaviors associated with multiple sensory modalities simultaneously were common, emphasizing the multi-sensory nature of children's behaviors in natural contexts. Implications for future research more explicitly considering context are discussed.

Keywords

autism spectrum disorders; sensory impairments; repetitive behaviors and interests; environmental factors

Introduction

Previous research suggests that children with autism spectrum disorder (ASD) engage in various sensory and repetitive behaviors in their everyday activities (Baranek et al., 2006; Dunn, 2007; Gabriels et al., 2005; Leekam et al., 2011). Despite a growing understanding that these behaviors are embedded in—and contribute to—the daily experiences of children with ASD and their families (Dickie et al., 2009; Dunn, 2007; Kirby et al., 2015c; Schaaf et al., 2011), there has been minimal systematic exploration of the contexts surrounding sensory and repetitive behaviors. Child development theories (e.g., Ecological Systems Theory; Brofenbrenner, 1979) expound the importance of context in understanding child

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behavior. However, the majority of the literature on sensory and repetitive behaviors has primarily focused on characterizing the type and frequency of these behaviors with minimal exploration of contextual factors that contribute to these behaviors in naturalistic contexts. In the current study, we aimed to address this gap in the literature through collection and subsequent behavioral coding of naturalistic video recordings of children with ASD in their home environments.

Sensory and repetitive behaviors

Although both sensory and repetitive behaviors are considered common among children with ASD (Ben-Sasson et al., 2009; Boyd et al., 2010), there is a lack of consensus in the literature about whether the two categories of behavior are conceptually distinct (Leekam et al., 2011; Rogers and Ozonoff, 2005). Perhaps because of this, each behavior type is often studied in isolation from the other. Some empirical work suggests the existence of separate, but related, patterns of sensory and repetitive behaviors (Boyd et al., 2010; Boyd et al., 2009; Gabriels et al., 2008), whereas other literature stresses their overlap (e.g., Ausderau et al., 2014). In the current version of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM5; APA, 2013), unusual sensory responses and repetitive/stereotypic behaviors are considered distinct, yet both subsumed under the restricted and repetitive symptom grouping for the diagnostic classification of ASD. As described in the DSM5, repetitive/stereotypic behaviors can include unusual and/or repetitious vocalizations or actions with one's own body or with objects (APA, 2013). Additionally, three variations of sensory behaviors are suggested in the DSM5 and are empirically supported, namely: (1) hyperresponsive (i.e., negative reactions to or avoidance of sensory input), (2) hyporesponsive (i.e., diminished or delayed reactions to sensory input), and (3) sensory seeking (i.e., unusual interest in or excessive interaction with sensory aspects of the environment) behaviors (Ben-Sasson et al., 2009; Boyd et al., 2010; Liss et al., 2006). Despite conceptual overlap, in the current study we maintain distinction in accordance with DSM5 classification. In addition to the diagnostic relevance of sensory and repetitive behaviors for children with ASD, such behaviors also are clinically important because of their negative associations with adaptive behavior (Gabriels et al., 2005; Baker et al., 2008; Lane et al., 2010) as well as frequency and quality of activity participation (Dickie et al., 2009; Hochhauser and Engel-Yeger, 2010).

Parent-report measures have been the primary mode of assessment for both sensory and repetitive behaviors in research and clinical work (e.g., Baranek et al., 2006; Boyd et al., 2009, 2010; Gabriels et al., 2005, 2008; Kern et al., 2006; Lane et al., 2010; Tomchek and Dunn, 2007). For example, measures such as the Sensory Profile (SP; Dunn, 1999), Short Sensory Profile (SSP; McIntosh et al., 1999), and Sensory Experiences Questionnaire (SEQ; Baranek, 2009) are commonly used to collect data about the frequency of sensory behaviors among children with ASD from parents' perspectives. These measures use items which provide specific examples of sensory-related behaviors and responses, and ask how frequently the child acts each way on 5-point scales (e.g., almost never to almost always). Similarly, a common measure of repetitive behaviors is the Repetitive Behavior Scale-Revised (RBS-R; Bodfish et al., 1999), which asks informants to rate items on a 4-point scale (i.e., does not occur to severe). Standardized questionnaire measures continue to be a

useful source of data about sensory and repetitive behaviors particularly for frequency and severity of behavior patterns, as well as the affected sensory modalities (e.g., tactile, auditory, proprioceptive). However, there is a need for observational research to address underexplored aspects of these behaviors, in particular, the role that context plays in their expression.

One potential benefit of observational research is to provide a more objective measure of sensory and repetitive behaviors that can corroborate or supplement parent-report measures. Observational studies have demonstrated success in measuring types and frequencies of sensory and repetitive behaviors in the laboratory (e.g., Kirby et al., 2015b; Militerni et al., 2002; Zwaigenbaum et al., 2005) as well as through retrospective home video analyses (e.g., Baranek, 1999a; Werner et al., 2000). Laboratory measures provide the benefit of a structured context to elicit and assess behavior, which is necessary if experimental control or standardization is important; whereas, home videos capture children in their natural environments and the behaviors that occur within them. Both of these methods can contribute to our conceptual and empirical understanding of children's behaviors. However, despite beliefs that contextual factors play a role in the manifestation of both sensory (Dunn, 2001) and repetitive (Leekam et al., 2011) behaviors, even studies conducted in natural contexts rarely incorporate aims specifically related to understanding the environmental features (e.g., social context, familiarity of the situation) that may contribute to the expression of these behaviors.

Contexts surrounding sensory and repetitive behaviors

Evidence from correlational and qualitative studies emphasizes a need to consider children's physical, social, and situational contexts in the expression of sensory and repetitive behaviors. For example, in a study of 49 children with ASD, Brown and Dunn (2010) found only moderate correlations on sensory avoiding and sensory seeking scores (r=.45 & .59 respectively) across home (on the Sensory Profile; Dunn, 1999) and school contexts (on the School Companion; Dunn, 2006). This result implies that either the child's behaviors, or the way they are interpreted by different caregivers, may change depending on the environment in which they occur. The importance of children's contexts and specific situations also emerged in two qualitative studies about sensory experiences involving interviews of children with ASD (Kirby et al., 2015a) and their parents (Dickie et al., 2009). Kirby and colleagues (2015a) noted that children with ASD interviewed in their study, "did not discuss their experiences as abstracted interactions with sensory stimuli but rather as situated experiences occurring within a particular time and place" (p. 324). Dickie and colleagues (2009) noted a similar phenomenon, in that, "parents [did] not typically deconstruct a child's experiences and reactions into components…sensory elements [were] embedded in the whole situation" (p. 178).

Additional aspects of a child's situation may contribute to their expression of sensory and repetitive behaviors. For example, the expressed behavior may be related to children's familiarity with their surroundings, the activities they are engaged in, or characteristics of the environment. Based on interviews with parents of children with ASD, Schaaf and colleagues (2011) suggested that unfamiliar spaces made sensory behaviors more

pronounced and problematic, and alternately, familiar contexts made performing everyday activities easier for the child and the family. Similarly, three adolescents with ASD interviewed by Ashburner and colleagues (2013) reported a preference for expected stimuli and an aversion to sensations that were unpredictable. The interviewees also expressed utilizing familiar and predictable stimuli as a coping strategy to avoid sensory discomfort (Ashburner et al. 2013). This idea of having control over sensory stimuli also emerged in Dickie and colleagues' (2009) study; the authors suggested that being able to decide when and how to interact with sensory stimuli often determined whether or not experiences were positive for children.

Finally, existing literature suggests the social nature of a child's situation may contribute to the expression of sensory and repetitive behaviors. Turner (1999) in fact summarized the literature related to the social contexts surrounding repetitive behaviors of children with ASD, noting that some studies have suggested social reinforcement may drive repetitive behaviors while others suggest that lack of social interaction may contribute to the expression of these behaviors. Regarding the social nature of sensory behaviors, Baranek and colleagues (2006, 2013) noted that hyporesponsive behaviors were more prevalent in response to social stimuli for children with ASD as compared to those with other developmental disabilities or typical development.

Study purpose

There is substantial evidence supporting the diagnostic and clinical importance of sensory and repetitive behaviors as they affect the everyday lives of children with ASD. Even though retrospective home videos have contributed to our understanding of behaviors in natural contexts, there remains a need to specifically examine the contexts themselves which surround sensory and repetitive behaviors as they naturally occur during home activities. Using in-home naturalistic video recordings and manualized behavioral coding procedures, we addressed two research aims: (1) Describe the home activity contexts within which children with ASD engage in four patterns of sensory and repetitive behaviors (i.e., hyperresponsive, hyporesponsive, sensory seeking, repetitive/stereotypic); (2) Describe the sensory modalities and stimulus characteristics associated with each pattern of sensory and repetitive behaviors. Based on existing literature, the following were our *a priori* hypotheses related to the first and second aims: (1a) hyperresponsive behaviors would occur most in the context of activities of daily living; (1b) hyporesponsive behaviors would occur most in the context of social activities; (1c) sensory seeking and repetitive/stereotypic behaviors would occur most in the context of free play activities; (2a) hyperresponsive behaviors would be most associated with novel and family-initiated stimuli; (2b) hyporesponsive behaviors would be most associated with family-initiated and social stimuli; (2c) sensory seeking and repetitive/stereotypic behaviors would be most associated with child-initiated stimuli.

Methods

This home video study was part of a larger, federally-funded longitudinal research project involving children with ASD, other developmental disabilities, and typical development recruited from developmental clinics, parent groups, schools, and university-based autism

participant registry. The main project protocol included, but was not limited to, standardized diagnostic assessments, developmental assessments and measures of sensory features and repetitive behaviors. Participants eligible for the home video study had confirmed ASD diagnoses and elevated scores (i.e., 2 SD above the mean on ≥1 sensory domain or 1 SD above the mean on ≥2 sensory domains) on one of two parent-report measures of sensory features: Sensory Experiences Questionnaire (SEQ; Baranek, 2009) or Sensory Profile (SP; Dunn, 1999). Families received monetary incentives for participation in the project, including $50 for completion of three home video visits. The university's review board approved this research which adhered to all recommended data security and informed consent/assent procedures.

Participants

The current study included 28 boys and 4 girls with ASD (2.4 – 12.7 years of age); see Table 1 for descriptions of the included participants. Each enrolled participant had a diagnosis of ASD from an independent licensed psychologist or physician (e.g., psychiatrist, developmental pediatrician), which was confirmed using standardized cutoffs on both the Autism Diagnostic Interview-Revised (Le Couteur et al., 2003) and Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999). Participants were excluded if they had a diagnosis of Fragile-X syndrome, tuberous sclerosis, seizure disorder, or cerebral palsy; mental age <6 months; or uncorrected visual or hearing impairment.

Video data collection

Video data were collected either as children entered or were followed-up with in the larger longitudinal study. Graduate student research assistants (videographers) visited the homes of participating families three times each to collect a series of naturalistic video recordings of each child in their home environment during everyday activities. Prior to the home observation, a brief phone interview was conducted with the child's parent to further explain the study, discuss current sensory and/or repetitive behaviors salient in the home environment, identify situations in which sensory and/or repetitive behaviors would be likely captured on video (e.g., right after school, dinner time), and schedule the first visit. During each of three visits per child (collected within a two-week timeframe), the videographer typically remained in a participant's home for 45–60 minutes and collected video recordings using a hand-held digital recorder in three segments lasting approximately 15 minutes each. The video segment from the middle third of each visit was used for behavioral coding to address the present research questions.

Behavioral coding

The research team developed a coding manual (Home Observational Coding System [HOCS]: Coding Sensory Features in Children with Autism) with detailed procedures, instructions, and operational definitions for behavioral coding, and completed coding using Observer XT 10.5 (Noldus Information Technology, 2011) software. The coding system included both point (frequency) and state (duration) codes in order to capture data on the activity contexts, sensory modalities (e.g., tactile, visual, auditory), and stimulus characteristics (i.e., novel/familiar, child-/family-initiated, social/nonsocial) surrounding children's engagement in sensory and repetitive behaviors at home. Coding descriptions of

sensory and repetitive behaviors were based on existing literature and measures of sensory (i.e., hyperresponsiveness, hyporesponsiveness, and sensory seeking; SP [Dunn, 1999]; SEQ [Baranek, 2009]; Sensory Processing Assessment [Baranek, 1999b]) and repetitive/ stereotypic (Direct Observation of Repetitive Behaviors Assessment [Boyd et al., 2011]; RBS-R [Bodfish et al., 1999]) behaviors. Table 2 includes descriptions of the codes of interest in the current study within behavior, activity, modality, and stimulus characteristic categories. The Appendix provides further details on the coding rules used in the study.

Interobserver agreement—Two graduate students (coders) independently scored videos with 23% randomly-selected overlap for reliability purposes. To determine the degree to which the coders achieved matching conclusions, both percentage agreement and Cohen's *kappa* were used (Kottner et al., 2011; McHugh, 2012). Percent agreement (number of agreements divided by total number of codes) was calculated by the Observer software; an *a priori* lower limit of agreement acceptability for our study was set at 80%. The coders achieved 82.1% (range: 52 – 100% across participants) total agreement across children's videos. Disagreements were often related to the timing or presence of a codable behavior. Together the coders re-watched any individual case with <80% agreement (n=2) to reach consensus about disagreements and one additional video was consensus coded by coder request due to its complexity. A *kappa* coefficient of 0.89 was calculated for the non-consensus videos, demonstrating strong interrater reliability (McHugh, 2012) for the HOCS.

Data analysis

Behavioral coding data were exported from Observer to Microsoft Excel and analyzed using SAS Software, Version 9.4 TS1M1 for Windows. In accordance with our research questions, the analyses involved generating descriptive statistics and cross-tabulations across coding categories for each sensory or repetitive behavior type. To test our hypotheses, we used weighted categorical analyses with each child's coded behavior weighted inversely to the number of behaviors he or she generated. The weighting approach was used to account for the fact that 32 participants were coded engaging in varying numbers of behaviors; using total counts of behaviors would have increased risk for Type 1 error. The weighted analysis resulted in each child only being counted once, regardless of how many behaviors he or she generated for each type (e.g., four hyperresponsive behaviors by one child were counted as . 25 of a behavior each in the analysis). Fisher's Exact Test (FET), which is equivalent to an exact test of the weighted Pearson chi-squared for 2×2 tables (Agresti, 1992, 2012; Lydersen, et.al. 2007; Mehta & Patel, 1983; SAS Institute, 2013), was used to compare the results in 2×2 tables (target behavior vs. other behaviors by target descriptor vs. others) for the hypothesized relationships (10 total analyses). When testing for a relationship between hyperresponsiveness and activities of daily living, for example, what was considered in the FET table was the proportion of instances children engaged in: (1) hyperresponsive behaviors during activities of daily living, (2) hyperresponsive behaviors in other contexts (combined), (3) other behaviors (combined) during activities of daily living, and (4) other behaviors (combined) during other contexts (combined). Finally, we generated a list of examples of each type of coded behavior from free-text comment boxes in which coders described the observed behaviors.

Results

Descriptive results are displayed in Table 3 including frequencies and percentages of activities, modalities, and stimulus characteristics associated with each behavior pattern (i.e., hyperresponsive, hyporesponsive, sensory seeking, repetitive/stereotypic). Of note, fourteen participants (44%) displayed multiple patterns of behavior either within a single visit or across their three visit videos. Specifically, one child was coded engaging in all four types of coded behavior, four children were coded engaging in three types of behaviors (i.e., hyperresponsive, sensory seeking, repetitive/stereotypic), and nine children were coded engaging in two types of behaviors (i.e., four hyperresponsive and sensory seeking; three hyperresponsive and repetitive/stereotypic; two repetitive/stereotypic and sensory seeking). Furthermore, many behaviors were coded as being associated with multiple sensory modalities; see Table 4 for tabulations of co-occurrences of modalities. Descriptive findings for all codes and Fisher's Exact Test results for each hypothesis are summarized in the following sections by behavior pattern with examples of coded behaviors provided for each.

Hyperresponsive behaviors

Eighteen participants were coded engaging in hyperresponsive behaviors a total of 110 times during video recordings. Observed behaviors included children covering their ears or negatively reacting in response to everyday sounds (e.g., television at moderate volume, sound of water running in the kitchen sink) and sights (e.g., sunlight through a window), as well as avoiding or expressing pain during everyday activities (e.g., hair brushing, teeth brushing, face washing, toenail clipping). These negative responses or avoidances of sensory input lasted less than a minute on average and occurred primarily within the context of activities of daily living, as hypothesized (Hypothesis 1a; FET, $p \leq 0.001$). The observed hyperresponsive behaviors often involved tactile, auditory, or gustatory stimuli, with overlapping auditory + visual stimuli associated with 5.5% of the coded behaviors. Furthermore, the stimuli associated with all of the observed hyperresponsive behaviors were nonsocial in nature. As hypothesized (Hypothesis 2a), hyperresponsive behaviors were most associated with family-initiated stimuli (FET, $p \leq 0.001$). However, contrary to Hypothesis 2a, we did not find a significant association with novel stimuli (FET, $p \leq 0.39$). In general, the majority of the videorecorded situations were familiar to the child, thus, most hyperresponsive behaviors were associated with familiar stimuli (versus novel).

Hyporesponsive behaviors

Despite inclusion of children with parent-reported hyporesponsive behaviors on the SEQ and SP measures, hyporesponsive behavior was only coded for one child (3 instances). Thus, there is not enough data to draw conclusions about this sensory pattern and our *a priori* hypotheses could not be tested. The child with recorded hyporesponsive behaviors was observed during free play; the child had no response or apparent awareness of parents and sibling calling her name and verbally trying to get her attention at clearly audible levels within close proximity.

Sensory seeking and repetitive/stereotypic behaviors

Sensory seeking and repetitive/stereotypic behaviors—coded in the videos of 21 (145 instances) and 12 (80 instances) participants, respectively—had similar results in terms of associated activities and stimulus characteristics. Aligning with our hypotheses (Hypotheses 1c & 2c), both behavior patterns most commonly occurred in the context of free play activities and involved child-initiated stimuli; however, these associations were significant for the sensory seeking pattern (free play: $p \leq 0.025$; child-initiated: $p \leq 0.001$) but not repetitive/stereotypic behaviors (free play: $p \leq 0.37$; child-initiated: $p \leq 1.0$). Both behaviors also most commonly involved familiar and nonsocial stimuli.

Regarding their differences, sensory seeking behaviors most commonly involved vestibular/proprioceptive stimuli (57%), followed by visual and tactile (33% each), and then auditory (21%), whereas repetitive/stereotypic behaviors most commonly involved visual stimuli (79%), followed by auditory (39%), and then vestibular/proprioceptive (11%). Both were commonly associated with multiple stimuli in different combinations: common sensory seeking overlapping modalities were vestibular/proprioceptive + auditory + visual (16.6%) and vestibular/proprioceptive + tactile (6%); common repetitive/stereotypic overlapping modalities were visual + auditory (32.5%) and visual + vestibular/proprioceptive (11.3%). Furthermore, repetitive/stereotypic behaviors were the only pattern with behaviors coded without identifiable associated stimuli or triggers (15%).

Observed sensory seeking behaviors—The behaviors coded as sensory seeking involved a wide array of gross motor movements (e.g., jumping on stairs, bouncing on large ball, trampoline jumping, headstands, throwing body into furniture or onto floor, rough-housing with family members) and unusual interests in the sensory aspects of their environments (e.g., intense or prolonged visual or tactile inspection of objects, rubbing objects on face and body, rolling around on carpeted floors, placing objects in mouth, pressing objects firmly into body). Furthermore, observed sensory seeking behaviors were often multi-sensory and complex in nature (e.g., trampoline jumping while listening to music on headphones and watching television, bringing face close to video screen and tensing whole body, swinging on swing with head tilted backwards to look at surroundings upside-down).

Observed repetitive/stereotypic behaviors—In accordance with the definitions specified in the HOCS (see Table 1), behaviors coded as repetitive/stereotypic similarly involved some actions with objects (e.g., lining up toys, repeatedly watching segments of video), some with children's own bodies (e.g., rocking back and forth, flapping hands, repeating phrases), and others with a combination of actions (e.g., bouncing a plastic hanger on the floor while rocking back and forth and vocalizing, twirling an object in front of face while watching same segments of video repeatedly and flapping hands).

Discussion

This study utilized naturalistic video observations and behavioral coding to explore the contexts surrounding the sensory and repetitive behaviors of 32 children with ASD. In particular, we coded the activity contexts, sensory modalities, and stimulus characteristics

associated with hyperresponsive, hyporesponsive, sensory seeking, and repetitive/stereotypic behaviors engaged in during everyday home activities.

However, despite our attempts to capture video recordings of all four behavior patterns, only one child in the study was ultimately coded for hyporesponsive behaviors. Although children with elevated hyporesponsiveness on parent-report measures were purposefully included, we found this to be a difficult behavior to code using the described methods. It is perhaps the nature of the behavior that was problematic, such that attempting to code the *absence* of something was more elusive with our study design than coding more active behaviors such as hyperresponsive, sensory seeking, or repetitive/stereotypic behaviors. Laboratory-based measurements have demonstrated success in capturing hyporesponsive behaviors in a structured situation using a series of presses to test children's responsiveness (Baranek et al., 2013) and retrospective infant video studies have reported success coding orienting and responsiveness (e.g., Baranek, 1999a). However, because of the limited observations of hyporesponsive behaviors in our study, we were unable to test our hypotheses that they would be most associated with social activities and with family-initiated and social stimuli. Future research should explore alternate methods to collect naturalistic observational data to better capture the contextual details surrounding this behavior.

Our first research aim endeavored to understand the activity contexts during which sensory and repetitive behaviors occurred. As hypothesized, hyperresponsive behaviors were most common during activities of daily living and sensory seeking was most common during free play. Our second aim was to describe the sensory modalities and characteristics associated with each behavior pattern. Also as hypothesized, hyperresponsive behaviors were most associated with family-initiated stimuli and sensory seeking most associated with child-initiated stimuli. The descriptive findings (unweighted) suggest repetitive/stereotypic behaviors most commonly occurred during free play and were associated with child-initiated stimuli, but these findings were not significant using Fisher's Exact Test on the weighted 2×2 tables.

Contrary to our hypothesis, hyperresponsive behaviors were not commonly observed in association with novel stimuli. This is likely due to the nature of our data collection methods and the fact that we did not observe many novel stimuli in general. Our use of parent report to guide the scheduled video sessions as well as restricting data collection within the home environment seemed to support observation of familiar stimuli, thus limiting opportunities to observe novel stimuli. Previous work suggests that unfamiliar environments may exacerbate the intensity or degree of interference sensory behaviors play in daily life, whereas familiar environments were suggested to facilitate successful activities for children with ASD and their families (Schaaf et al. 2011). However, the current study suggests that although novel stimuli may be most salient to parents, hyperresponsive behaviors persist in the context of familiar stimuli in familiar surroundings (i.e. child's home).

Another finding of interest, though not significant, was that 13% of sensory seeking behaviors occurred in the context of social activities and that 10% of the behaviors were associated with social stimuli. Thus, this study adds to a growing body of literature suggesting some social components to these behaviors. Dickie et al. (2009) noted how,

during interviews, parents of children with ASD often described a child's sensory seeking behaviors as opportunities for and experiences of positive interpersonal touch between parent and child. Future consideration should be given to understanding the role of sensory seeking behaviors on social relationships within the family.

The current study also explored sensory modalities associated with sensory and repetitive behaviors and allowed for measurement of multiple modalities at once. However, the gustatory stimulus code was used as a broad code for food-related behaviors due to the difficulty in determining what aspects of the food a child was responding to. It is likely that the simultaneous visual, olfactory, tactile, and gustatory properties of food contributed to the observed behaviors. Thus, considering the gustatory modality as a multi-sensory experience, the rates for multiple stimuli were quite high across behaviors (40% hyperresponsive; 30% sensory seeking; 45% repetitive/stereotypic). This makes sense because the majority of stimuli encountered in the natural world are multisensory (Iarocci & McDonald, 2006). However, the literature is just beginning to understand how behaviors associated with multiple modalities may be distinct; Iarocci and MacDonald (2006) suggested that there may be additive or synergistic effects when processed neurologically. The current common methods for collecting data on sensory features using parent-report may be insufficient for understanding the multi-modality nature of stimuli associated with children's behaviors; however, a recent laboratory-based observational study demonstrated success measuring multiple overlapping modalities (Kirby et al., 2015b). Further work is needed to expound upon these complex properties and their effects on sensory and repetitive behaviors in real-world environments.

There are a few notable limitations to this study. First, although the individualized and naturalistic methods used have numerous strengths (e.g., understanding aspects of children's real-life contexts associated with their parent-reported behaviors), the generalizability of the findings may be limited to the situations specified and experiences captured during our scheduled recording sessions. Furthermore, although we attempted to capture truly naturalistic contexts, the presence of a videographer and camera may have had unintentional effects on child and family behavior during visits. Finally, we were limited by the sample size and lower frequency of particular behaviors (i.e., hyporesponsive and repetitive/stereotypic behaviors).

As previously stated, in this study we aimed to explore sensory seeking and repetitive/stereotypic behaviors as separate constructs in alignment with the DSM5 and previous literature suggesting they are related but distinct. In order to code these behaviors reliably, we set clear guidelines for the current study. However, there remains a need to understand the relationship between these behaviors in order to help children effectively manage behaviors that may negatively impacting learning, socialization, or quality of life. In the current study, we identified similarities across sensory seeking and repetitive/stereotypic behaviors (as defined in the HOCS) in associated activities and stimulus characteristics, but differences in associated modalities. These identified similarities and differences may further inform work to understand the relationship between these constructs.

Conclusion

In the current study, we utilized naturalistic video recordings to study sensory and repetitive behaviors with a focus on context. Overall, this study adds new knowledge about contextual factors surrounding hyperresponsive, sensory seeking, and repetitive/stereotypic behaviors engaged in by children with ASD in their homes. Contexts were found to be highly related to the expression of the studied behaviors, in particular the activities they occurred during as well as the characteristics of associated stimuli such as modality, control, and the social nature. Future research should consider interventions that examine appropriate environmental modifications or adaptations in order to support children with ASD in their everyday functioning.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Child and Family Characteristics

	Sample Description *N*=32
Chronological age in years *M (SD)*	6.4 (2.8)
Mental age† in years *M (SD)*	4.7 (3.7)
SRS t-score: Autism Severity *M (SD)*	80.3 (8.4)
SEQ Domain Mean Scores *M (SD)*	
Hyperresponsiveness	2.32 (0.8)
Hyporesponsiveness	2.52 (0.5)
Sensory Seeking	2.57 (0.6)
Male gender	28 (87.5%)
Race & Ethnicity	
White	27 (84.4%)
Black	3 (9.4%)
Asian	1 (3.1%)
Multiple races	1 (3.1%)
Hispanic ethnicity	4 (12.5%)
Mother's Education	
High school graduate/GED	5 (15.6%)
Associate's degree or partial college	5 (15.6%)
Bachelor's degree	15 (46.9%)
Master's, doctorate, or other professional degree	4 (12.5%)

Note.

†, Mental age calculated from the Mullen Scales of Early Learning (Mullen, 1995) or the Stanford-Binet (Roid, 2003). SRS, Social Responsiveness Scale (Constantino & Gruber, 2005); t-score interpretation: <60=normal, 60–75=mild-moderate, >75=severe. SEQ, Sensory Experiences Questionnaire (Baranek, 2009); items rated on a 5-point scale (0=almost never, 4=almost always).

Table 2

Relevant Codes and Descriptions from the Home Observation Coding System

Code	Description
Activities (State)	*Coded throughout videos*
Activities of Daily Living	eating, bathing, dressing, grooming, food preparation, household chores (e.g., included activities such as a parent vacuuming near child)
Social Activities	social activities with another person; other person must be actively engaged for social purposes (i.e., not merely helping child engage in an otherwise solitary activity)
Free Play	any play or leisure activities not otherwise described, including play with equipment (e.g., trampoline, swings)
Behaviors (State/Point)	*Coded when behaviors occurred, lasting at least 5 seconds*
Hyperresponsive	child demonstrates negative or exaggerated response to stimulus or actively avoids stimulus
Hyporesponsive	child does not react/respond to stimulus in their environment within 5 seconds
Sensory Seeking	child engages and seems particularly interested in activities that provide intense, unusual, or prolonged sensory input (other than those listed under repetitive/stereotypic below)
Repetitive/Stereotypic	child engages in 5 seconds or 3 repetitions of specific unusual behaviors (i.e., rocking, flapping, lining up toys, object flicking, and repeating phrases or video segments)
Sensory Modality† (Point)	*Used as descriptors of coded sensory & repetitive behaviors*
Tactile	behavior clearly related to sensation of touch/texture on skin
Auditory	behavior clearly related to sounds perceived by ears
Gustatory	behavior clearly related to food/oral stimuli
Olfactory	behavior clearly related to scents perceived by nose
Visual	behavior clearly related to perception through the eyes
Vestibular/Proprioceptive	behavior clearly related to sensation of body movement
Stimulus Characteristic (Point)	*Used as descriptors of coded sensory & repetitive behaviors*
Novel or Familiar	whether stimulus was new or previously-known to child
Child- or Family-Initiated	whether child chose to engage or was directed/introduced to stimulus by family/other person
Social or Nonsocial	whether stimulus itself was social in nature (distinct from social activity)

Notes. State codes measure duration; Point codes identify events as they occur.

†, Multiple modalities could be coded for a single behavior; however, gustatory code was used solely to capture all food/oral stimuli and other related modalities (e.g., tactile, olfactory) were not coded concurrently in these instances.

Autism. Author manuscript; available in PMC 2017 March 07.

Table 3

Descriptive Statistics by Behavior

	Hyperreponsive	Hyporesponsive	Sensory Seeking	Repetitive/Stereotypic
Total Instances (total children)	*n*=110 (18)	*n*=3 (1)	*n*=145 (21)	*n*=80 (12)
Average Duration (range)	50 seconds (6 – 399)	9.5 seconds (6 – 11)	46 seconds (5 – 512)	89 seconds (1 – 1183)
Activities				
Activities of Daily Living	86 (78.2%)	0	1 (0.69%)	6 (7.5%)
Social Activities	0	0	19 (13.1%)	1 (1.2%)
Free Play Activities	24 (21.8%)	3 (100%)	125 (86.2%)	73 (91.3%)
Sensory Modalities[†]				
Tactile	44 (40%)	0	48 (33.1%)	1 (1.3%)
Auditory	25 (22.7%)	3 (100%)	31 (21.4%)	31 (38.8%)
Gustatory	38 (34.5%)	0	4 (2.8%)	0
Olfactory	0	0	0	0
Visual	9 (8.2%)	0	48 (33.1%)	63 (78.8%)
Vestibular/Proprioceptive	0	0	82 (56.6%)	9 (11.3%)
Multiple	6 (5.5%)	0	43 (29.7%)	36 (45%)
Stimulus Characteristics				
Novel	9 (8.2%)	0	2 (1.4%)	0
Familiar	101 (91.8%)	3 (100%)	143 (98.6%)	68 (85%)
Child-Initiated	3 (2.7%)	0	140 (96.6%)	65 (81.2%)
Family-Initiated	107 (97.3%)	3 (100%)	5 (3.4%)	3 (3.8%)
Social	0	3 (100%)	15 (10.3%)	2 (2.5%)
Nonsocial	110 (100%)	0	130 (89.7%)	66 (82.5%)
Unknown Stimulus	0	0	0	12 (15%)

Notes.

[†], Individual modality percentages total over 100 due to allowance for multiple modalities to be coded for a single behavior; ‘Multiple’ row lists number (and percentage) of behaviors associated with more than one modality (see Table 4).

Table 4

Total and Overlapping Coded Sensory Modalities for Hyperresponsive, Sensory Seeking, and Repetitive/Stereotypic Behaviors

	Tactile H/S/R	Auditory H/S/R	Gustatory H/S/R	Olfactory H/S/R	Visual H/S/R	Vest./Prop. H/S/R
Tactile	44/48/1					
Auditory	0/2*/0	25/31/31				
Gustatory	0/3*/0	0/1*/0	38/4/0			
Olfactory	0/0/0	0/0/0	0/0/0	0/0/0		
Visual	0/2/1	6/27*/26	0/0/0	0/0/0	9/48/63	
Vest./Prop.	0/9/0	0/24*/0	0/0/0	0/0/0	0/25*/9	0/82/9

*Notes.*Vest./Prop.=Vestibular/Proprioceptive. Values listed in order: Hyperresponsive (H), Sensory Seeking (S), and Repetitive/Stereotypic (R). Total number of modality codes associated with each behavior are listed on the diagonal and rates of co-occurrence of modalities associated with each behavior are listed below the diagonal. Star (*) denotes some instances coded as part of a group of three modalities associated with a single behavior.