Sensory Interventions

Olive Healy, Rhona Dempsey, Helena Lydon, and Leanne Grealish

Difficulties in processing sensory inputs known as sensory processing difficulties are recognized as a core diagnostic feature of autism in the latest *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). The sensory characteristics seen across autism are considered heterogeneous. Any of the senses may be over- or under-sensitive (hyper or hypo), or a combination, and these sensitivities are fluid and variable temporally and contextually, for any individual. The idiosyncratic and dynamic nature of sensory difficulties experienced by autistic people renders approaches to address difficulties less than straightforward. Furthermore, measuring physiological changes can be impractical so in general there is a reliance on interpreting sensory processing difficulties through behavioral responses. An individual with hypersensitivity to a stimulus is likely to react quickly, in contrast to an individual with hyposensitivity who may respond slowly or not react to a stimulus. In an efficient system an individual will react in an adaptive manner appropriate to situational demands (Falkner, 2020; Lombard, 2015).

Sensory processing difficulties in autism are evident in early development and have been shown to predict diagnostic status later in childhood (Gliga et al., 2015; Robertson & Baron-Cohen, 2017; Turner-Brown et al., 2013). These sensory processing difficulties may also predict higher-order deficits in social skills and cognition in adults (Robertson & Simmons, 2010; Tavassoli et al., 2014). Such difficulties, also referred to as "sensory behaviors" (Ben-Sasson et al., 2009; Kern et al., 2008;

O. Healy (✉) · R. Dempsey
Trinity College Dublin, The University of Dublin, Dublin, Ireland
e-mail: olive.healy@tcd.ie

H. Lydon · L. Grealish
National University of Ireland Galway, Galway, Ireland

J. L. Matson, P. Sturmey (eds.), *Handbook of Autism and Pervasive Developmental Disorder*, Autism and Child Psychopathology Series,
https://doi.org/10.1007/978-3-030-88538-0_59

Table 1 Some examples of factors involved in sensory processing

Perceptual capacity is related to the degree of reactivity by an individual to sensory stimuli. A larger perceptual capacity relates to a higher sensory sensitivity (Brinkert & Remington, 2020).
Stimulus over-selectivity describes a phenomenon in which an individual responds only to a subset of the stimuli present in the environment and, thus, may restrict learning. Kelly and Reed (2021) found that over-selectivity was associated with IQ and stereotyped behavior but was not related to levels of cognitive flexibility in autistic individuals.
Robertson and Baron-Cohen (2017) describe the attention to sensory detail which can present for some autistic individuals as a relative bias to local more detailed features over the global features of "a sensory scene". This is sometimes considered an advantage depending on task demands, however it can render a person unable to filter out extraneous information and to selectively attend.
Hyper- or hypo- reactivity to sensory stimuli may occur due to impaired regulation of central nervous system arousal (Baranek, 2002; Randell et al., 2019).
Hyper-reactivity might manifest in hypersensitivity to bright lights or certain light wavelengths. Certain sounds, smells and tastes may be overwhelming. Types of touch (light or deep pressure) can cause extreme discomfort.
Hyper-reactivity may sometimes be associated with aggression in an attempt by an individual to communicate discomfort due to being in an overstimulating environment (Pengelly et al., 2009).
The **sensory acuity** a person has to a sensory stimulus describes their individual sensitivity to a stimulus. The degree of acuity varies from person to person and contextually.

Lane et al., 2010; Rogers & Ozonoff, 2005) may manifest as unusual activities involving seeking or avoiding various types of auditory, tactile, visual or oral stimuli. In some instances, individuals may actively seek sensory stimulation within these sensory systems and in others there may be a lack of response to the presence of such stimuli (Lang et al., 2012). Sensory behaviors in autism may also include intense interest in specific objects or textures, for example (Weitlauf et al., 2017). Furthermore, the topography, frequency and severity of such unusual sensory related behaviors have been reported to vary significantly across individuals with autism spectrum disorder (ASD) (Rogers & Ozonoff, 2005).

Sensory stimulation influences a person's arousal levels (Top Jr. et al., 2019). These sensory difficulties experienced by autistic people and heightened, or conversely, suppressed arousal levels can impact a person's reaction or response to stimuli presented and the information received. Arousal levels can contribute to stress and anxiety experienced in everyday environments (Top Jr. et al., 2019). A person's behavioral responses, movement, socialization and ability to cope with their environment can be affected, influencing all facets of life and daily living, and this can have a profound effect on a person's wellbeing and life. These experiences can result in avoiding certain environments or situations (Lydon et al., 2013). As an example, an individual whose sensory systems are either overly sensitive or not responsive enough to register a stimulus might be fearful of moving or could experience a desire to push sensory experiences further, possibly in some cases leading to injury (Lydon et al., 2013). Some of the ways sensory processing difficulties might arise and manifest are presented in Table 1.

Sensory Processing Disorder: Disputation and Consensus

The sensory processing difficulties described above have been proposed to constitute a proliferation of symptoms constituting a condition or indeed a "diagnosis" of Sensory Processing Disorder (SPD). There are many references in the literature on autism symptomology and intervention for this assumed condition (May-Benson & Koomar, 2008; Parham et al., 2007a). Concisely, it is a condition espoused predominantly within the field and practice of occupational therapy and has been proposed to arise from a flawed neurological "integration" of specific types of sensory stimuli including items of varying textures, sounds and appearances. To date, SPD does not have an entry in either the *Diagnostic and Statistical Manual of Mental Disorders 5th edition* (DSM5; APA, 2013) or the World Health Organisation's *Classification of Diseases 11th edition* (ICD-11; World Health Organization, 2018). Credibility of the disorder within the fields of psychology and psychiatry remains controversial. Despite this, there is an assumption that SPD is a legitimate diagnosis among many health and educational professionals. As a result, parents of autistic children frequently receive information and resource intensive recommendations from health and educational professionals in this regard.

The American Academy of Pediatrics (AAP) which is considered a significant influential organisation on policy creation conducted a review that concluded "because there is no universally accepted framework for diagnosis, sensory processing disorder generally should not be diagnosed." (AAP, 2012, p. 1186). However, there remains a questionable position purported that sensory processing issues play a role in the development of disability suggesting that this questionable disorder plays a causal role in progressing children's disabilities in autism and other disorders (Dunn et al., 2016; Watts et al., 2016).

The DSM5 (APA, 2013) lists sensory issues as being correlated with ASD not a potential contributing factor to the cause of ASD. The AAP states that "it is unclear whether children who present with sensory-based problems have an actual disorder of the sensory pathways of the brain or whether these deficits are characteristics associated with other developmental and behavioral disorders" (AAP, 2012, p. 1186). If clinical practice in the field of autism intervention is to be led by empirical evidence, then it must be concluded that the evidence for the existence of SPD is currently weak. Considering sensory processing difficulties as correlates of ASD may provide a focus on *behaviour* rather than *condition*, and so behavioural assessment involving for instance functional analysis, would be considered the gold standard starting point for any therapeutic intervention to address specific concerns. This type of focus shifts the emphasis away from potential fallible explanations underlying putative labelling such as SPD towards a consideration of behavior as discrete functional components. It shifts the focus also from topography to underlying cause of specific sensory related behaviors in a particular context. A dependency on behaviour outcomes as a proxy for estimating underlying sensory difficulties is imperfect and requires thorough and complete analyses to optimise accuracy with regard to interpretation. Behaviors sometimes assumed to be rooted in sensory

processing difficulties are possibly an emerging pattern acquired through repetition and have become habit forming rather than as a response to sensory stimuli. This focus may also provide practitioners the opportunity to discriminate between different aspects of sensory-seeking or sensory-reducing associated behaviours and the context in which they occur. The presence of such behaviors in a person's vast repertoire of responses may or may not be connected, i.e., they may or may not share any functional properties.

We argue that assembling under- and oversensitivity responses to sensory stimuli, under a banner such as SPD limits, and possibly obscures, the context of interpretation and fails to enrich our understanding of the reasons *why* such responding occurs. If a child is seeking tactile stimulation for instance, there may be several possibilities within a given context as to why this is occurring. Similarly, when a person avoids social contact, a number of contextual factors may be influencing such avoidance. These factors or variables are often fluid, changing across environmental contexts and time periods all requiring scrutiny to determine their impact on a person's automatic or determined response patterns. Nowadays, the view of autism as a "conceptual organising principle" is well challenged and some have argued that "attempts at a single explanation for the symptoms of autism have failed" (Happé et al., 2006, p. 1218).

Understanding *how* responses to sensory input occurs is important. The senses encompass the faculties by which a person perceives a stimulus. Senses relay any information received by a person's central nervous system via auditory, ocular, tactile, gustatory, and olfactory systems (Glass et al., 2014). The central nervous system receives, registers, organizes and assimilates the information received from multiple sensory inputs simultaneously and this processing equips a person with knowledge, to act on, based around their internal state and their surrounding environment. The manner in which the information input from the senses to the central nervous system is received, registered, organized and assimilated is affected for a person with sensory processing difficulties, and this in turn affects the person's internalized (covert) and externalized (overt) responses or reactions (Miller et al., 2007).

Given the complexity involved in processing sensory information there are clearly many ways information reception and output can be flawed which can impact on associate arousal levels and behavioural reactivity. This lack of overt reaction to specific stimuli such as speech, loud noises and pain (described as hypo-reactivity) and heightened sensitivity, agitation or distress in response to particular textures or to everyday noises (described as hyper-reactivity) have previously been described in autistic individuals (Liss et al., 2006). Atypical behavioral reactions are considered characteristic of autism and oftentimes used as criteria that distinguish the condition from other developmental disorders (Klintwall et al., 2011; Wiggins et al., 2009). Such reactions can manifest as internalizing and externalizing behaviours that complicate participation for example in typical leisure, social and educational activities (Reynolds et al., 2011; Tseng et al., 2011). Several researchers have hypothesized that deviations in physiological reactivity may underlie sensory/behavioural issues in autism, wherein hyper-arousal is associated with experiences

of fear, anxiety and avoidance (e.g., Dalton et al., 2005) and hypo-arousal is associated with feelings of dullness, under-stimulation and sensory seeking (e.g., Rogers & Ozonoff, 2005). A further discussion of the evidence relating to whether physiological reactivity is typical in the autistic population and the specific factors which may differentiate autistic individuals who present with atypical physiological reactivity from those who do not is provided by Lydon et al. (2016).

Sensory processing and behavioral reactivity are important in order to navigate everyday living and life with ease. Successful coordination and integration of multiple information inputs prepares a person for an appropriate reaction, thus enabling them, for example, to walk, run, work, learn etc. It is unsurprising that people with a disability, parents, education and health professionals turn to methods in an effort to address sensory difficulties which may be associated with distress, hyper- or hypo-reactivity.

The hypothesis that sensory related behaviors or sensory processing difficulties are caused by a defect in the nervous system in which sensory stimuli are processed and integrated in some anomalous fashion resulting in "sensory integrative dysfunction" and "dysregulation" is popular (Schaaf & Miller, 2005). Challenges to this hypothesis continue however, given that the specific nature of impairment within the nervous system and how it precisely impacts sensory processing abilities remains under question (e.g., Iarocci & McDonald, 2006; Lane & Schaaf, 2010). The hypothesis extends to claim that providing specific forms and appropriate "dosages" of sensory stimulation may improve an individual's neuroplasticity augmenting their ability to process multi-sensory stimuli. Providing sensory interventions, it is claimed, improves the nervous system, reduces perceived problem behaviors and facilitates more coherent skill acquisition (Baranek, 2002; Lane et al., 2010; Schaaf & Miller, 2005). The next section of this chapter will provide an overview of such sensory interventions involving the underlying theory, a description of their implementation with autistic persons, and supporting evidence for their usage to date.

Sensory Interventions

It is only where sensory processing difficulties are at a level that significantly and detrimentally impact on daily life and wellbeing that sensory interventions should be considered. These interventions are designed to commonly address perceived sensory processing difficulties in order to improve a person's interaction within various contexts or environments. To our knowledge, research to date has examined the use of sensory interventions incorporating various kinds of sensory experiences with autistic people to address a range of behavioral outcomes including for example, attention, cognitive abilities and distressed behaviours. This body of research has leveraged a range of interventions which incorporate sensory experiences in an attempt to address sensory related behaviors. For example, in addition to the interventions we discuss further, the range of available interventions also spans the proposal of music therapy (Geretsegger et al., 2014), school-based sensory interventions

(e.g., Galpin et al., 2018; Mills et al., 2016), environmental enrichment (Woo et al., 2015; Woo & Leon, 2013), visual therapy (e.g., Carmody et al., 2001), a variety of individual touch-based approaches, tactile-based tasks and many more as ways of improving autistic persons' ability to better navigate their environment. The outcomes of a number of systematic literature reviews on the topic of sensory interventions have also varied largely but overall result in identification of a lack of consistency in mechanisms and outcomes targeted. Given the scant research and largely absent evidence base for some proposed sensory interventions (such as those listed) these are not described below.

We will now consider some of the more commonly cited interventions and provide further detail under the headings of Sensory Integration, sensory based interventions, and Auditory Integration Therapy.

Sensory Integration: Theory and Description

Sensory Integration was first proposed by Jean Ayres in the 1970s. The therapy was developed to assist individuals with perceived sensory processing difficulties. Ayres (1979) speculated that the sensory system could develop over time, like other aspects of development (e.g., motor, language, etc). The hypothesis was formed that by providing appropriate "types and dosages" of sensory stimulation (e.g., auditory, visual, proprioceptive, vestibular), the nervous system may begin processing sensory stimuli more efficiently (Baranek, 2002; Lane et al., 2010; Schaaf & Miller, 2005). Numerous studies have documented the application of sensory integration in autistic populations (Lang et al., 2012).

In 2011, Parham and colleagues developed the *Ayres Sensory Integration Fidelity Measure* which outlines ten essential characteristics of an effective sensory integration session (see Table 2). Ayres Sensory Integration (ASI) is trademarked (Parham et al., 2011) and is distinct from other sensory integration therapies and "sensory based interventions". Sensory integration in this section of the chapter refers to those interventions which are associated with Ayres' prescribed method. ASI is typically administered by trained Occupational Therapists (OT) or by paraprofessionals trained by an OT to implement the activities and techniques in clinic settings (Dempsey & Foreman, 2001). Schaaf and Blanche (2011) proposed that in order to meet the "gold standard" in designing sensory integration for an individual, an assessment of sensory processing entails: (a) Sensory Integration and Praxis Test (Ayres, 1989); (b) Sensory Profile (Dunn, 1999); (c) Sensory Processing Measures (Parham et al., 2007b); and (d) structured clinical observations (Blanche, 2010).

Ayres' *Sensory Integration Fidelity Measure*, based on the trademark "Ayres Sensory Integration", outlines 10 essential characteristics of an effective sensory integration session (Parham et al., 2011; see Table 2). According to Parham et al. (2011) it is these 10 components of the intervention that distinguishes it from other sensory based interventions or sensory integration therapies. Additional distinctions are suggested which depend on "clinic-based" delivery and "multisensory input"

Table 2 Ten proposed essential characteristics of an effective sensory integration session (Adapted from Parham et al., 2011)

Characteristic
1. Ensures physical safety.
2. Presents sensory opportunities.
3. Helps the child to attain and maintain appropriate levels of alertness.
4. Challenges postural, ocular, oral, or bilateral motor control.
5. Challenges praxis and organization of behavior.
6. Collaborates in activity choice.
7. Tailors activity to present just-right challenge.
8. Ensures that activities are successful.
9. Supports child's intrinsic motivation to play.
10. Establishes a therapeutic alliance.

for ASI versus "non clinic-based" delivery and "a variety of sensory strategies" for sensory based interventions or sensory integration therapies. Whether we consider these distinctions as meaningful or superficial will be discussed further at the end of this section of the chapter.

Sensory Integration: Evidence-Base

In 2012, Lang and colleagues provided a systematic literature review of sensory integration therapy for autism spectrum disorders. Certainty of evidence was examined for 25 included studies. It was concluded by the authors that evidence for the use of Sensory Integration methods to educate or address difficulties in autistic children is not apparent. In recent years there has been a move by practitioners in the field of Sensory Integration to draw a clearer distinction between ASI and Sensory Integration and other sensory based interventions which was noted as a shortcoming of the 2012 literature review described. As a result, this has yielded a new wave of systematic reviews to examine the extant evidence base and to report the findings separately for Sensory Integration termed ASI. Two such reviews (see Table 3) have been reported by Case-Smith et al. (2014) and Watling and Hauer (2015). The review by Case-Smith and colleagues examined the effects of ASI on children with sensory processing difficulties. The second review by Watling and Hauer (2015) examined the effects of ASI on performance in daily activities and occupations for autistic children. However, the authors of both reviews highlighted the variability of outcome measures across studies as a limiting factor prohibiting the identification of a precise benefit of intervention. Other limitations of included studies involved limited or no follow-up measures, difficulties in interpreting meaningful changes in behavior due to the types of measures employed and insubstantial blinding methods employed. Finally, Schoen et al. (2019); see Table 3) undertook a systematic literature review to examine the outcomes of ASI for children with a diagnosis of ASD

Table 3 Three systematic literature reviews with studies examining Ayres Sensory Integration extracted

Studies and Findings Case-Smith et al. (2014)
(i) Two RCT studies, (ii) one group design with a comparison group (treatment as usual), (iii) one single subject research design and (iv) one case report. of which: – One study reported no effect; one reported low effect; two reported low to moderate effects (i.e., improvement was noted in two of the four measures), and the case study reported positive findings which were not generalizable.
Studies and Findings Watling and Hauer (2015)
(i) four studies utilizing Ayres Sensory Integration Studies reported positive effects on individualized goals for autistic individuals,
(ii) three RCT studies and one single subject research design the RCT studies were identified as showing low risk of bias; improvements were noted on measures of sensory and motor skills for children receiving sensory integration compared with other interventions; various limitations of studies were reported.
Studies and Findings Schoen et al. (2019)
(i) Three studies examining ASI of which: – one RCT study met 100% CEC criteria for evidence-based practice – one RCT study met 85% CEC criteria – one study met 50% CEC criteria The authors concluded that ASI meets the CEC criteria for evidence-based practice.

ASI Ayres sensory integration, *CEC* Council for exceptional children

with a measured IQ above 65 and concluded that it met the criteria for evidence-based practice according to the Council for Exceptional Children (CEC, 2014).

At present, the only guiding document with respect to Sensory Integration is the fidelity measure developed by Parham et al. (2011). This document provides practitioners and researchers with recommendations for structural and process elements of ASI but is not widely used within research (Pfeiffer et al., 2011; Schaaf et al., 2014) and only a small number of published studies have reported to incorporate the 10 "essential" principles of an effective sensory integration session. In addition, this fidelity measure does not provide information on recommended duration or frequency of intervention. Interventions described in the reviews in Table 2 varied significantly in duration making direct comparisons across studies difficult. Therefore, it is required that Sensory Integration/ASI practitioners develop clearer guidelines for practice in relation to the duration and frequency of intervention, to support more vigorous recommendations. In addition, guidelines for implementation would enable more consistent and reliable application.

A recent reiteration of analysis and evaluation of the intervention literature related to evidence-based practices for autistic children and adolescents revealed that ASI may be considered a new evidence-based practice category (Hume et al., 2021). This finding is based on what the authors refer to as three published group designs. In this "third generation review" of evidence, ASI is specifically described as "interventions that target a person's ability to integrate sensory information (visual, auditory, tactile, proprioceptive, and vestibular) from their body and environment in order to respond using organized and adaptive behavior" (online ahead

of print). However, the three studies incorporated to determine this outcome were not detailed in the review. According to Weitlauf et al. (2017) and previous reviews of sensory integration (Lang et al., 2012), low to moderate empirical support for studies on the effectiveness of this intervention is demonstrated. However, in line with Hume et al. (2021), reviews which identified manualized sensory integration interventions from sensory based interventions reported stronger evidence.

It appears that a separation of Sensory Integration from other sensory based interventions or sensory integration therapies based on the fidelity measures proposed by Parham et al. (2011) facilitates proponents of this intervention to distinguish studies that do not result in benefits to autistic individuals and determine that they are not "true sensory integration" interventions. We have concerns with this position. First, the inherent difficulties are elucidated on closer examination of the 10 proposed checklist items (Table 2). Many other sensory based interventions or sensory integration therapies reported in the literature meet several (or all) of the criteria e.g., ensuring physical safety, presenting sensory opportunities, requiring a level of "alertness", and establishing a therapeutic alliance. Second, Parham et al. (2011) have not presented evidence for differentiating "true sensory integration" based on a differential mechanism of action due to setting type (e.g., clinic vs school-based). We argue that this categorization requirement is not well empirically supported. Third, categorizing Sensory Integration by its utility of "multisensory input" provided through a multitude of strategies is not a meaningful and well-defined distinction from other sensory based interventions. These sensory based interventions are addressed in the next section.

Sensory Based Interventions: Theory and Description

Similar to Sensory Integration, sensory-based interventions are based on neuroscience models which hypothesize that an individual's nervous systems' ability to process sensory information can be enhanced through the application of sensations to promote change in arousal state (Case-Smith et al., 2014). Sensory based interventions are used with the intention of producing short term effects on what are referred to as "self-regulation", "attention", or "behavioral organization" (Watling et al., 2011).

Sensory based interventions involve the delivery of sensory activities or experiences. However, it has been proposed that they do not meet all of the characteristics of the fidelity measure set out by Parham et al. (2011) and are distinguishable by **one** of the following: (a) somatosensory and vestibular activities are provided but suspension equipment is not used; (b) typically involve the delivery of one technique associated with Sensory Integration (e.g., body brushing, massage, swinging, bouncing on a therapy ball); (b) adult lead and passively applied requiring minimum engagement from the child; or (d) focused on cognitive outcomes. These interventions are typically delivered by a family member, teacher or carer and are designed to be used in the natural environment and integrated into daily routines in a

systematic manner across the day or as deemed necessary in response to a child's self-regulation, often referred to as a "Sensory Diet" (Watling & Hauer, 2015).

Sensory Based Interventions: Evidence-Base

In 2012, Lang and colleagues completed a systematic literature review which included Sensory Integration and sensory based interventions specific to autistic children. However, Lang et al. did not separately analyse studies relating to Sensory Integration and sensory based interventions. Subsequently reviews by Case-Smith et al. (2014) and Watling and Hauer (2015) have separately evaluated the outcomes for both Sensory Integration and sensory based interventions for autistic children. Case-Smith et al. (2014) examined the effect of sensory based interventions on sensory processing difficulties for autistic children across 14 included studies. A number of outcome variables were measured including attention or engagement, responding to tasks, self-regulation, stereotypical and self-injurious behaviors. Overall, the review by Case-Smith et al. (2014) concluded that outcomes provided limited evidence of positive effect for sensory based interventions.

Similarly, Watling and Hauer (2015) examined the effects of sensory based interventions on improving performance in daily life activities and occupations for autistic children, across 18 included studies. The authors subdivided their analysis to evaluate multisensory interventions (included two or more sensory stimuli), single sensory interventions or modifications to the sensory environment. Overall, the authors concluded that at best sensory based interventions offered mixed results and also highlighted two key limitations of the related literature: (a) A wide variety of strategies used may render the category sensory based interventions undefined, and (b) the subdivision of strategies within sensory based interventions may not be adequately sensitive, concluding that each strategy should instead be evaluated separately.

In 2015, Wan Yanus, Liu, Bissett and Penkala conducted a systematic literature review to analyze sensory based interventions for children referencing behavioral problems as the primary outcome measure (Wan Yunus et al., 2015). Across 14 studies included in their review, the authors categorized three sensory based interventions as tactile, proprioceptive and vestibular. The majority of participants in the included studies were autistic (180 of 298 participants) and although results were not analyzed for participant cohorts separately, conclusions drawn indicate that evidence concerning the effectiveness of these interventions remains obscure.

Due to the methodological limitations of the available literature (e.g., variations in procedural implementation, small sample sizes, lack of blinded evaluations, etc.) it is not possible to draw conclusive findings with any certainty for any of the strategies housed under the label sensory based interventions on an individual basis. A compounding limitation involves the variability in the outcomes measured across studies which prohibits conclusive findings on the effects of these specific sensory interventions on any aspect of functioning and the generalizability of these proposed effects.

Auditory Integration Therapies: Theory and Description

Auditory Integration Therapies theorize that autistic individuals are unable to efficiently process auditory input (Berard, 1993). The underlying theory offers the idea that irrespective of hearing ability, a person may be considered to have a sensitivity to certain frequencies of soundwaves which may be associated with a range of learning problems (Berard, 1993). Evidence on the mechanisms of Auditory Integration Therapy is not provided but it is claimed that it "re-educates" the hearing process and purports to exercise and tone the muscles in the ear in order to improve the brain's ability to process sounds (Davis, 2007).

Interventions to overcome perceived auditory sensitivities are collectively called auditory integration therapies. They consist of Auditory Integration Training, Tomatis Sound Therapy and Samonas Sound Therapy, with the latter two emerging from modifications to Auditory Integration Therapy. The intended aim of all three methods is cited as being to overcome auditory processing deficits and improve concentration (Sinha et al., 2006). Auditory Integration Therapy consists of 10 hours of exposure to electronically modified music at a pre-specified decibel level, delivered using headphones across 10 days for an individual. The Auditory Integration Therapy equipment dampens sound frequencies to which the individual is said to be hypersensitive to and modulates sounds of high and low frequencies and intensities (Berard, 1993).

Tomatis Sound Therapy was developed by Alfred Tomatis and uses electronically modified human voice and music delivered through an "Electronic Ear" (Baumgaertel, 1999). Intervention is individualized with variations in the duration of therapy and scheduling of treatment blocks. Samonas Sound Therapy was a further development of the Tomatis methods and involves listening to recordings of voices and sounds of nature through headphones. Guidelines for the implementation of all three interventions are vague. In contrast to Berard (1993), Sinha and colleagues cite that intensity of the intervention (duration and frequency) may vary for example at the discretion of individual therapists and the person's perceived needs (Sinha et al., 2011).

Auditory Integration Therapies: Evidence-Base

To date, two systematic literature reviews (Sinha et al., 2006; Sinha et al., 2011) have been undertaken to examine the evidence base for auditory integration therapies for autistic individuals. The first, undertaken in 2006, identified six randomized control trials (RCTs) of Auditory Integration Therapy. Subsequently a Cochrane Review by Sinha et al. was published in 2011 and added one RCT of Tomatis Sound Therapy. Three of the six RCTs included in both reviews reported improvements in behavioral difficulties at three months for the groups who received Auditory Integration Therapy. The measure for behaviour was based on the *Aberrant*

Behaviour Checklist (Aman & Singh, 1986) however, total scores rather than subscale scores were analyzed which is considered a limitation. In addition, methodological flaws, such as risk of bias, lack of allocation concealment, and blinding, were present across the studies. The one RCT which examined Tomatis Sound Therapy found no difference in outcomes. In summary, the reviews concluded that the respective studies included a wide range of variable outcome measures and reported mixed findings, thus, prohibiting a definitive conclusion or replication of findings.

The American Academy of Pediatrics (2016) states that Auditory Integration Therapy has not proved to be scientifically valid and suggests that currently available information does not support the claims that it may be considered an efficacious sensory intervention. Despite the absence of evidence to support its effectiveness, Auditory Integration Therapy continues to be implemented as a means to reduce specific sensory related behaviors, in particular stereotypy (LaFrance et al., 2015). Auditory Integration Therapy and sound therapies remain costly interventions which have a limited evidence base to support their use, and which also result in a loss of instructional time which could be devoted to other empirically supported interventions.

Comparing Sensory Interventions to Other Interventions

In clinical practice, for a behavior to be considered problematic is when it leads to substantial consequences for the person such as medical, physical or psychosocial impacts. In this instance assessment and subsequent intervention may be required. This means that a behavior should only be considered problematic if it is detrimental to the person (Woods & Houghton, 2016). Proponents of sensory interventions have theorized that behavioral problems in autistic children are associated with sensory processing difficulties (Wan Yunus et al., 2015). Under this thesis lies an *assumption* that particular behavioral responses in autism are a result of sensory seeking or sensory avoiding (Ben-Sasson et al., 2009). On this basis, sensory interventions are often recommended by health and educational professionals as a way of addressing behavioral problems caused by so-called dysfunction in sensory processing (Case-Smith & Arbesman, 2008). In this section of the chapter, we address this contention of sensory interventions by presenting research that has specifically challenged the assumption that behavioral responses are a result of this proposed sensory dysfunction.

A body of research exists directly comparing the therapeutic effects of specific sensory interventions with other interventions for autistic individuals where specific behaviors have been determined to have significant detrimental impacts for an individual. This section of the chapter will examine a number of these studies.

Devlin et al. (2011) sought to compare the effects of Sensory Integration and behavioral intervention on rates of challenging behaviour using an alternating treatments design. A pre-intervention functional analysis demonstrated that the function

of participants' challenging behavior was to escape demands or to access preferred items. Function-based behavioral interventions were developed as part of the behavioural intervention phase for each participant. The findings of the study demonstrated that individualized behavioral interventions targeting challenging behavior in tandem with functionally equivalent replacement behaviors was more effective than sensory integration in reducing challenging behavior.

The authors argued that incorporating functional analysis to determine the underlying context (motivation, outcomes, and environmental variables) for behavior that may be distressing for an individual supersedes assumptions that may arise in real-world settings. Undertaking functional analysis and determining the underlying context for distressed behaviour was a more reliable and valid approach than forming and acting on untested assumptions in real world settings. Assuming that specific behavioral reactivity is underscored by an impaired ability to deal with sensory information may result in unsuccessful intervention outcomes or indeed strengthening the occurrence and intensity of such behaviour in some cases (Devlin et al., 2011).

Quigley et al. (2011) compared a sensory based intervention to a behavioural intervention with three participants ranging in age from 4 to twelve years, with a diagnosis of autism and Attention Deficit Hyperactivity Disorder. Functional analyses revealed that participant's challenging behaviours (e.g., destruction of property, hitting others, kicking, biting own hand) functioned to escape demands or access preferred items. A single case research design, was used to evaluate the effects of wearing a weighted vest compared to functional communication training whereby difficult behaviour was replaced with more appropriate communication that achieved the same outcome for the individual. No decrease in challenging behaviour was observed with the introduction of weighted vests. However, functional communication training, resulted in a reduction in challenging behaviour for all participants. These results are consistent with previous findings, which demonstrate that single and multi-sensory based interventions were not effective in reducing rates of challenging behaviour observed in autistic children (Devlin et al., 2009; Devlin et al., 2011). Together these studies highlight the importance and value of providing function-based interventions for specific behavioral responses and a need for further analyses of protocols to determine specific replacement behaviors.

In some cases, distressed behaviors shown by autistic individuals may not function to acquire some form of social reinforcement (i.e., attention, preferred items, escape demands/discomfort) described in the studies above. The analysis of behavior maintained by automatic reinforcement (in the absence of the social environment e.g., hair pulling to produce sensations in the scalp or skin scratching to relieve irritation) has been well documented (Wacker et al., 2004). However, conceptualizing behavior as simply "automatically reinforcing" may be of limited use for intervention design (Cunningham & Schreibman, 2008; LeBlanc et al., 2000; Vollmer et al., 1994). Observing another person's sensory experiences is difficult because they occur internally. Researchers have suggested examining a relationship between physiology and sensory related behaviors that produce some changes in arousal levels to supplement the design of individualized intervention (Lydon et al.,

2015). This suggestion is based on demonstrations of successful arousal-inducing (e.g., physical exercise; Lang et al., 2010) or de-arousing strategies (e.g., relaxation training protocols; Lynne Mullins & Christian, 2001) in impacting specific sensory related outcomes.

The identification of the internal variables which are positively or negatively reinforcing sensory related behaviors may allow for the development of function-based behavioral intervention (Lydon et al., 2013). Behavioral interventions have been shown to be effective in improving outcomes where sensory related behavior is a function of alterations in internal states e.g., sensory extinction and access to noncontingent 'matched' stimuli that substitutes for the sensory stimulation produced by the behaviors. It may be argued that in cases where some form of sensory reinforcement is sought providing a person with an effective means of accessing such stimulation (e.g., utilizing functional communication training) would be beneficial. Providing frequent free access to such sensory reinforcement may also be favorable (e.g., non-contingent reinforcement) or providing alternative activities or items that provide same/similar sensory pay offs may be useful (e.g., matched stimulation). Each of these interventions could be tailored to meet a person's preferences and needs once the underlying tenet(s) of the behavior have been discovered.

To date, there are still limitations in the number and types of studies comparing the efficacy of different intervention practices to address problem behavior rooted in sensory difficulties in autistic individuals. Where these direct comparisons have occurred, positive effects were reported for behavioral interventions to reduce sensory responses maintained by a variety of identified functions displayed by autistic individuals (Patterson et al., 2010). Where the function of sensory responses for autistic individuals is determined to be a need for unique sensory input or an attempt to avoid or remove specific sensory stimulation, we believe that an effective intervention can be designed to meet those specific needs incorporating a range of communication and adaptive skills.

Outcomes of specific sensory based interventions have also been compared to interventions other than function-based behavioral interventions. These include a fine motor skills intervention (Pfeiffer et al., 2011), manualized occupational therapy (Schaaf et al., 2014), "usual care" (Fazlioğlu & Baran, 2008), and an eclectic group-based therapy including social skill training, communication training, kinetic activities, and child-parent play (Iwanaga et al., 2014). Overall findings from these studies indicate that sensory integration may result in improved outcomes when compared to usual care. While these small, short-term studies demonstrated improved outcomes on sensory related behaviors and motor skills in children receiving a sensory intervention, the difference in outcomes reported were typically not statistically significant. The reliance on parent report of outcomes in unblinded studies is also considered a limitation.

Conclusions

The heterogeneous sensory characteristics seen in autistic individuals have presented challenges in determining how to characterize corresponding sensory processing difficulties and behavioral reactivity. The debate continues among the medical profession and the field of occupational therapy specifically as to how best to describe the distinctive nature of associated sensory processing difficulties in autistic populations and understand underlying contributing factors. An understanding of these parameters is important as it feeds into determining how best to support individuals with sensory processing difficulties, where these are impacting negatively. If clinical practice in the field of autism intervention is intended to be evidence-based, the evidence for sensory processing disorder to date is poor. Determining whether interventions for sensory related behaviors are necessary should involve a consideration of the idiosyncratic strengths and needs of the child or young person as well as family views and interpretations of the potential contextual factors. Conducting functional behavioral assessments to assist in this process is recommended to develop comprehensive interventions grounded in science. Professionals from health, medicine, education, psychology as well as other therapies must work with individuals and their families to determine whether sensory related behaviors displayed by an autistic person function to seek or avoid specific types of stimuli. When such unusual responses to achieve or avoid sensory stimulation is reported by the individual themselves, or where necessary alongside their parents/carers/teachers to interfere with a person's potential to flourish and thrive across environments, is an important factor in deciding to provide intervention. The rate and intensity of the responding can also play a role in this determination. Importantly, decisions in relation to selecting and implementing sensory interventions need to be guided by clinical practice housed within an evidence-based practice decision making model.

We conclude that examining the underlying function of a particular behavior to determine if it is sensory related and considering sensory difficulties as part of the individualization of intervention services is advisable. Where the function of behavioral responses for individuals is determined to be a need for unique sensory input, the clinical expertise of occupational therapists who work with autistic individuals may prove to be a valuable resource in designing comprehensive intervention (Patterson et al., 2010). Moreover, consultation with a Board Certified Behaviour Analyst (BCBA®) can aid in developing and implementing effective interventions that are person centred.

Some controversial sensory interventions have yet to develop a base of empirical evidence to support their use to reduce or improve sensory related behaviors in autistic individuals, yet they are being implemented in homes, schools and services internationally (Leong et al., 2015). Parents receive conflicting and sometimes unqualified recommendations from professionals involved with their children. Following such recommendations may result in diverting resources from beneficial interventions. Identifying sensory processing difficulties and gaining insight into an

individual's sensory needs and context can inform and tailor interventions to support the individual where sensory difficulties are impacting detrimentally. Any intervention should also have an evidence base before it can be considered.

From a clinical viewpoint diagnosis is critical in terms of driving intervention. A diagnosis aids understanding and informs intervention. There is no condition ascribed to sensory processing in the DSM5 as there is insufficient evidence and thus a lack of an informed or agreed basis to approach any individual needs. Indeed, making assumptions that are underscored by a presumed impaired ability to deal with sensory information could impact negatively in a number of ways. There is an urgent need for policy makers and clinicians to ensure they are knowledgeable in limitations of current practices and the implementation of others.

References

Aman, M. G., & Singh, N. N. (1986). *Aberrant behavior checklist*. Slosson.

American Academy of Pediatrics. (2012). Policy statement: Sensory integration therapies for children with developmental and behavioral disorders. *Pediatrics, 129*(6), 1186–1189. https://doi.org/10.1542/peds.2012-0876

American Academy of Pediatrics. (2016). *Prescribing therapy services for children with motor disabilities*. June 2004. Reaffirmed December 2016.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). APA.

Ayres, A. J. (1979). *Sensory integration and the child*. Western Psychological Services.

Ayres, A. J. (1989). *Sensory integration and praxis test*. Western Psychological Services.

Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders, 32*, 397–422. https://doi.org/10.1023/A:1020541906063

Baumgaertel, A. (1999). Alternative and controversial treatments for attention deficit hyperactivity disorder. *Pediatric Clinics North America, 46*, 977–992. https://doi.org/10.1016/s0031-3955(05)70167-x

Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A Meta-analysis of sensory modulation symptoms in individuals with Autism Spectrum Disorders. *Journal of Autism & Developmental Disorders, 39*(1), 1–11. https://doi.org/10.1007/s10803-008-0593-3

Berard, G. (1993). *Hearing equals behaviour*. Keats Publishing.

Blanche, E. I. (2010). *Observations based on sensory integration*. [Video and Book] Torrance, CA: Pediatric Therapy Network.

Brinkert, J., & Remington, A. (2020). Making sense of the perceptual capacities in autistic and non-autistic adults. *Autism: The International Journal of Research and Practice, 24*(7), 1795–1804. https://doi.org/10.1177/1362361320922640

Carmody, D. P., Kaplan, M., & Gaydos A. M. (2001). Spatial orientation adjustments in children with autism in Hong Kong. *Child Psychiatry and Human Development. 31*, 233–247. https://doi.org/10.1023/a:1026481422227

Case-Smith, J., & Arbesman, M. (2008). Evidence-based review of interventions for autism used in or of relevance to occupational therapy. *American Journal of Occupational Therapy, 62*, 416–429. https://doi.org/10.5014/ajot.62.4.416

Case-Smith, J., Weaver, L. L., & Fristad, M. A. (2014). A systematic review of sensory processing interventions for children with autism spectrum disorders. *Autism, 19*, 133–148. https://doi.org/10.1177/1362361313517762

Council for Exceptional Children [CEC]. (2014). *Council for Exceptional Children: Standards for evidence-based practices in special education*. CEC. Retrieved from http://www.cec.sped.org/~/media/Files/Standards/Evidence%20based%20Practices%20and%20Practice/EBP%20FINAL.pdf

Cunningham, A. B., & Schreibman, L. (2008). Stereotypy in autism: The importance of function. *Research in Autism Spectrum Disorders, 2*(3), 469–479. https://doi.org/10.1016/j.rasd.2007.09.006

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., Alexander, A. L., & Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8*, 519–526. https://doi.org/10.1038/nn1421

Davis, D. S. (2007). Alternative therapies: Sound-based interventions. In D. Geffner & D. Ross-Swaim (Eds.), *Auditory processing disorders: Assessment, management and treatment* (pp. 457–470). Plural Publishing.

Dempsey, I., & Foreman, P. (2001). A review of educational approaches for individuals with autism. *International Journal of Disability, Development, and Education, 48*(1), 103–116. https://doi.org/10.1080/10349120120036332

Devlin, S., Healy, O., Leader, G., & Hughes, B. (2011). Comparison of behavioural intervention and sensory integration therapy in the treatment of challenging behaviour. *Journal of Autism and Developmental Disabilities, 41*(10), 1303–1320.

Devlin, S., Leader, G., & Healy, O. (2009). Comparison of behavioral intervention and sensory-integration therapy in the treatment of self-injurious behavior. *Research in Autism Spectrum Disorders, 3*(1), 223–231.

Dunn, W. (1999). *The sensory profile: User's manual*. Psychological Corporation.

Dunn, W., Little, L., Dean, E., Robertson, S., & Evans, B. (2016). The state of the science on sensory factors and their impact on daily life for children: A scoping review. *OTJR: Occupation, Participation and Health, 36*(2_suppl), 3S–26S. https://doi.org/10.1177/1539449215617923

Falkner, L. M. (2020). *Sensory intelligence. An exploratory programme evaluation in a secondary school autism resource base*. Doctorate in Educational Psychology. Cardiff University, UK

Fazlioğlu, Y., & Baran, G. (2008). A sensory integration therapy program on sensory problems for children with autism. *Perceptual and Motor Skills, 106*(2), 415–422.

Galpin, J., Osman, L., & Paramore, C. (2018). Sensory snack time: A school-based intervention addressing food selectivity in autistic children. *Frontiers in Education, 3*, 77. https://doi.org/10.3389/feduc.2018.00077

Geretsegger, M., Elefant, C., Mössler, K. A., & Gold, C. (2014). Music therapy for people with autism spectrum disorder. *Cochrane Database Systemic Reviews*, (6), CD004381. https://doi.org/10.1002/14651858.CD004381.pub3

Glass, L., Ware, A. L., & Mattson, S. N. (2014). Chapter 25—Neurobehavioral, neurologic, and neuroimaging characteristics of fetal alcohol spectrum disorders. *Handbook of Clinical Neurology, 125*, 435–462. https://doi.org/10.1016/B978-0-444-62619-6.00025-2

Gliga, T., Bedford, R., Charman, T., Johnson, M. H., & Team, B. A. S. I. S. (2015). Enhanced visual search in infancy predicts emerging autism symptoms. *Current Biology, 25*(13), 1727–1730. https://doi.org/10.1016/j.cub.2015.05.011

Happé, F., Ronald, A., & Plomin, R. (2006). Time to give up on a single explanation for autism. *Nature Neuroscience, 9*(10), 1218–1220. https://doi.org/10.1038/nn1770

Hume, K., Steinbrenner, J. R., Odom, S. L., Morin, K. L., Nowell, S. W., Tomaszewski, B., et al. (2021). Evidence-Based practices for children, youth, and young adults with autism: Third generation review. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-020-04844-2

Iarocci, G., & McDonald, J. (2006). Sensory integration and the perceptual experience of persons with autism. *Journal of Autism & Developmental Disorders, 36*(1), 77–90. https://doi.org/10.1007/s10803-005-0044-3

Iwanaga, R., Honda, S., Nakane, H., Tanaka, K., Toeda, H., & Tanaka, G. (2014). Pilot study: Efficacy of sensory integration therapy for Japanese children with high-functioning autism spectrum disorder. *Occupational Therapy International, 21*(1), 4–11. https://doi.org/10.1002/oti.1357

Kelly, M. P., & Reed, P. (2021). Examination of stimulus over-selectivity in children with autism spectrum disorder and its relationship to stereotyped behaviors and cognitive flexibility. *Focus on Autism & Other Developmental Disabilities, 36*(1), 47–56. https://doi.org/10.1177/1088357620943504

Kern, J. K., Garver, C. R., Carmody, T., Andrews, A. A., Mehta, J. A., & Trivedi, M. H. (2008). Examining sensory modulation in individuals with autism as compared to community controls. *Research in Autism Spectrum Disorders, 2*(1), 85–94. https://doi.org/10.1016/j.rasd.2007.03.004

Klintwall, L., Holm, A., Eriksson, M., Carlsson, L. H., Olsson, M. B., Hedvall, A., Gillberg, C., & Fernell, E. (2011). Sensory abnormalities in autism: A brief report. *Research in Developmental Disabilities, 32*, 795–800. https://doi.org/10.1016/j.ridd.2010.10.021

LaFrance, D. L., Miguel, C. F., Donahue, J. N., & Fechter, T. R. (2015). A case study on the use of auditory integration training as a treatment for stereotypy. *Behavioral Interventions, 30*(3), 286–293.

Lane, A. E., Young, R. L., Baker, A. E. Z., & Angley, M. T. (2010). Sensory processing subtypes in autism: Association with adaptive behavior. *Journal of Autism & Developmental Disorders, 40*(1), 112–122. https://doi.org/10.1007/s10803-009-0840-2

Lane, S. J., & Schaaf, R. C. (2010). Examining the neuroscience evidence for sensory-driven neuroplasticity: Implications for sensory-based occupational therapy for children and adolescents. *American Journal of Occupational Therapy, 64*(3), 375–390. https://doi.org/10.5014/ajot.2010.09069

Lang, R., O'Reilly, M., Sigafoos, J., Machalicek, W., Rispoli, M., Lancioni, G. E., Aguilar, J., & Fragale, C. (2010). The effects of an abolishing operation intervention component on play skills, challenging behavior, and stereotypy. *Behavior Modification, 34*(4), 267–289. https://doi.org/10.1177/0145445510370713

Lang, R. O., Reilly, M., Healy, O., Rispoli, M., Lydon, H., Streusand, W., Davis, et al. (2012). Sensory integration therapy for autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 6*(3), 1004–1018. https://doi.org/10.1016/j.rasd.2012.01.006

LeBlanc, L. A., Hagopian, L. P., & Maglieri, K. A. (2000). Use of a token economy to eliminate excessive inappropriate social behavior in an adult with developmental disabilities. *Behavioral Interventions, 15*(2), 135–143. https://doi.org/10.1002/(SICI)1099-078X(200004/06)15:2<135::AID-BIN51>3.0.CO;2-3

Leong, H. M., Carter, M., & Stephenson, J. R. (2015). Meta-analysis of research on sensory integration therapy for individuals with developmental and learning disabilities. *Journal of Developmental and Physical Disabilities, 27*(2), 183–206. https://doi.org/10.1007/s10882-014-9408-y

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006). Sensory and attention abnormalities in autistic spectrum disorders. *Autism: The International Journal of Research & Practice, 10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Lombard, A. (2015). *Rethink the way we live. (Course handbook)*. Sensory Intelligence Consulting.

Lydon, S., Healy, O., & Dwyer, M. (2013). An examination of heart rate during challenging behavior in Autism Spectrum Disorder. *Journal of Developmental and Physical Disabilities, 25*, 149–170. https://doi.org/10.1007/s10882-012-9324-y

Lydon, S., Healy, O., Reed, P., Mulhern, T., Hughes, B. M., & Goodwin, M. S. (2016). A systematic review of physiological reactivity to stimuli in autism. *Developmental Neurorehabilitation, 2014*, 1–21. https://doi.org/10.3109/17518423.2014.971975

Lydon, S., Healy, O., Roche, M., Henry, R., Mulhern, T., & Hughes, B. M. (2015). Salivary cortisol levels and challenging behavior in children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 10*, 78–92. https://doi.org/10.1016/j.rasd.2014.10.020

Lynne Mullins, J., & Christian, L. (2001). The effects of progressive relaxation training on the disruptive behavior of a boy with autism. *Research in Developmental Disabilities, 22*(6), 449–462. https://doi.org/10.1016/S0891-4222(01)00083-X

May-Benson, T. A., & Koomar, J. A. (2008). AOTA's centennial vision and the sensory integration frame of reference. *Sensory Integration Special Interest Section Quarterly, 31*(1), 1–4.

Miller, L. J., Anzalone, M. E., Lane, S. J., Cermak, S. A., & Osten, E. T. (2007). Concept evolution in sensory integration: A proposed nosology for diagnosis. *American Journal of Occupational Therapy, 61*(2), 135–140. https://doi.org/10.5014/ajot.61.2.135

Mills, C., Chapparo, C., & Hinitt, J. (2016). The impact of an in-class sensory activity schedule on task performance of children with autism and intellectual disability: A pilot study. *British Journal of Occupational Therapy, 79*(9), 530–539. https://doi.org/10.1177/0308022616639989

Parham, L. D., Cohn, E. S., Spitzer, S., Koomar, J. A., Miller, L. J., Burke, J. P., et al. (2007b). Fidelity in sensory integration intervention research. *American Journal of Occupational Therapy, 61*(2), 216. https://doi.org/10.5014/ajot.61.2.216

Parham, L. D., Ecker, C., Miller-Kuhaneck, H., Henry, D. A., & Glennon, T. J. (2007a). *Sensory Processing Measure (SPM): Manual*. The Western Psychological Corporation.

Parham, L. D., Roley, S. S., May-Benson, T. A., Koomar, J., Brett-Green, B., Burke, J. P., & Schaaf, R. C. (2011). Development of a fidelity measure for research on the effectiveness of Ayres Sensory Integration® Intervention. *American Journal of Occupational Therapy, 65*, 133–142. https://doi.org/10.5014/ajot.2011.000745

Patterson, S. Y., Smith, V., & Jelen, M. (2010). Behavioural intervention practices for stereotypic and repetitive behaviour in individuals with autism spectrum disorder: A systematic review. *Developmental Medicine & Child Neurology, 52*(4), 318–327. https://doi.org/10.1111/j.1469-8749.2009.03597.x

Pengelly, S., Rogers, P., & Evans, K. (2009). Space at home for families with a child with autistic spectrum disorder. *British Journal of Occupational Therapy, 72*(9), 378–383. https://doi.org/10.1177/030802260907200902

Pfeiffer, B. A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). Effectiveness of sensory integration interventions in children with autism spectrum disorders: a pilot study. *The American Journal of Occupational Therapy, 65*, 76–85. https://doi.org/10.5014/ajot.2011.09205

Quigley, S. P., Peterson, L., Frieder, J. E., & Peterson, S. (2011). Effects of a weighted vest on problem behaviors during functional analyses in children with pervasive developmental disorders. *Research in Autism Spectrum Disorders, 5*(1), 529–538. https://doi.org/10.1016/j.rasd.2010.06.019

Randell, E., McNamara, R., Delport, S., Busse, M., Hastings, R. P., Gillespie, D., et al. (2019). Sensory integration therapy versus usual care for sensory processing difficulties in autism spectrum disorder in children: Study protocol for a pragmatic randomised controlled trial. *Trials, 20*(1), 1–11. https://doi.org/10.1186/s13063-019-3205-y

Reynolds, S., Bendixen, R. M., Lawrence, T., & Lane, S. J. (2011). A pilot study examining activity participation, sensory responsiveness, and competence in children with high functioning autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*, 1496–1506. https://doi.org/10.1007/s10803-010-1173-x

Robertson, A. E., & Simmons, D. R. (2010). Sensory sensitivities in autism spectrum disorders: A qualitative analysis. *International Meeting of Autism Research (IMFAR)*, 22–20 May, Philadelphia.

Robertson, C. E., & Baron-Cohen, S. (2017). Sensory perception in autism. *Nature Reviews Neuroscience, 18*(11), 671–684. https://doi.org/10.1038/nrn.2017.112

Rogers, S. J., & Ozonoff, S. (2005). Annotation: What do we know about sensory dysfunction in autism? A critical review of the empirical evidence. *Journal of Child Psychology & Psychiatry, 46*(12), 1255–1268. https://doi.org/10.1111/j.1469-7610.2005.01431.x

Schaaf, R., & Blanche, E. I. (2011). Comparison of behavioral intervention and sensory-integration therapy in the treatment of challenging behavior. *Journal of Autism Developmental Disorders, 41*(10), 1436–1441. https://doi.org/10.1007/s10803-011-1303-0

Schaaf, R. C., Benevides, T., Mailloux, Z., Faller, P., Hunt, J., van Hooydonk, E., Freeman, R., et al. (2014). An intervention for sensory difficulties in children with autism: A randomized trial. *Journal of Autism and Developmental Disorders, 44*(7), 1493–1506. https://doi.org/10.1007/s10803-013-1983-8

Schaaf, R. C., & Miller, L. J. (2005). Occupational therapy using a sensory integrative approach for children with developmental disabilities. *Mental Retardation & Developmental Disabilities Research Reviews, 11*(2), 143–148. https://doi.org/10.1002/mrdd.20067

Schoen, S. A., Lane, S. J., Mailloux, Z., May-Benson, T., Parham, D., Smith Roley, S., & Schaaf, R. C. (2019). A systematic review of Ayres sensory intervention for children with autism. *Autism Research, 12*, 6–19. https://doi.org/10.1002/aur.2046

Sinha, Y., Silove, N., Hayen, A., & Williams, K. (2011). Auditory integration training and other sound therapies for autism spectrum disorders: A systematic review. *Cochrane Database of Systematic Reviews*, (12), CD003681. https://doi.org/10.1002/14651858.CD003681.pub3

Sinha, Y., Silove, N., Wheeler, D., & Williams, K. (2006). Auditory integration training and other sound therapies for autism spectrum disorders: A systematic review. *Archives of Disease in Childhood, 91*(12), 1018–1022. https://doi.org/10.1136/adc.2006.094649

Tavassoli, T., Hoekstra, R. A., & Baron-Cohen, S. (2014). The Sensory Perception Quotient (SPQ): development and validation of a new sensory questionnaire for adults with and without autism. *Molecular Autism, 5*(1), 1–16. https://doi.org/10.1186/2040-2392-5-29

Top, D. N., Jr., Luke, S. G., Stephenson, K. G., & South, M. (2019). Psychophysiological arousal and auditory sensitivity in a cross-clinical sample of autistic and non-autistic anxious adults. *Frontiers in Psychiatry, 2019*, 9. https://doi.org/10.3389/fpsyt.2018.00783

Tseng, M. H., Fu, C. P., Cermak, S. A., Lu, L., & Shieh, J. Y. (2011). Emotional and behavioral problems in preschool children with autism: Relationship with sensory processing dysfunction. *Research in Autism Spectrum Disorders, 5*, 1441–1450. https://doi.org/10.1016/j.rasd.2011.02.004

Turner-Brown, L. M., Baranek, G. T., Reznick, J. S., Watson, L. R., & Crais, E. R. (2013). The first year inventory: A longitudinal follow-up of 12-month-old to 3-year-old children. *Autism: The International Journal of Research and Practice, 17*(5), 527–540. https://doi.org/10.1177/1362361312439633

Vollmer, T. R., Marcus, B. A., & LeBlanc, L. (1994). Treatment of self-injury and hand mouthing following inconclusive functional analyses. *Journal of Applied Behavior Analysis, 27*(2), 331–344. https://doi.org/10.1901/jaba.1994.27-331

Wacker, D., Berg, W., Harding, J., & Cooper-Brown, L. (2004). Use of brief experimental analyses in outpatient clinic and home settings. *Journal of Behavioral Education, 13*(4), 213–226. https://doi.org/10.1023/B:JOBE.0000044732.42711.f5

Wan Yunus, F., Liu, K., Bissett, M., & Penkala, S. (2015). Sensory-based intervention for children with behavioral problems: A systematic review. *Journal of Autism & Developmental Disorders, 45*(11), 3565–3579. https://doi.org/10.1007/s10803-015-2503-9

Watling, R., & Hauer, S. (2015). Effectiveness of Ayres sensory integration ® and sensory based interventions for people with autism spectrum disorder: A systematic review. *The American Journal of Occupational Therapy, 69*(5), 180,030. https://doi.org/10.5014/ajot.2015.018051

Watling, R., Koenig, K. P., Davies, P. L., & Schaaf, R. C. (2011). *Occupational therapy practice guidelines for children and adolescents with challenges in sensory processing and sensory integration*. AOTA Press.

Watts, S. J., Rodgers, J., & Riby, D. (2016). A systematic review of the evidence for hyporesponsivity in ASD. *Review Journal of Autism and Developmental Disorders, 3*(4), 286–301. https://doi.org/10.1007/s40489-016-0084-y

Weitlauf, A. S., Sathe, N., McPheeters, M. L., & Warren, Z. E. (2017). Interventions targeting sensory challenges in autism spectrum disorder: A systematic review. *Pediatrics, 139*(6), 1–22. https://doi.org/10.1542/peds.2017-0347

Wiggins, L. D., Robins, D. L., Bakeman, R., & Adamson, L. B. (2009). Brief report: Sensory abnormalities as distinguishing symptoms of autism spectrum disorders in young children. *Journal of Autism and Developmental Disorders, 39*, 1087–1091. https://doi.org/10.1007/s10803-009-0711-x

Woo, C. C., Donnelly, J. H., Steinberg-Epstein, R., & Leon, M. (2015). Environmental enrichment as a therapy for autism: a clinical trial replication and extension. *Behavioral Neuroscience, 129*(4), 412–422. https://doi.org/10.1037/bne0000068

Woo, C. C., & Leon, M. (2013). Environmental enrichment as an effective treatment for autism: A randomized controlled trial. *Behavioral Neuroscience, 127*(4), 487–497. https://doi.org/10.1037/a0033010

Woods, D. W., & Houghton, D. C. (2016). Evidence-based psychosocial treatments for pediatric body-focused repetitive behavior disorders. *Journal of Clinical Child & Adolescent Psychology, 45*(3), 227–240. https://doi.org/10.1080/15374416.2015.1055860

World Health Organization (2018). *International Statistical Classification of diseases and related health problems* (11th ed.; ICD-11).