RESEARCH

An Update on Sensory Responsivity, Sensory Reactivity, and Arousal in Persons with Autistic Spectrum Disorders: Current Research and Promising Interventions

by Lucy Jane Miller, Ph.D., OTR & Susan Hepburn, Ph.D.

There is a huge gap between the popular conceptualizations of the role of sensory functioning in autistic spectrum disorders and the evidence from scientific inquiries. The first-person accounts of Temple Grandin, Donna Williams, and others provide striking examples of how some individuals with autism experience sensory events in a manner that is clearly different than typically developing individuals. Talk to any parent of a child with an autism spectrum disorder and you will hear examples of unusual responses to sensory events in the environment. Teachers and therapists often report that children have difficulties coping with sensory events in the classroom or in treatment sessions. While parents, teachers, therapists and persons with autism describe unusual sensory responses, the science of sensory processing disorders has a long way to go.

One of the problems with the research is that few scientists are defining the constructs in a consistent fashion. The umbrella term for difficulties with sensory functioning is Sensory Processing Disorder. A subset of individuals have difficulty grading their responses appropriately to the situation, resulting in over-or under-responsivity to sensory stimuli, also called Sensory Modulation Dysfunction. This article focuses on individuals who have this type of dysfunction.

We'd like to propose three definitions that might help clarify terms so that in this discussion readers will better understand what we are discussing.

Sensory responsivity – a quality that seems biologically hard-wired, in the sense that each of us has greater or lesser observable responses to inputs into different sensory channels (e.g., auditory, visual). Some children seem to over-respond, with strong and intense responses when seemingly small amounts of stimulation are present. Other children seem to under-respond, hardly noticing environmental events at all, even when the stimuli are intense. Still others seem to vacillate back and forth between the two extremes....over-responding one minute and under-responding the next.

Sensory reactivity – the physiologic reaction that occurs when a person is exposed to sensory stimuli. This occurs in the central nervous system and can be measured with a variety of psychophysiologic evaluations. It is possible, common even, for a person to have a behavioral under-response but to experience a physiologic hyper-responsivity.

Arousal – a physiological state that occurs after the sensory event has transpired; arousal levels are, therefore, influenced by sensory responsivity, sensory reactivity and environmental demands. For example, if a child who is particularly sensitive to loud noises is in a crowded train station with no clear expectations of what is going to happen next, he may experience more arousal when hearing loud noises in that setting than if he heard a loud noise while playing in his own backyard. He may show either sensory over-responsivity (e.g., getting upset, crying) or sensory under-responsivity (e.g., freezing, becoming withdrawn).

Sensory reactivity and arousal are regulated by the central nervous system. The nervous system reacts in many ways to changes in sensory information, resulting in changes in arousal levels. For example, neurochemical changes, alterations in motor behavior, and other biological responses that help the individual bring arousal levels back to a tolerable, well-regulated point can occur. This balance point, when the individual is well regulated, is referred to as "homeostasis." In this state, internal stability exists that allows the person to respond appropriately to both internal and external stimuli. Growing evidence suggests that people learn better when they are in this homeostatic place. They feel what is called "an optimal level of arousal" – enough arousal to be interested and engaged, but not so much that they become too overwhelmed to respond appropriately (Mayes, 2000).

Scientists have long recognized that autism spectrum disorders are neurobiological conditions that seem to affect the integrity of the central nervous system. Thus, persons with autism may have difficulty with these self-regulatory capacities

(sensory responsivity, sensory reactivity and arousal). In fact, evidence from parent reports indicates that children with autism demonstrate more unusual auditory, visual, and taste/smell responses than children with other developmental disabilities (Kientz & Dunn, 1997; Rogers, Hepburn, & Wehner, in press). Dahlgren & Gillberg (1989) also reported that 2-year old children with autism were less consistent in their responses to sound, were more likely to become over-excited by being tickled, and were less responsive to temperature changes than children with other developmental disabilities. Lord and colleagues detected autism-specific impairments in sensory functioning in several studies (Lord, 1995; Lord, Rutter, & LeCouteur, 1994; Lord, Storoschuk, Rutter, & al., 1993). However, not all researchers have confirmed that children with autism have atypical sensory responses. Cox and colleagues (1999) found no differences in sensory responsiveness between children with autism, language impairments, and those developing typically. Retrospective videotape studies of infant development have noted the presence of unusual sensory responses within the first year of life, including a lack of response to name (Adrien et al., 1993; Osterling & Dawson, 1994), poor orienting to visual stimuli, response to touch, and atypical amounts of mouthing (Baranek, 1999). Clinical reports suggest that sensory dysfunction in persons with autism can occur in any modality (e.g., tactile, auditory, visual, olfactory, taste, vestibular [movement of head in relations to gravity] or proprioceptive [sensations generated inside the body that marks where the parts of the body are in relation to each other]) and may change with development.

Some physiological studies suggest that children with autism tend to be under-reactive to sensory events (Miller, Reisman, McIntosh, & Simon, 2001), while others suggest that they tend to be over-reactive to small changes in sensory events. Yet, others have suggested that persons with autism have difficulty attending to the relevant sensory stimuli and filtering out irrelevant aspects (Boucsein, 1992). Cognitive theorists disagree that this is a sensory phenomena. They suggest instead that poor filtering is related to a lack of central coherence (Burack, Charman, Yirmiya, & Zelazo, 2001) or difficulty attending to the whole experience and focusing too much on a detail (relevant or not). The available data on children with developmental disabilities (some of whom have autism) suggests abnormal patterns of arousal regulation and sensory reactivity are common in children with neurodevelopmental disorders (Boyce et al., 2001). Clearly, more physiological studies of children with autism (where the participants are well described and diagnosed using state-of-the-art diagnostic criteria) are needed.

Conducting rigorous scientific studies in this area are challenging because: (1) problems exist defining concepts clearly enough to test them; (2) a lack of objective physiological measurements that are of practical use with autistic individuals exists; (3) generally researchers only have access to small samples; (4) pragmatic limitations (i.e., need to keep child still while being assessed physiologically). These challenges have presented limitations in research on sensory-based impairments in individuals with autistic disorders.

While scientists continue to examine sensory reactivity and arousal in persons with autism and other neurodevelopmental disorders, the assessment and intervention literature continues to grow. Recent reviews of the effectiveness of several intervention approaches designed to help an individual better regulate arousal have been published. (Baranek, 2002; Dawson & Watling, 2000; Mayes, 2000).

Assessment

Sensory responsivity can be assessed in three ways: standardized tests, observation, and parent report. The three standardized instruments most commonly used are the Sensory Integration and Praxis Tests (SIPT, Ayres, 1989), the DeGangi-Berk Test of Sensory Integration (TSI, Berk & DeGangi, 1983) and the Miller Assessment for Preschoolers (Miller, 1982, 1988). Special training is required to administer these scales in the required standardized manner, which can be difficult for children with autism who have difficulty attending for long periods of time. None of these assessments measures sensory responsivity directly, focusing instead on sensory discrimination and praxis (motor panning responses). Observation methods developed by Smith & McEnulty (1980) and modified by Cook (Cook, 1990) require further validation. A new tool, The Sensory Profile (Dunn, 1999) and the Short Sensory Profile (McIntosh, Miller, Shyu, & Dunn, 1999), show tremendous promise as parent report scales of sensory symptoms.

Our research team is examining psychophysiological reactions to sensory inputs in children with autism spectrum disorders, which we hope to add to a clinical assessment battery in the future. In our paradigm, children are evaluated in a "pretend space-ship" where a series of 50 sensory stimuli are administered. We evaluate sympathetic (fight or flight) and parasympathetic (brings the system back to homeostasis) reactions to sensory input. Currently, we are conducting a comprehensive study of the responses of 40 children with autism, 20 of whom are tested twice so we can measure the test-retest reliability of the paradigm. Soon we hope to have an objective, quantifiable

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measure of sensory reactivity, which we can administer in addition to clinical observations of sensory responsivity. We will be able to verify whether the particular child has sensory dysfunction and study its role in the development of other autism symptoms. In addition, we have proposed a project using psychophysiologic measures of sensory reactivity in evaluating the effectiveness of therapies (such as Occupational Therapy) designed to ameliorate these difficulties.

Interventions

Interventions to promote improvements in sensory responsivity and arousal modulation were first developed by A. Jean Ayres in the 1970s. Dr. Ayres' theories have been further developed and applied to children and adults with many diagnoses. Studies of the effectiveness of sensory-based therapies are plentiful (Bundy, Lane, & Murray, 2002; Roley, Blanche, & Schaaf, 2001), but most are plagued with methodologic difficulties and are very difficult to interpret. Specific interventions include: the use of a *sensory diet* (prescribing daily regimens of sensory experiences designed to promote optimal arousal levels); *lifestyle interventions* (incorporating changes in diet, exercise, and daily activities to promote optimal arousal); *sensory integration therapy* (or the provision of a specific clinical reasoning process to guide the child to activities thought to stimulate the neurodevelopmental network to improve processing of sensory inputs); and *functional accommodations* (such as providing environmental modifications to promote coping with overarousal – such as giving headphones to a child who is sensitive to noises, or gloves to a child who is tactile-defensive). To date, no rigorous randomized clinical trial assessing the effectiveness of these approaches has been completed. *This means that these techniques are unproven; it does not mean these techniques are ineffective.* In this arena clinical work has moved past basic science. Given the anecdotal reports supporting the use of sensory-based therapies, it becomes a responsibility of the scientific community to evaluate the effectiveness of these approaches.[1]

Conclusion

Disorders of sensory responsivity, sensory reactivity and arousal are complex and are not unique to autism. Sensory dysfunction is not believed to be a core deficit of autism; however, severe sensory dysfunction can affect arousal regulation ultimately influencing learning, social participation, self-regulation, self-esteem and other functional outcomes. The study of these impairments is challenging. Yet, given the prevalence of symptom expression in individuals with Autistic Spectrum Disorders, rigorous scientific study of sensory disorders in Autism must be supported. The idea that physiological differences in responsiveness might mediate differences in behavioral symptoms and outcomes in autism spectrum disorders must be studied.

Advancements in neuroimaging and other psychophysiological methods will undoubtedly contribute to gains in this area. Documentation of the sensory atypicalities using objective measures is crucial; we must determine if more than one sensory phenotype exists in Autism. Given the anecdotal evidence related to effective outcomes using sensory-based occupational therapy, rigorous randomized trials are essential.

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1 We have applied for a NIH grant to conduct a rigorous randomized controlled trial of OT with a sensory-based arousal regulation approach, compared to an active placebo play time. If funded, this will be the first rigorous treatment effectiveness trial of this type with children with autistic spectrum disorders.

BIOS

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(Editor's Note: The 26 references supporting this article are available by sending a request to veronica@autismdigest.com)