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Sensory Over-Responsivity in Elementary School: Prevalence and Social-Emotional Correlates

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Abstract

Sensory over-responsivity (SOR) towards tactile and auditory input can impact children's participation in academic and social activities; however the prevalence of SOR behaviors and their relation to social-emotional problems and competence has not been rigorously studied. This study investigated SOR in a representative sample of elementary school-aged children (n=925, 50% boys, ages 7–11 years) who were followed from infancy. Sixteen percent of parents reported that at least four tactile or auditory sensations bothered their children. Being bothered by certain sensations was common while others were relatively rare. Parents of children with versus without elevated SOR in school-age reported higher frequencies of early and co-occurring internalizing, externalizing, and dysregulation problems, and lower levels of concurrent adaptive social behaviors. Early identification of elevated SOR and assessment of concurrent social-emotional status are important to minimize their impact on social adaptive behaviors at school age.

Keywords

Sensory over-responsivity; Social; Emotional; Internalizing; Externalizing; Competence; Elementary school

Individuals differ in their response to sensation in aspects such as the type, intensity, affective tone of response, and the onset and offset of response. Further, some individuals evidence clinically significant difficulties regulating their response to sensation to a degree that sensory responses interfere with participation in daily activities. A pattern of extreme sensory over-responsivity (SOR) is defined as a type of sensory modulation disorder (SMD) manifested by behavioral responses to sensory input that are rapid in onset, prolonged, and

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greater in intensity compared to peers (Miller et al. 2007). People with clinically significant SOR experience otherwise non-noxious sensation as harmful, painful, or distracting, may not habituate to, and cannot function effectively in their presence. Children with SOR may show negative responses to specific sensations, in the form of fear, avoidance, distraction, over-vigilance, and/or aggression especially when the stimulus is not self-initiated (Ayres 1964; Dunn 1997; Miller et al. 2007). Further, elevated SOR behaviors can impede performance of daily activities, academic skills, and social participation (Stagnitti et al. 1999). Studying the prevalence of SOR behaviors in school-aged children is important for understanding these more extreme manifestations. SOR may become evident with school entry, as the social and physical environment in schools is often more stimulating than at home, children may have less control over their environments, and learning demands increase (Miller and Summers 2001). SOR has been linked to social-emotional problems, such as anxiety and depression (Kinnealey and Fuiek 1999). The functional and emotional consequences of SOR emphasize the need for empirical study of this phenomenon.

The goals of this investigation were to (1) examine the distribution and prevalence of tactile and auditory over-responsivity behaviors in a representative elementary school sample; (2) evaluate the association between tactile and auditory over-responsivity behaviors; and (3) investigate concurrent and early social-emotional problems and competence levels associated with over-responsivity.

SOR Symptoms, Mechanism, and Prevalence

Although SOR was already identified as a clinical phenomenon by occupational therapists in the 60's (Ayres 1964) there is an ongoing debate in disciplines such as psychiatry and psychology as to its justification as an independent diagnostic entity. The controversy surrounding the diagnosis of SOR is influenced by (1) an absence of formal diagnostic criteria, (2) high prevalence among children with developmental disorders such as autism spectrum disorders (e.g., Ben-Sasson et al. 2007), (3) unknown etiology, and (4) lack of epidemiological evidence related to this condition. SOR was included as a subtype of SMD under the umbrella of Sensory Processing Disorders (SPD) in the classification of the Interdisciplinary Council of Developmental and Learning disorders (ICDL 2005). This was the first step in the acknowledgment of SOR as a clinical disorder with developmental and health policy repercussions. SOR is not included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR: American Psychiatric Association 2000) or in the International and Statistical Classification of Diseases and Related Health Problems (ICD-10: World Health Organization 2006). In the personality and temperament literature, sensory sensitivity (which shares commonalities with SOR) is commonly referred to as either a temperamental trait or behavioral problem (Aron and Aron 1997; Carter et al. 2003; Fox and Polak 2004). Consistent with normative variation in temperamental dimensions such as activity level, negative emotionality or behavioral inhibition, there appears to be a continuum of SOR behaviors. Thus SOR behaviors may be viewed as a temperamental dimension that can place children at risk for psychopathology (e.g., Caspi et al. 1995; Frick and Morris 2004). In occupational therapy science and practice, SOR is considered 'impairing' once an individual shows high rates of SOR behaviors that differ from normative cutoffs coupled with their interference with daily living skills (Dunn 1997; Reynolds and

Lane 2008; Schoen et al. 2008). Understanding the distribution of SOR behaviors in the general population can inform the debate regarding the validity of SOR as a diagnostic entity, by indicating which behaviors are uncommon among typically developing children and documenting rates of co-occurring tactile and auditory SOR behaviors.

In support of SOR as an independent clinical condition there is an accumulating body of evidence indicating unique physiological characteristics of children with a sensory processing/modulation disorder. Children with a behaviorally diagnosed SPD have increased electrodermal responses and habituate slower on a series of sensory stimuli (McIntosh et al. 1999), show different Event Related Potential patterns (Davies and Gavin 2007), and differ in their parasympathetic responses (Schaaf et al. 2003) compared to children without a clinically identified SPD. There is also preliminary evidence in support of genetic susceptibility for SOR behaviors. In a recent study, monozygotic twins were more likely to show concordant sensory defensiveness as reported by parents than dizygotic twins (Goldsmith et al. 2006). Furthermore elevated SOR in rhesus monkeys, as measured by an observation of their degree of withdrawal from tactile stimuli, was associated with D2-type receptor binding (Schneider et al. 2007) supporting the notion that genetic factors contribute to the expression of SOR behaviors.

To date, there is one population-based study documenting the rates of SPD in a non-referred sample of preschool children (Ahn et al. 2004). Findings from this study suggest that the prevalence of SPD is 5% to 13% in children 4 to 6 years old (n=710), depending on whether non-responders are considered negative for SPD or not. It is unclear how many of these children specifically experienced SOR, a subset of SPD, although McIntosh et al. (1999), who applied the same Short Sensory Profile cutoff for defining SPD, note that most of their participants with SPD had SOR. In addition, Ahn and colleagues had a 39% return rate thus results may not be representative of the population of preschoolers. Furthermore, the prevalence rate of SOR in preschool-age does not necessarily apply to school-age as SOR may change in presentation across development as environmental opportunities and demands are modified.

When compared to normative data and samples, there is a much higher prevalence of SOR in clinical populations such as children with autism spectrum disorders (ASD) (e.g., 56% Ben-Sasson et al. 2007), Fragile X (e.g., ~40%; Baranek et al. 2008) and ADHD (e.g., 69%; Parush et al. 2007). In certain disorders such as ASD (Ben-Sasson et al.) and Fragile-X (Baranek et al.) sensory under-responsivity, which is another type of SMD, was even more prevalent than SOR. Characterizing the normative range of over-responsive behaviors with no other developmental condition can advance our understanding of the manifestation and mechanism of SOR among children with developmental disorders.

A literature review indicated that SOR has been primarily assessed via caregiver questionnaires measuring the frequency of sensory processing behaviors (Reynolds and Lane 2008; e.g., Sensory Profile: Dunn 1999). The advantage of parent report for evaluating SOR is the longitudinal and daily context of behavior that parents provide. This is important as SOR can be more pronounced in certain contexts in which specific aversive sensations are present, or in those that involve unexpected and intense sensation, hence may be missed in a

one-time evaluation. Moreover, complicating direct assessment, SOR can have a slowly intensifying appearance rather than a sudden onset. Parent report also facilitates large-scale epidemiological studies, which are necessary for estimating prevalence. Nonetheless there are limitations to relying on parent report, as parents may employ varying thresholds for rating similar behaviors due to differences in memory and emotional biases.

There are several theoretical and measurement approaches to the sub-classification of SOR behaviors. Evidence supports both a unidimensional structure of SOR (Aron and Aron 1997; Goldsmith et al. 2006; O'Boyle and Rothbart 1996), and a multidimensional structure (e.g., Dunn 1997). According to Dunn's model, SOR reflects a low neurological threshold (i.e., nervous system requires less intense and frequent stimuli to respond). Dunn describes two types of SOR behaviors: (1) Avoiding, which describes active attempts to control exposure to the perceived aversive stimuli, and (2) Sensitivity, which describes passive distress and distractibility towards the overwhelming sensations. These two types have been supported through multiple factor analytic studies (e.g., Brown and Dunn 2002; Dunn 2002). Other studies differentiate types of SOR based on sensory modality (Baranek et al. 1997; Goldsmith et al.); with tactile and auditory the most frequently reported modalities (e.g., Royeen and Fortune 1990). Factor analytic evidence indicates that tactile sensitivity behaviors in individuals with developmental disabilities cluster separately from sensitivities in auditory and other modalities (Baranek et al.). Goldsmith et al.'s findings further support the distinction between tactile (e.g., distress from messy materials on fingers) and auditory (e.g., distressed from loud sounds) over-responsivity, as these subscales had a low correlation, differed in their gender distributions, and showed different patterns of heritability. At the same time, Goldsmith and colleagues studied a general SOR score since the internal consistency within the auditory and tactile subscales was low. The small number of behaviors sampled in each modality in Goldsmith et al.'s (10 items) and Baranek et al.'s (6 items) studies limits conclusions. In the current work, 41 behaviors that tap into auditory and tactile over-responsivity were examined, in line with a modality specific classification (e.g., Baranek et al.; Goldsmith et al.) and with Dunn's definition of Sensitivity.

SOR and Social-Emotional Problems

SOR has been associated with social-emotional problems, particularly in the internalizing domain (e.g., anxiety, depression, withdrawal). The association between SOR and internalizing symptoms has been documented across studies of typically developing individuals across the life span (Aron and Aron 1997; Carter et al. 2003; Goldsmith et al. 2006; Kagan and Snidman 1991; Kinnealey and Fuiek 1999) as well as in clinical populations such as ASD (e.g., Pfeiffer et al. 2005). Although less commonly reported, SOR has been modestly linked with the presentation of externalizing behaviors (e.g., aggression, activity/impulsivity) in typically developing toddlers (Carter et al.; Goldsmith et al.). Children with SOR may have independently co-occurring social-emotional problems or SOR may be a risk factor for social-emotional problems.

SOR, Competence and Social Adaptive Skills

In addition to social-emotional problem correlates of SOR, this study sought to assess associations with competence. The ability to respond in a modulated manner (rather than over-respond) to external or internal input has been proposed to be the foundation of developing competence in social, academic, and self-care skills (Ayres 1964; Dunn 1997). Reactivity levels that match the context of an engaged activity allow one to focus, maintain, and shift attention to relevant input without over-allocating attention to monitor threat for potentially noxious sensation. It enables one to confidently approach and explore the human and non-human environments while practicing caution in response to age and/or context appropriate threatening events.

Adaptive social behaviors are defined as a set of behaviors that promote the development and maintenance of relationships and social acceptance (i.e., *social*) and reflect routine use of age-appropriate social abilities across varied situational demands that are encountered in multiple settings such as home and school (i.e., *adaptive*) (Dirks et al. 2007; Sparrow et al. 1984). Taking a friend's perspective, cooperating during a problem solving task, and considering others' emotional states are examples of adaptive social behaviors. Regulated sensory responsivity is particularly important for adaptive social behaviors as (1) social interaction requires a flexible response to multiple, simultaneous, ongoing, and unpredictable input, and (2) adequate sensory responsivity allows one to notice social cues and respond positively to the input involved in social interactions (e.g., light touch, loud voices). There is a need to study this proposed inter-relation between SOR and social competence and problems independent of other developmental barriers.

Risk Factors and SOR

Socioeconomic characteristics have rarely been studied in relation to SOR. Yet sociodemographic factors may impact a child's risk for presenting with SOR. For instance, mothers in families of low socioeconomic status may experience higher levels of stress during pregnancy, and may have a higher likelihood to be exposed to violence and/or alcohol. Increased stress in human pregnancy (Foster 2006) and in rhesus monkeys compared to control monkeys (Schneider et al. 2007) has been found to reduce postnatal capacity for sensory processing and regulation, decrease attention regulation, and yield difficult temperaments in the offspring. It is clear that SOR cannot solely be explained by a child's innate makeup, but it is unclear how genetic and pre- and post-natal environmental risk factors interact to form SOR.

Younger gestational age and/or lower birth weight may also increase a child's susceptibility for SOR possibly as a result of the immature nervous system. Studies have shown that preterm infants (Case-Smith et al. 1998) or infants of younger gestational age (Aylward et al. 1984) compared with full term babies/older gestational age are compromised in their ability to maintain and modulate their responses to sensation and tend to respond in an extreme manner to environmental input. Shorter gestational age was also associated with elevated SOR in infants (Dunn 2002; Goldsmith et al. 2006). Therefore, we controlled for the variance in SOR accounted by socioeconomic variables.

Method

Participants

Participants included parents followed longitudinally, initially selected randomly from birth records at the State of Connecticut Department of Public Health for births at Yale New Haven Hospital from July, 1995 to September, 1997 (see details in Briggs-Gowan et al. 2001) for children living in the 15 towns comprising the regional Standard Metropolitan Statistical Area of the 1990 Census at the time of their birth. Children were ineligible if they: (1) were likely to have developmental delays (e.g., due to birth weight below 2,200 g, gestational age less than 36 weeks, low APGAR scores, birth complications such as hypoxia) n=675; (2) had a sibling who was sampled, n=277; (3) were identified as deceased through death record review, n=4; (4) had adoption reported on record, n=14; or (5) were the child of an investigator, n=1. After excluding these birth records, a random probability sample of 1,788 was drawn from a total eligible sample of 7,433 eligible children. The sample was selected to have equal proportions of boys and girls and to be equally distributed between 11 months and 35 months of age at recruitment. After initial sampling, the following inclusion criteria were applied: (1) at least one parent able to participate in English (excluded n=50); (2) child still in the custody of biological parent (excluded n= 17); and (3) family living in the State (excluded n=116). Two children were excluded because the only available biological parent was severely ill. Despite a year of intensive searching, 112 children were excluded because it was not possible to locate the family to verify eligibility. Compared with the post-sampling ineligible sample (n= 297), the final eligible sample of 1,491 was significantly higher in birthweight, paternal and maternal age, maternal education, and years at the birth address, and less likely to be of minority ethnicity (*t-values* range 2.84–6.26, p<0.01); but these differences were all of small effect size (Cohen's d range 0.18–0.41). There were no significant differences in gestational age, paternal education, or child gender.

After exclusions, 1,329 families participated in one or two annual surveys in the Early Childhood portion of the study, when children were between the ages of 11 months and 56 months. The response rate for the Early Childhood portion of the study was 89%. Participants (n=1,329) and nonparticipants (n=162) were similar in child age, child sex, minority status, birth weight, gestational age, paternal age, maternal age paternal education, maternal education, and length of time at the birth address. Participants were generally comparable to statistics for the region in terms of ethnicity: 74% versus 77% Caucasian; single parent families: 20% versus 19%; and poverty status: 19% versus 14%.

All participants in the Early Childhood surveys were followed to School-age. Families were contacted for the School-age survey in the Spring of the Second Grade year. Due to time required to locate families and obtain participation, some families did not participate until the next school year, resulting in a sample of Second to Third Grade children. At the time of the School-age survey, 17 children were excluded on the basis of significant genetic disorders or developmental delays identified in the course of the Early Childhood or School-age survey, resulting in an eligible sample of 1,312 families. The families who were lost to follow-up (n=273) were more likely to have lower maternal and paternal education, be living

in poverty, be living in a single parent household, and be of minority ethnicity than the retained sample (n=1,039; 78% retention rate from Early Childhood to School-age) (*Chi-square* range 7.10–45.00, p<.01, *phi* range −0.08– −0.19). The effect sizes for these differences tended to be small (*phi*=.08–.19). There were no significant differences in child gender.

The Sensory Over-Responsivity inventory (Schoen et al. 2008) was added to the School-age survey after data collection had begun and thus was obtained for 925 families (71% of the School-age sample). This sub-sample did not differ significantly from the full school-age sample in demographic features. In this sub-sample, children were between ages 7 and 11 years (*mean*=8.09, *SD*=0.55), 48% were boys, and 62% were Caucasian. Informants were between 23 to 65 years of age (*mean*=38.18, *SD*=6.57), and 95% were biological mothers. Most informants had a partner, were working, and had an education level that was greater than high school.

In this paper we focused on three time points (two in early childhood and one at school age) as part of a larger longitudinal study. Children in this subsample were between 11–42 months (*mean*=22.28 months) at Year 1 and between 22–56 months (*mean*=34.35 months) at Year 2. See Tables 1 and 2 for demographics.

Sampling Weights—Weights were applied in all analyses to adjust for unequal probabilities of initial selection and retention across the longitudinal study. Information from birth records concerning sociodemographic background (e.g., parental age and race) and birth status (e.g., birth weight and gestational age) were used to calculate sampling weights (see notes for Tables 3 and 4 for their use in analyses).

Measures

Sensory Over-Responsivity Scales (SensOR: Schoen et al. 2008)—This inventory includes 76 items that describe sensations in all sensory domains that may bother a child. In the present study, 41 items from the auditory and tactile modalities were included as sensitivities in these modalities are most frequently reported (e.g., Royeen and Fortune 1990). Parents are asked to mark all items that apply to their child. Items are divided into five lists that assess tactile over-responsivity (garments, activities, experiences, surfaces, and materials) and three lists that assess auditory over-responsivity (specific sounds, background noises, and loud places). A total over-responsivity score as well as subset modality scores are computed.

This inventory was validated through factor and reliability analyses as well as discriminant analysis. Scores on this measure were highly correlated with comparable scores on the Short Sensory Profile (Dunn 1999) or Adult Sensory Profile (Brown and Dunn 2002) (see Schoen et al. 2008). Schoen et al. also had occupational therapists with expertise in sensory modulation identify children with SOR. Their inclusion criteria for SOR were: (1) presence of over-responsivity in at least one sensory domain, which the therapist assessed as significantly interfering with daily life activities, and (2) endorsing a majority of sensory over-responsive items on the Short Sensory Profile or the Adult Sensory Profile. Schoen and colleagues found that the sensitivity and specificity of the SensOR inventory in

differentiating children with SOR (n=101) from typically developing children (n=120) was highest (sensitivity= 69.09, specificity=84.16) when at least four tactile *or* auditory items were present.

Based on data from the current study, internal consistency between all 41 items on the SensOR was good as indicated by Cronbach's alpha of 0.74. For the tactile scale (22 items) Cronbach's alpha was 0.64, and for the auditory scale (19 items) it was 0.63, indicating moderate internal consistency. There was no item that if deleted improved the consistency of the total, tactile or auditory scales. The auditory and tactile scales' scores were significantly, but moderately, correlated, r=0.50, p<0.001.

Child Behavior Checklist (CBCL: Achenbach and Rescorla 2001)—The CBCL is comprised of 113 items across three domains, Internalizing, Externalizing and Total Problems. Caregivers rate items from 0 'not true' to 2 'very true or often true'. The CBCL provides *T* scores, and percentiles for three competence scales (Activities, Social, and School), Total Competence, and Internalizing, Externalizing, and Total Problems. The CBCL for ages 6–18 has demonstrated good test-retest reliability (r=0.91–0.94 for the domains), cross-informant agreement (mother-father r=0.72–0.85), and success in discriminating between referred and non-referred children (Achenbach and Rescorla 2001).

The Infant Toddler Social and Emotional Assessment (ITSEA: Carter and Briggs-Gowan 2006)—The ITSEA is a parent report measure of social-emotional and behavioral problems and competencies in infants and toddlers. Parents rate their child's behavior in the past month on a 3-point scale from 0 'not true/rarely' to 2 'very true/often'. This measure yields three problem domain scores: 1) Internalizing, comprised of General Anxiety, Depression/Withdrawal, Separation Distress, & Inhibition to Novelty Scales (e.g., seems nervous, tense, or fearful); 2) Externalizing, which is comprised of Aggression/ Defiance, Activity/Impulsivity; and Peer Aggression Scales (e.g., is restless and can't sit still); and 3) Dysregulation, comprised of Negative Emotionality, Sleep Problems, Eating Problems, and Sensory Sensitivities scales (e.g., must be held to fall asleep) and a Competence domain, which is comprised of Attention, Compliance, Empathy, Mastery Motivation, Imitation Play Skills, and Prosocial Peer Skills (e.g., plays with toys for 5 min or longer). Scores are interpreted both as continuous dimensions and relative to the 90th percentile cutoff points. The ITSEA has adequate psychometric properties, with good validity and test-retest and inter-rater reliability (Carter and Briggs-Gowan 2006).

Adaptive Social Behavior Ratings (ASBR: Briggs-Gowan et al., in preparation)—The ASBR is a research measure developed for this study using factor analyses with a set of 31 items drawn from several measures including the Behavior Assessment System for Children (BASC: Reynolds and Kamphaus 1992); the Child Behavior Scale (Ladd and Profilet 1996); the Penn Interactive Peer Play Scale (PPIS: Fantuzzo et al. 1995); the ITSEA (Carter and Briggs-Gowan 2006); and the Teacher Social Competence Rating Scale (Kam and Greenberg 1998). All items were rated on a frequency scale from 1 'Never' to 4 'Always'. Four first-order factors were identified: social problem-solving; flexibility; consideration; and affiliation. These factors were identified using data from an earlier wave of the current study, and replicated in the current wave. Results of exploratory and

confirmatory models indicated high factor loadings of the items on the first-order factors (most >.6), and acceptable model fit for the first-order factors. The second-order model, fit the data equally well (model loadings 0.57–0.87) (See Briggs-Gowan & Carter, under review).

Procedure

The current study describes three surveys that have been completed since the study began in 1998, with separate parent consent obtained at each time point (the study included two more surveys which are not described in this paper). Among other measures, the first and second surveys included the ITSEA questionnaire and demographic information, while the third survey included the SensOR, CBCL, and ASBR questionnaires. Data collection for the third survey began in the 2002/2003 academic year and continued through the 2005/2006 academic year with families first contacted to identify whether or not their children had entered second grade. Because a significant period of time was often required to locate families and obtain participation, some surveys were gathered while the child was in third grade and a small number of surveys were not collected until the summer months after the child had completed third grade. Parents received $25 for each of the first two surveys and $30 for the third survey.

Results

Prevalence of Individual SOR Items

Figures 1a, b present the number of children bothered by tactile or auditory sensations as reported on the SensOR. The sensations that parents reported bothered children most frequently were tactile, with the most frequently reported tactile sensations being: tags in clothing (39%), cutting finger or toe nails (19%), hair brushing (16%), and mud (11%). The tactile sensations that least bothered children were: light stroking touch, play dough (both 1%), getting dressed, and finger painting (both 2%). Very few parents reported auditory sensations as bothersome to their child with the most frequent sounds being alarms (12%), sirens, and concerts (both 10%), and the least noises from restaurants (0%), malls, gymnasium and door bell ringing (all 1%). There were 27 sensations that bothered no more than 5% of the sample. Fifty percent of school-age children were bothered by one to three sensations.

Prevalence of Elevated SOR in Elementary School Age

The *mean* total SensOR score was 2.36 (*SD*=2.73, *range* 0–20), the *mean* tactile score was 1.76 (*SD*=1.92, *range* 0–15), and the *mean* auditory score was 0.61 (*SD*=1.16, *range* 0–8). We examined the prevalence of elevated SensOR scores using a cutoff which was validated in previous research with the SensOR (Miller personal communication April 2007; Schoen et al. 2008). The cutoff was the presence of four or more tactile *or* auditory items. This cutoff was used (1) as it has been validated clinically and empirically, and (2) it enabled us to capture a substantial group of children with elevated SOR scores to run comparative analyses. We found that 16.5% (*n*= 148) of children in this study had SOR scores that were above this cutoff (i.e., at least four bothering sensations). Within this group that evidenced

elevated SOR, 76.4% (n=113) had only elevated tactile scores, 6.8% (n=10) had only elevated auditory scores, and 16.9% (n=25) had both elevated tactile and auditory scores.

Demographic Risk Factors of SOR

In addition, risk factors that may relate to the presentation of SOR were explored. Table 2 presents findings indicating that children with elevated SOR scores (n=148) had a significantly lower birth weight, gestational duration, were more likely to be of minority ethnicity, were more likely to be living with a single parent and/or a non-employed parent, and were of lower economic status than children with low SOR scores (n=751). There were no significant differences between groups in child (*mean*=8.08, *SD*=0.57 versus *mean*=8.09, *SD*=0.54 respectively) and informant age (*mean*=37.49, *SD*=7.18 versus *mean*=38.32, *SD*=6.44 respectively).

Early and Concurrent Social-Emotional Problems of Children with SOR

Children with elevated SOR in school age had higher mean ITSEA Internalizing, Externalizing, and Dysregulation scores at Year 1, and higher mean ITSEA Internalizing, and Dysregulation at Year 2 controlling for SES (i.e., minority ethnicity, single parent, and poverty; see Table 3) than those without SOR. In addition, children with versus without elevated SOR scores in school age showed significantly higher concurrent CBCL Total, Internalizing, and Externalizing scores controlling for the above SES variables. Table 3 shows that there were more children in the elevated SOR group with ITSEA and CBCL composite scores above cutoff than in the group without elevated SOR.

Early and Concurrent Competence of Children with SOR

Analysis of covariance, controlling for SES (i.e., minority ethnicity, single parent, and poverty) indicated that children with elevated SOR scores in school age did not differ in their ITSEA Competence scores at Years 1 or 2 from children without elevated SOR (see Table 4). In contrast to early levels of competence, parents of children with elevated SOR reported significantly lower mean adaptive social behaviors at school age than children with lower SOR. This was true for the ASBR composite as well as individual ASBR scales (see Table 4). When examined relative to the 20th percentile cutoff point for social adaptive behavior, children with versus without elevated SOR were nearly four times more likely to have lower ASBR scores.

Discussion

The present study contributes to the understanding of the prevalence of SOR behaviors in school-age children and their association with social-emotional problems and competencies. Findings indicated that: (1) elevated SOR, defined as being bothered by at least four tactile or auditory sensations, was prevalent in 16.5% of 7–11 years old children; (2) tactile and auditory over-responsivity were associated but relatively independent aspects of SOR; (3) most of the sample (78%) was bothered by less than three sensations; (4) sociodemographic risk factors such as having a single parent, and living in poverty were associated with an increased risk for elevated SOR behaviors; and (5) parents of children with versus without

elevated SOR at school age reported more early and concurrent social-emotional problems, and lower levels of concurrent adaptive social skills controlling for SES variables.

Prevalence of SOR in Elementary School

This is the first study of SOR in a birth-cohort sample representative of the population in terms of sociodemographic features. In this study parents of 16.5% of elementary school aged children reported that their children had elevated SOR behaviors in the tactile and/or auditory modalities using a previously studied cutoff of four bothersome sensations. This rate is higher than the previously reported incidence of SPD in preschool children (5–13%; Ahn et al. 2004) but is not comparable as evidence was based on different cutoff points, ages, and measures. It is also important to note that rates would not be expected to be comparable as the current study is the only epidemiologically rigorous study in which SOR has been examined. The rate of elevated SOR as defined in this study is likely an underestimation of clinically significant SOR as the current sample did not include children with developmental disorders or those delivered preterm, who are more likely to experience extreme SOR. A full clinical assessment is necessary to determine which children evidence impairment associated with SOR behaviors, which could warrant clinical intervention.

Tactile and Auditory Over-Responsivity as Distinct Subtypes

Findings in the present study that support the distinction between tactile and auditory over-responsivity were (1) the higher frequency of children who showed only elevated tactile over-responsivity versus only auditory over-responsivity, and (2) the moderate correlation between scales. This is consistent with Goldsmith et al.'s (2006) findings in twin toddlers. The question of modality specificity in SOR remains open as we (1) only studied two sensory modalities, and (2) found the total internal consistency to be higher than internal consistencies within each modality scale. Clinical accounts point to a greater efficacy of sensory-integrative based intervention for decreasing tactile defensiveness than auditory defensiveness (Koomar and Bundy 2002), supporting their distinction for intervention planning. Investigation of the underlying mechanisms of tactile versus auditory over-responsivity and/or their differential response to intervention may justify their distinction.

Frequency and Quality of Individual Sensations

There was great variability among the individual sensations that parents reported bothered their elementary school children. For instance, very few children were bothered by changing from long to short pants, light stroking, or radio sounds. On the contrary, many parents reported that their children were bothered by sensations such as tags on clothing, cutting nails, or the sound of alarms. Sensations that rarely bothered children (i.e., 27 sensations that fewer than 6% of children presented) should be considered as core indicators in measures of SOR in elementary school as their presence may indicate an atypical pattern of over-responsivity. It is important to simultaneously evaluate opportunities, as low frequency may also reflect limited exposure to those sensations. To advance our knowledge of core indicators we need to corroborate this evidence by measuring the qualitative aspects of a response (e.g., intensity, duration, context).

Besides the assessment of the frequency and type of sensation, the impact of being bothered by a particular sensation must be evaluated. Being bothered by some sensations may be more 'impairing' than being bothered by others. For instance being bothered by washing face, being hugged, getting dressed, hearing the sound of people talking, and hearing the sounds of gymnasiums and malls can have direct implications for a child's participation in self-care and social activities while other sensations are less frequently encountered and can be avoided (e.g., course carpet, concerts).

SOR and Social-Emotional Problems

One way to determine whether elevated SOR is impairing is to evaluate its association with social-emotional problems. As a group, children with elevated SOR had more social-emotional problems at school age and infancy that were not limited to the ITSEA Dysregulation domain (which has a Sensitivity scale that overlaps with SOR). Of the nine ITSEA problem scales assessed at two time points, only one was not increased among children with elevated SOR. Children with elevated SOR were four times more likely to have clinically concerning Internalizing scores, and three times more likely to have clinically relevant Externalizing scores. These findings are consistent with Goldsmith et al.'s (2006) findings with 2-year-old twins. These social-emotional problems could not be accounted for by SES differences. These problems together with SOR are a life long pattern and are difficult to separate from one another. It is possible that this overall profile is what results in impairment more than a single problem (Briggs-Gowan et al. 2006).

SOR and social-emotional problems can each impact the emergence of the other. SOR may play a role in the emergence of social-emotional problems by causing an individual to withdraw, and/or avoid negatively perceived sensations and become anxious in anticipation of the stressful sensory experience (Aron and Aron 1997), or by causing some children to respond with resistance and aggression when they encounter an aversive sensation such as touch (Stagnitti et al. 1999). Alternatively, social-emotional problems may complicate a child's ability to cope with over-stimulation, and/or may lead parents to notice a child's over-response. For individuals with ASD, this association may have greater implications as it is complicated by an independent impairment in social skills (Ben-Sasson et al. 2007).

SOR and Social-Emotional Competence

Another indicator of the impairing nature of SOR is its association with lower levels of concurrent social competence. Children with elevated SOR in the current study evidenced lower levels of social consideration ('shows recognition of feelings of others'), affiliation ('encourages others to join play'), problem-solving ('shares toys'), and flexibility ('adjusts to changes in routines'). The association between SOR and social competence in elementary school may indicate that (1) a child's SOR impacts his/her participation in social interaction or (2) that both are part of a global developmental and/or psychological condition. The findings of SOR not being associated with social competence in infancy but associated in elementary school, is consistent with the former interpretation. Interestingly differences in competence were not evident early on, although the ITSEA Competence score includes Pro-social and Empathy scales. This is consistent with Goldsmith et al.'s (2006) cross-sectional findings of a non-significant correlation between ITSEA Competence and SOR in toddlers.

The lack of difference early on may also reflect the developmental nature of social competence, which increases in complexity and in the role it plays in children's lives with age. Young children spend more time at home and/or in child care with familiar caregivers who may adapt these environments and their expectations to meet the child's sensory needs. In elementary school age, the child encounters social contexts that are less predictable and tailored for their sensory needs, thus the impact of individual reactivity levels may become pronounced later on.

SOR may compromise social skills due to the child's avoidance of the unpredictable and changing nature of social sensory input and/or due to difficulties in attending to relevant social cues.

Risk Factors of SOR

In the present study, there were more parents of children with elevated SOR that were of minority ethnicity, needed poverty assistance, and were single than those with few or no bothering sensations. Children genetically susceptible for SOR may be more likely to present it when growing up in lower versus middle to high SES families. The co-occurrence of SOR and externalizing problems seems to be associated with SES more than the other problem areas as indicated by its nonsignificance once SES was controlled for statistically. One possibility is that a low socioeconomic environment may consist of cluttered, intense and uncontrolled input (e.g., more people in a smaller space, loud noises), thus a child with a predisposition for SOR may be more challenged by such an environment. Another possibility is that the impact of the environment on the presentation of SOR occurs prenatally as described in the human and non-human primate evidence (Foster 2006; Schneider et al. 2007). It is also possible that parents of lower SES report more sensations that bother their child due to their own elevated stress. Testing the reliability of parent report of SOR behaviors in families of lower SES can unfold such a bias by indicating whether these parents tend to over-report over-responsivity in their children. There is also need to investigate the role of the pre- and post-natal environment in modifying a child's reactivity style.

Although only full-term babies were recruited for this study, shorter gestation duration and lower birth weight were associated with elevated school-age SOR. We hypothesize that this relation would be more pronounced if tested in preterm babies in line with previous findings (Aylward et al. 1984; Case-Smith et al. 1998). Goldsmith et al.'s (2006) non-significant difference in gestation age between defensive and non-defensive children may relate to a higher rate of preterm births in their sample, as they only included twins. Interestingly, lower SES may increase the risk of lower birth weight due to factors such as poor health care, alcohol consumption, and impoverished nutrition, thus birth status cannot be differentiated from SES.

Study Limitations

Although there are great advantages to the type of SOR measure used in this study due to ease of implementation, we acknowledge that SOR measurement was limited by relying upon a single parent informant and focusing on only two sensory modalities. In addition, the

checklist format did not allow us to distinguish between ‘does not bother’, ‘don’t know’ or ‘no opportunity’ and might not have captured the severity of over-response. To estimate the prevalence of SOR as a disorder there is a need to validate the cut-score with direct assessments of children that include an evaluation of the impact of SOR upon participation in daily activities. Data on the prevalence of impairing SOR as a ‘disorder’ will aid in projecting the cost of SOR to society, in terms of public health-care policy and the allocation of services within the school system (Hennekens and Buring 1987). In addition, including a physiological measure of differences between SOR subgroups can advance our understanding of etiological mechanisms and their relation to emotional mechanisms. Future research is needed to measure the presence of other types of SMDs (i.e., under-responsivity and seeking behaviors) in children with elevated SOR in order to determine their independence and interplay.

Conclusions and Implications

Findings from this study support the independence of SOR from other developmental disorders, as our sample excluded children with diagnosed medical/developmental conditions. This study provided an opportunity for examining SOR in a representative sample, revealing its association with socio-economic risks as factors that may contribute to the presentation and report of SOR. Parent report of bothering sensations may also be influenced by the type of sensory experiences children have and by the nature of the physical and social input in the child’s home, school, and community. Greater effort needs to be invested in investigating the development and ‘impairing’ nature of SOR to advance the definition of this construct. There is also need for determining whether the association between SOR and other emotional problems is part of a broader developmental profile or a consequence of one another. While clinically meaningful emotional problems were present in children with elevated SOR early on and increased during development, associations with social competence were only apparent concurrently in elementary school. This suggests that there is a potential opportunity to provide interventions that could prevent the ramifications of SOR upon adaptive social behaviors.

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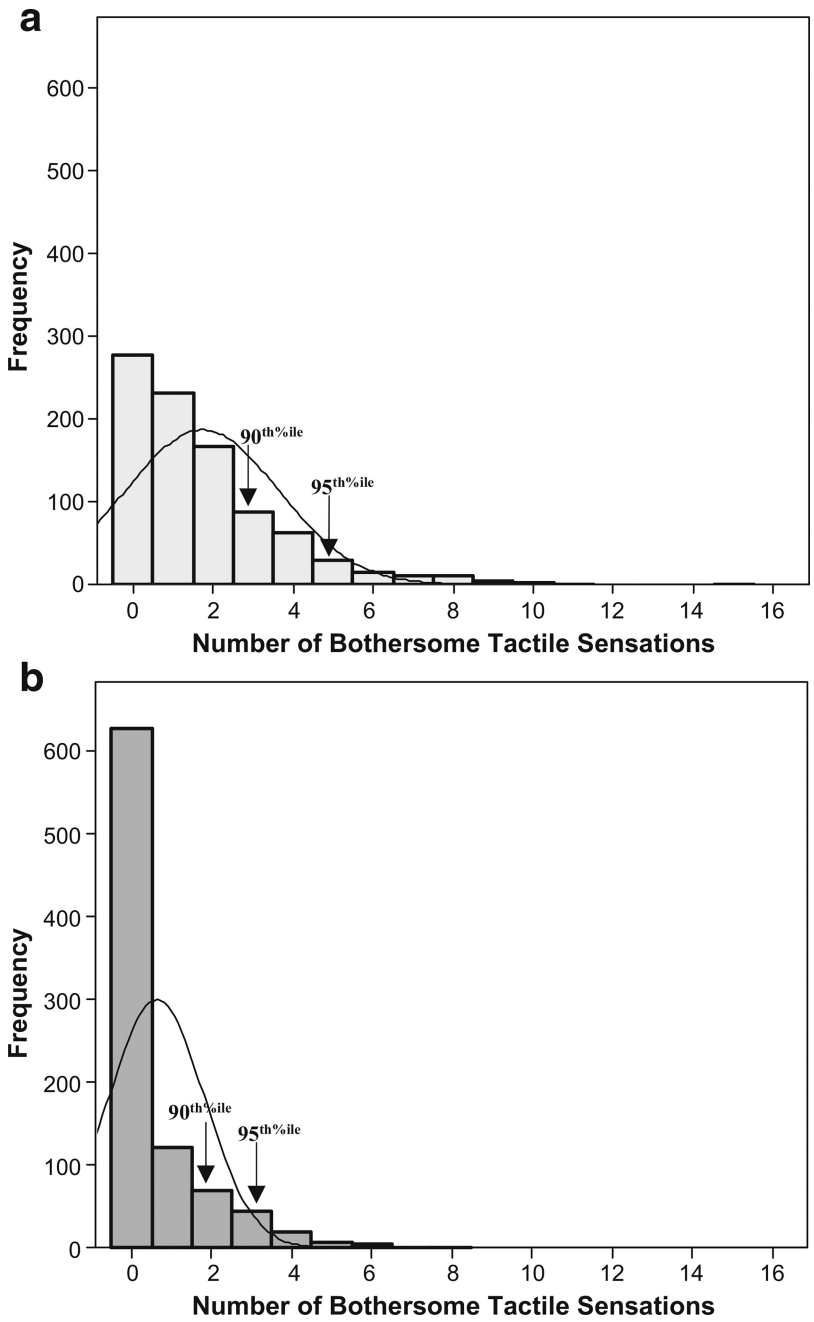

Fig. 1.

Frequency of bothersome sensations in school-age children. Frequency of tactile sensations (**a**). Frequency of auditory sensations (**b**)

Table 1

Sequence of Longitudinal Data Collection

Time point	N	Age	Questionnaires
Year 1: Early childhood survey 1	1039	11–42 months	ITSEA
Year 2: Early childhood survey 2	1039	22–56 months	ITSEA
Year 3: School age survey	925	7–11 years	SensOR, CBCL, ASBR

ITSEA= Infant Toddler Social Emotional Assessment; SensOR= Sensory Over-responsivity inventory; CBCL= Child Behavior Checklist; ASBR= Adaptive Social Behavior Rating.

Table 2

Characteristics of Children with Versus without Elevated SOR in Elementary School

Characteristics	SOR (n=148)	No SOR (n=751)	Test Statistic	Effect Size/Odds Ratio (95% CI)
Boys/Girls	78/70	388/363	χ^2=0.05	OR=1.04 (0.73–1.48)
Birth weight (kg) Mean (*SD*)	3.31 (0.46)	3.43 (0.47)	F=9.17**	η^2=0.01
Gestational week Mean (*SD*)	39.05 (1.49)	39.36 (1.32)	F=6.33*	η^2=0.01
Ethnicity (%)				
Minority	71 (48.0%)	268 (35.6%)	χ^2=8.01*	OR=1.67 (1.17–2.38)
Not minority	77 (52.0%)	484 (64.4%)		
Employment (%)				
Not employed	59 (39.9%)	232 (30.9%)	χ^2=4.55*	OR=0.67 (0.47–0.97)
Employed	89 (60.1%)	519 (69.1%)		
Education level (%)				
Up to high school	46 (31.7%)	176 (23.7%)	χ^2=4.18*	OR=0.67 (0.45–0.99)
Above high school	99 (68.3%)	567 (76.3%)		
Marital/partnership status (%)				
Single	49 (33.3%)	148 (19.8%)	χ^2=3.01**	OR=2.02 (1.37–2.98)
Partner	98 (66.7%)	598 (80.2%)		
Poverty assistance (%)				
Poverty assistance	36 (26.5%)	107 (14.7%)	χ^2=11.50**	OR=2.09 (1.36–3.22)
No poverty assistance	100 (73.5%)	621 (85.3%)		

SOR=Sensory Over-responsivity.

*$p<0.05$;

**$p<0.01$.

Table 3

ITSEA and CBCL Scores of Children with Versus without Elevated SOR in Elementary School

	Mean (*SD*)		F	% Above cut point[a]		OR (95% CI)	Correlation with SOR
	SOR	No SOR		SOR	SOR		
ITSEA Year 1							
Internalizing	0.61 (0.25)	0.50 (0.21)	25.12**	32 (23.0%)	55 (7.4%)	3.72 (2.30–6.02)**	0.25**
Externalizing	0.60 (0.32)	0.47 (0.29)	17.11**	22 (15.9%)	68 (9.2%)	1.86 (1.11–3.13)*	0.16**
Dysregulation	0.56 (0.28)	0.45 (0.24)	16.60**	22 (15.9%)	75 (10.2%)	1.67 (1.00–2.80)*	0.22**
ITSEA Year 2[b]							
Internalizing	0.63 (0.26)	0.48 (0.23)	37.90**	30 (21.4%)	67 (9.3%)	2.66 (1.66–4.28)**	0.31**
Externalizing	0.56 (0.30)	0.48 (0.30)	2.98	18 (12.9%)	88 (12.2%)	1.07 (0.62–1.85)	0.17**
Dysregulation	0.59 (0.29)	0.46 (0.24)	24.96**	35 (25.0%)	65 (9.0%)	3.36 (2.12–5.33)**	0.27**
CBCL Year 3[c]							
Total	23.99 (21.00)	15.05 (14.62)	31.52**	17 (11.5%)	12 (1.6%)	7.89 (3.68–16.92**	0.33**
Internalizing	6.47 (5.76)	3.47 (4.08)	52.87**	11 (7.5%)	14 (1.9%)	4.21 (1.87–9.47)**	0.34**
Externalizing	6.66 (7.14)	4.34 (5.37)	14.29**	12 (8.2%)	22 (2.9%)	2.94 (1.42–6.09)**	0.25**

CBCL= Child Behavior Checklist; ITSEA= Infant Toddler Social Emotional Assessment; SOR= Sensory Over-responsivity. Unadjusted means were compared using MANCOVA controlling for minority ethnicity, single parent, and poverty, percentages were compared using Chi squares. Weight variable for the CBCL was based on Year 3 demographics and weight for the ITSEA analyses was based on weight of Year 3 with Year 1 or Year 2.

[a] ITSEA cutoff points were compared to the 90th percentile cutoff. CBCL cutoff points are based on a t-score of 67.

[b] For the CBCL there were 146 children with SOR and 817 without.

[b] For the ITSEA Year 1 there were 136 children with SOR and 807 without, and for Year 2 there were 141 children with SOR and 805 without.

* $p<0.05$;

** $p<0.01$.

Table 4

Competences and Adaptive Social Behaviors of Children with Versus without Elevated SOR in Elementary School

	Mean (*SD*)		F	% Above Cutoff		OR (95% CI)	Correlation with SOR
	SOR	No SOR		SOR	No SOR		
ITSEA Competence Year 1[c]	1.34 (0.29)	1.36 (0.31)	0.00	17 (12.2%)	86 (11.6%)	1.06 (0.61–1.84)	−0.05
ITSEA Competence Year 2[b]	1.46 (0.27)	1.49 (0.25)	0.10	16 (12.3%)	66 (9.3%)	1.28 (0.72–2.29)	−0.11**
Adaptive Social Behavior	2.90 (0.57)	3.20 (0.48)	33.18**	36 (24.5%)	56 (7.7%)	3.92 (2.46–6.23)**	−0.28**
Rating (ASBR) Year 3[a]							
Child affiliation	2.89 (0.60)	3.09 (0.55)	4.23**	23 (15.5%)	47 (6.4%)	2.69 (1.58–4.59)**	−0.19**
Social problem solving	2.88 (0.57)	3.15 (0.52)	6.79**	28 (18.9%)	60 (8.1%)	2.64 (1.62–4.31)**	−0.25**
Empathic concern	3.02 (0.67)	3.28 (0.59)	6.30**	34 (23.15%)	61 (8.35)	3.33 (2.09–5.30)**	−0.21**
Flexibility	2.92 (0.70)	3.33 (0.60)	15.61**	40 (27.0%)	65 (8.7%)	3.89 (2.50–6.06)**	−0.30**

SOR= Sensory Over-responsivity; ITSEA= Infant Toddler Social Emotional Assessment. MANCOVAs computed were: Unadjusted mean ASBR total, and four ASBR scales. Both models were co-varied for minority ethnicity, single parent, and poverty. ITSEA Competence scores from Years 1 and 2 were included in the models described in Table 3. ITSEA Competence scores were compared to the 90th percentile cutoff and ASBR scores relative to the 1.5*SD* cutoffs.

[a]For the ASBR there were 147 children with SOR and 731 without.

[b]For the ITSEA Year 1 there were 136 children with SOR and 807 without.

[c]For Year 2 there were 141 children with SOR and 805 without.

*$p<0.05$;

**$p<0.01$.