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Sensory Processing Specificity in Autism

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Currently, autism is defined at the behavioral level. Although much has been learned about the genetic, environmental, structural, and neuropsychological etiologies of autism much more research must be conducted to reach a full comprehensive definition of the disorder. At the behavioral level, a significant portion of individuals with autism have some level of sensory processing deficit, studies report 100% prevalence in this population. The goal of many researchers in the autism field is to identify how abnormal sensory response patterns differentiate this group from those with other developmental disorders as well as those who are typically developing. Findings show atypical sensory response patterns in various sensory systems, in early development, and in response to particular types of stimuli. The present study sought to verify previous findings and further the investigation of unique modulation patterns across sensory systems in this population. This was be evaluated with the use of the Short Sensory Profile, a questionnaire given to caregivers to asses his/her child's response to sensory stimuli while performing a variety of tasks in daily life. Participants included parents or legal guardians of individuals diagnosed with autism, individuals diagnosed with attention-deficit hyperactivity disorder, and individuals without a diagnosis demonstrating typical developmental patterns.

Keywords*:* Autism, social reciprocity, restricted, repetitive behaviors, sensory processing, sensory modules.

Although recent knowledge in the scientific and nonscientific communities regarding the etiology of autism has grown, it remains a highly mysterious disorder. It is complicated by its changing definition, heterogeneous nature, and the dispute over the underlying mechanisms that can define autism at all levels of analysis. Researchers in pursuit of coming to a complete comprehensive definition of autism withstanding the heterogeneous nature of the disorder would greatly benefit from knowledge of the symptoms that differentiates autism from other disorders. The DSM V defines autism only at the behavioral level because it can only be described with certainty at this level. Researchers have long sought to define autism beyond the behavioral phenotype but a significant impediment to reaching this goal is the heterogeneous nature of the disorder (Georgiades, Szatmari, & Boyle, 2013). Any findings that prove to surpass heterogeneity, that can be used to define autism beyond the behavioral phenotype, and that can differentiate it both from the neuro-typical population and from other similarly defined disorders will be beneficial in developing instruments sensitive enough to detect autism early and specific enough to differentiate it from other disorders.

While autism is characterized by heterogeneity in symptoms severity and etiology at all levels of analysis, it is unified under broad behavioral phenotypes. Namely, autism is differentiated from other disorders by a deficit in social reciprocity and the presentation of restricted, repetitive behaviors (American Psychiatric Association, 2013). Research suggests that individuals diagnosed with autism also present with difficulty processing sensory

information in up to 100% of autistic participants (Hilton, Harper, Holmes Kueker, Runzi Lang, Abbacchia, Todrov, & Lavesser, 2010).

In response to this staggering prevalence of sensory processing difficulties reported among those who have received a diagnosis of autism, many studies have been conducted to determine if there is a sensory profile that can differentiate autism from other disorders and from the neuro-typical population. In this pursuit, researchers have found uniform modulation abnormalities in several sensory systems while, at the same time, been burdened by heterogeneity in sensory processing amongst participants diagnosed with autism.

Specifically, researchers have indicated that individuals with autism present with a unique combination of hyperresponsiveness, hyporesponsivenenss, and sensory-seeking within the auditory sensory system which responsible for the perception of sound, the proprioceptive sensory system which is responsible for the perception of input from joint capsules, ligaments, muscles, tendons, and skin, and in the multisensory system which is responsible for the summation of input from all other sensory systems (Ashburner, Bennett, Rodger, & Ziviani, 2013; Baranek, Fabian, Poe, Stone, & Watson, 2006; Blanche, Reinoso, Chang, & Bodison, 2012; Colligan, Charbonneau, Peters, Nassim, Lassonde, Lepore, Mottrom, & Bertone, 2013; Haswell, Izawa, Dowell, Mostofsky, & Shadmehr, 2009; Lane, Young, Baker, Angley, 2010; O'Riordan & Passetti, 2006; Tecchio, Benassi, Zappasodi, Gialloreti, Palermo, Seri, & Rossini, 2003).

The most prevalent modulation difficulties in autism are in the auditory sensory system. Researchers agree that auditory dysfunction affects 93% of individuals across the spectrum (Ashburner et al., 2013; Lane et al., 2010). While atypical modulation in the auditory sensory system is not specific to autism, there is a unique pattern of responsiveness that can differentiate this population from other disorders as well as from the neuro-typical population. Specifically, individuals with autism struggle significantly with auditory filtering or the ability to orient to relevant stimuli while disregarding extraneous auditory stimuli (Ashburner et al., 2013). Several studies have been conducted to show that difficulties in the auditory system seen in autism arise from enhanced discrimination between auditory stimuli (O'Riordan & Passetti, 2006). In one study, children diagnosed with high functioning autism were compared to a control group made up of neuro-typical children to determine how abilities in auditory discrimination could be differentiated between the groups. Using auditory stimuli recorded on a compact disc these researchers found that participants diagnosed with autism were significantly slower at identifying two identical tones when compared to the neuro-typical participants (O'Riordan & Passetti, 2006). Moreover, results of this study showed enhanced discrimination between similar but different auditory samples amongst autistic participants. O'Riordan and Passetti (2006) explain these results by stating that the decreased ability to identify two identical tones indicates that autistic participants perceived the two auditory samples as different longer than the neuro-typical group. These authors go on to speculate that the autistic participant's increased ability to differentiate auditory stimuli that were different but similar is directly related to the unique cognitive style seen in this population.

Robust findings have implicated distinct proprioceptive response patterns as well in individuals with autism, which may be differentiated from individuals with other

disorders and from the neuro-typical population (Blanche et al., 2012). In one study, Blanche and associates (2012) used the Comprehensive Observations of Proprioception to compare the proprioceptive response patterns displayed by participants diagnosed with autism and compared them to participants diagnosed with other developmental disorders. Results show distinctive patterns of proprioceptive responses and processing in individuals with autism. These differences were evident in feedback-related motor planning, tip-toeing, pushing of others or object, crashing, falling, and running. According to the researchers these findings have implications beyond the experimental condition. Individuals with autism have decreased motor-planning capabilities, difficulties with postural control, and disruptive, sensory-seeking behaviors. In another study, Haswell, Izawa, Dowell, Mostofsky, and Shadmehr (2009) used observation measures to compare motor control and imitation in children with autism to their neuro-typical peers. Results show difficulty in motor control amongst participants diagnosed with autism were related to difficulty matching proprioception motor planning and visual orientation as well as over dependence on the proprioceptive sensory system.

Within the autistic population multisensory system abnormalities have also been reported. The multisensory system's proper functioning is essential for the integration of stimuli accumulated from the rest of the sensory systems for accurate perception of the environment. A study by Colligan, Charbonneau, Peters, Nassim, Lassonde, Lepore, Mottrom, and Bertone (2013) showed that the dysfunction of the multisensory system in autism rests in abnormal integration. In the above study, autistic participants were compared to neuro-typical participants to investigate multisensory integration abilities. Using a combination of visual search tasks and auditory stimuli these authors report that participants in the autistic sample had more difficulty integrating sensory information from the two systems used as compared to participants from the neuro-typical participants. These results further indicate that integration dysfunction in autism is present in both complex sensory integration tasks, such as social interaction, as well as low level sensory integration tasks, such as matching audio stimuli to visual stimuli (Collignon et al.). Interestingly, additional researchers that have observed sensory integration dysfunction in the autistic population speculate that this may be directly related to reduced long-range connectivity (Tecchio et al., 2003). The functionality of multisensory integration depends on the connectivity of cortices and sub-cortical regions responsible for the perception of sensory information brought in by the six other sensory systems. Due to the reduced long-range connectivity between brain regions seen in autism the proper integration of sensory information for the complete perception of the environment suffers (Tecchio et al.).

A common limitation shared by previous studies has been in the selection of comparison groups. All studies have used a neuro-typical comparative group and those studies, which use a second comparative group have made them up with individuals diagnosed with other disorders with little to no correlative defining characteristics. In the present study, there were two comparative groups, a neuro-typical group and an attention-deficit hyperactivity (ADHD) group, a disorder with a similar behavioral definition. The first question asked was whether the autism group and the ADHD group could be differentiated from the neuro-typical group on the basis of sensory responsiveness. It was hypothesized that the autism group and the ADHD group could be

differentiated from the neuro-typical group on the basis of sensory responsiveness. The second question asked whether the autism group could be differentiated from the neuro-typical group. It was hypothesized that the autism group can be differentiated from the neuro-typical group on the basis of sensory responsiveness. The third research question asked whether the ADHD group could be differentiated from the neuro-typical group on the basis of sensory responsiveness. It was hypothesized that the ADHD group can be differentiated from the neuro-typical group on the basis of sensory responsiveness. The fourth research question asked whether the autism group could be differentiated from the ADHD group on the basis of sensory responsiveness. It was hypothesized that the autism group could be differentiated from the ADHD group on the basis of sensory responsiveness as measured by the Short Sensory Profile (SSP).

METHOD

Participants

Inclusion criteria for the present study were parents or caregivers of children diagnosed with ADHD or autism as well as parents or caretakers of typically developing children. Additionally, the present study included parents or caretakers of children with a diagnosis received from a qualified professional or no diagnosis. Participants for the present study will be recruited from the community. Specifically, participants were recruited from various sources including local treatment clinics, school-based programs, and other public sources. All participants were parents or caretakers of children between the ages of 1 and 18 years old to ensure consistency and valid comparisons. Participants who submitted incomplete questionnaires or incorrectly completed questionnaires and participants who did not have a diagnosis that fit within the three groups were not included in this study.

There were three groups included in this study. The first group was comprised of 8 parents or caretakers of children diagnosed with autism. Because of the limited pool and availability of these individuals, parents or caretakers of children diagnosed with autism across intellectual abilities and symptom severity were accepted. The second group was comprised of 7 parents or caretakers of children diagnosed with ADHD. The third group was comprised of 10 parents or caretakers of children who show typical patterns of development.

Participants in the autism group were comprised of one male and seven females. The male in this group identified himself as the father of the child the questionnaires were filled out for and the seven females in this group identified themselves as the mothers of the children the questionnaires were filled out for. The mean age of participants in this group was 31. The children in the autism group were all formally diagnosed with autism. The mean age for the children in this group was 8.6. Seven children in this group were male and one child was female. Treatment used for the children in this group was one medication based, four therapy-based, one nontraditional, one used a combination of treatments, and one used a nontraditional treatment.

Participants in the ADHD group were comprised of 7 females and no males. Six participants in this group identified themselves as the mothers of the children for, which the questionnaires were filled out and one participant identified herself as another caregiver. The mean age for participants in this group was 26. The children in the ADHD group were formally diagnosed with ADHD and had a mean age of 10.3. Three children in this group were identified as being male and four children

were identified in this group as being female. Treatment used for the children in this group included five mostly medication based, one therapy based, and one used another kind of treatment not specified.

The neuro-typical group was comprised of two males and eight females. Two participants identified themselves as the fathers of the children for which the questionnaires were filled out and eight participants identified themselves as the mothers of the children for which the questionnaires were filled out. The mean age of the participants in this group was 24. Children in the neuro-typical group were void of any diagnosis. The mean age of the children in this group was 5.1. Four children in this group were male and six children in this group were female. Six children in this group used no treatment, one child used a therapy-based treatment, one child used an unidentified treatment, and two participants did not answer this question on the demographic questionnaire.

Measures

The Short Sensory Profile is a 38-item parent or caregiver report questionnaire comprised of items selected from The Sensory Profile (Chen, 2009). The questions selected for this questionnaire are focused primarily on determining response pattern in each of the sensory systems with the exception of the multisensory system. Scoring for The Short Sensory Profile is on a 5-point Likert scale in which an answer of (1) is high and indicates "always," (2) is "frequently," (3) indicates "occasionally," (4) indicates "seldom," and (5) indicates "never." Each item on The Short Sensory Profile asks respondents how often the child in question engages in particular activities which then can be interpreted to indicate sensory responsiveness in the vestibular, proprioceptive, tactile, olfactory, auditory, and visual sensory systems. Interpretation of the data collected from The Short Sensory Profile is outlined in detail in the manual for the test which includes a Summary score sheet.

Internal consistency for The Short Sensory Profile total score was determined using the Cronbach's alpha and is α=.95 (Chen et al., 2009). Developers for the Sensory Profile and The Short Sensory Profile, Tomcheck and Dunn (2007), have found that 95% children diagnosed with autism show differentiating sensory features using only The Short Sensory Profile (as cited in Chen et al., 2009). Other tests of reliability such as test-retest reliability have not been reported due to the evolving nature of sensory responsiveness throughout development.

Procedures

The Short Sensory Profile was administered individually to each of the parents or caretakers. Participants were asked to consider behaviors and sensory responses of the child in question over the last six months and indicate the frequency of the behaviors or sensory responses for each question on The Short Sensory Profile. Participants were asked to circle a (1) if the behavior or response is observed "always," a (2) if it is observed "frequently," a (3) if it is observed "occasionally," a (4) if it is observed "seldom," and a (5) if the behavior is observed "never." Participants were asked to complete the questionnaires with the examiner present and once completed, scores will be kept confidential and, with the exception of diagnosis, will be void of all personal information.

Data Analysis

The reported SSP classification for all three groups were compared using between subjects factorial ANOVAS. Between-group SSP classifications were

then compared using one-way ANOVAS. The total score was treated independently from the section scores and a difference was considered significant when the p value was below .01. Mean total scores are shown in figure 1. Mean section scores are shown in figure 2. Standard deviations are shown in table 1.

Results

All Group Comparison

A 3 (diagnosis) X 1 (SSP Total score) and 3 (diagnosis) X 1 (SSP section scores) between subjects factorial ANOVA were calculated comparing sensory responsiveness and diagnosis. A significant main effect for diagnosis was found in Total scores, Tactile Sensitivity section scores, Underresponsiveness/Seeks Sensation section scores, and Auditory Filtering section scores. The difference found in Total Scores (F (2,22) = 11.4 , p <.01) is the result of mean differences between participants in the three groups with participants in the neuro-typical group reporting the highest total mean score (M = 161.5, SD = 12.0) compared to the participants in the autism group (M = 112.9, SD =32.02) and participants in the ADHD group (M = 130.1429, SD = 19.00). The difference found in Tactile Sensitivity section scores (F (2,22) = 10.625, p < .01) were likewise the result of differences in mean scores with participants in the neuro-typical group again reporting the highest mean section score (M = 31.6, SD = 2.84) compared to participants in the autism group (M = 21.25, SD = 6.43) and participants in the ADHD group (M = 26.7, SD = 4.7). The difference found in Underresponsiveness/Seeks Sensation section scores (F (2,22) = 10.902, p <.01) was again due to differences in mean section scores with participants in the neuro-typical group reporting the highest mean section score (M = 28.9, SD = 5.22) compared to participants in the autism group (M = 21.00, SD = 7.23) and the ADHD group (M = 15.14, SD = 5.81). Finally, differences in Auditory Filtering section scores (F (2,22) = 13.787, p < .01) were the result of differences in mean section scores between participants in the three groups with participants in the neuro-typical group reporting the highest Auditory Filtering mean section score (M = 22.80, SD = 3.20) compared to participants in the autism group (M = 15.50, SD = 6.23) and participants in the ADHD group (M = 11.57, SD = 3.69).

In comparing diagnosis with Total score and section scores in a 3 (diagnosis) X 1 (Total score) and in 3 (diagnosis) X 1 (section scores) between subjects factorial ANOVAs the main effect for diagnosis was not significant for Taste/Smell Sensitivity section scores (F (2,22) = 3.880, p > .01), Movement Sensitivity section scores (F (2,22) = 2.897, p > .01), Low Energy/Weak section scores (F (2,22) = 4.99, p > .01), and Visual/Auditory Sensitivity section scores (F (2,22) = 3.318, p > .01). It appears that the presence of a diagnosis of either ADHD or autism does not have a significant effect on taste and smell sensitivity, movement sensitivity, low energy or weakness, or visual and auditory sensitivity.

Between Group Comparisons

Autism versus Neuro-Typical. A one-way ANOVA was computed comparing total score and all section scores between participants in the autism group and the neuro-typical group. A Bonferroni HSD was then calculated to determine the nature of the difference found, if any. For all results, if a difference was found, it was the result of differing mean scores between groups, which could be reviewed in figure 1 and figure 2.

A significant difference was found among the mean Total scores, mean Tactile Sensitivity section scores, and Auditory Filtering section scores. The difference found between Total scores (F (1,16) = 19.843, $p < .01$) reported by participants in the autism group and the neuro-typical group was significant indicating a difference in overall sensory processing. There was also a difference in Tactile Sensitivity mean section scores (F (1,16) = 5.979, $p < .01$) between the two groups. Finally, a significant difference in the Auditory Filtering mean section scores (F (1,16) = 10.422, $p < .01$) was found between the two groups.

There was no significant difference found between the groups on the Taste/Smell Sensitivity section score(F (1,16) = 5.070, $p > .01$), Movement Sensitivity section score(F (1,16) = 5.493, $p > .01$), Underresponsive/Seeks Sensation section score (F (1,16) = 7.265, $p > .01$), Low Energy/Weak section score(F (1,16) = 6.028, $p > .01$), and the Visual/Auditory Sensitivity section score (F (1,16) = 7.626, $p > .01$). This indicates that the diagnosis of autism does not have a significant effect on taste and smell sensitivity, movement sensitivity, underresponsiveness or seeking behaviors, low energy or weakness, and visual and auditory sensitivity.

ADHD versus Neuro-Typical. A one-way ANOVA was computed comparing total score and all section scores between participants in the ADHD group and the neuro-typical group. A Bonferroni HSD was then calculated to determine the nature of the difference found, if any. For all results, if a difference was found it was the result of differing mean scores between groups which could be reviewed in Figure 1 and Figure 2.

A significant difference was found between the mean Total scores, Underresponsive/Seeks Sensation section scores, and Auditory Filtering section scores. The difference found between Total scores (F (1,15) = 17.546, $p < .01$) reported by participants in the ADHD group and in the neuro-typical group was significant indicating a difference in overall sensory responsiveness. There was also a significant difference found in Underresponsiveness/Seeks Sensation section scores (F (1,15) = 26.107, $p < .01$) between the two groups. Finally, a significant difference was found between the two group's reported mean scores in the Auditory Filtering section (F (1,15) = 44.932, $p < .01$).

There was no significant difference between groups in Tactile Sensitivity section scores (1,15) = 7.233, $p > .01$), Taste/Smell Sensitivity section scores (F (1,15) = .049, $p > .01$), Movement Sensitivity section scores (F (1,15) = 4.086, $p > .01$), Low Energy/Weak section scores (F (1,15) = .170, $p > .01$), and in Visual/Auditory Sensitivity section scores (F (1,15) = .449, $p > .01$) between the ADHD group and the neuro-typical group. This indicates that the diagnosis of ADHD does not have a significant effect on tactile sensitivity, taste and smell sensitivity, movement sensitivity, low energy or weakness, or visual and auditory sensitivity.

Autism versus ADHD. A one-way ANOVA was computed comparing total score and all section scores between participants in the autism group and the ADHD group. A Bonferroni HSD was then calculated to determine the nature of the difference found, if any. There was no significant difference between participants in the autism group and participants in the ADHD group on the reported mean total scores and mean section scores. The one-way ANOVA revealed no significant difference in mean Total scores (F (1,13) = 1.548, $p > .01$), in mean Tactile Sensitivity

section scores (F (1,13) = 3.443, p > .01), in mean Taste/Smell Sensitivity section scores (F (1,13) = 4.221, p > .01), in mean Movement Sensitivity section scores (F (1,13) = .395, p > .01), in mean Underresponsive/Seeks Sensation section scores (F (1,13) = 2.927, p > .01), in mean Auditory Filtering section scores (F (1,13) = 2.118, p > .01), in mean Low Energy/Weak section scores (F (1,13) = 5.279, p > .01), or in mean Visual/Auditoory Sensitivity section scores (F (1,13) = 2.143, p > .01).

	Autism	**ADHD**	**Neuro-Typical**
Tactile Sensitivity	6.43095	4.68025	2.83627
Taste/Smell Sensitivity	5.92814	4.64451	3.12872
Movement Sensitivity	4.92080	3.38765	1.57762
Underresponsive/Seeks Sensation	7.23089	5.81460	5.21643
Auditory Filtering	6.23355	3.69040	3.19026
Low Energy/Weak	9.02279	3.40168	3.59011
Visual/Auditory Sensitivity	6.14120	6.31702	3.43350
Total	32.02427	19.00376	11.99305

Table 1 Standard Deviations

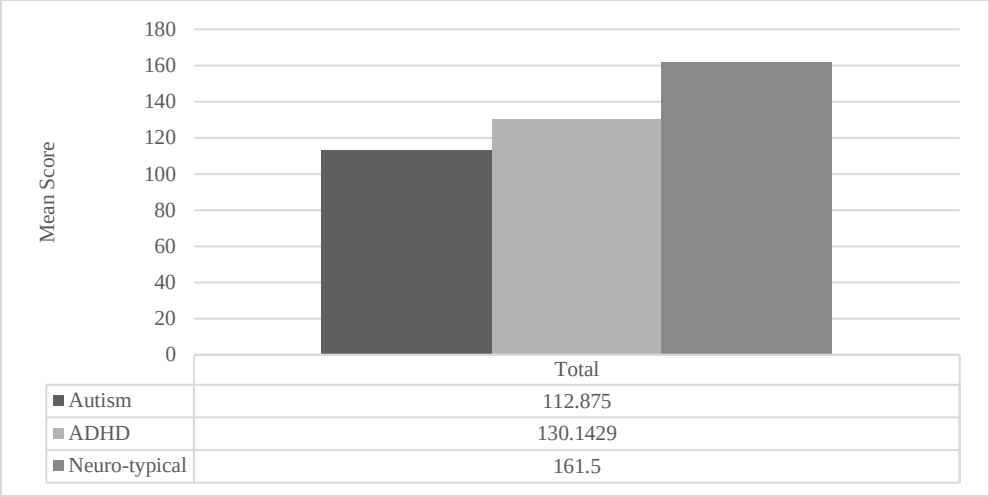

Figure 1 Short Sensory Profile Total Scores

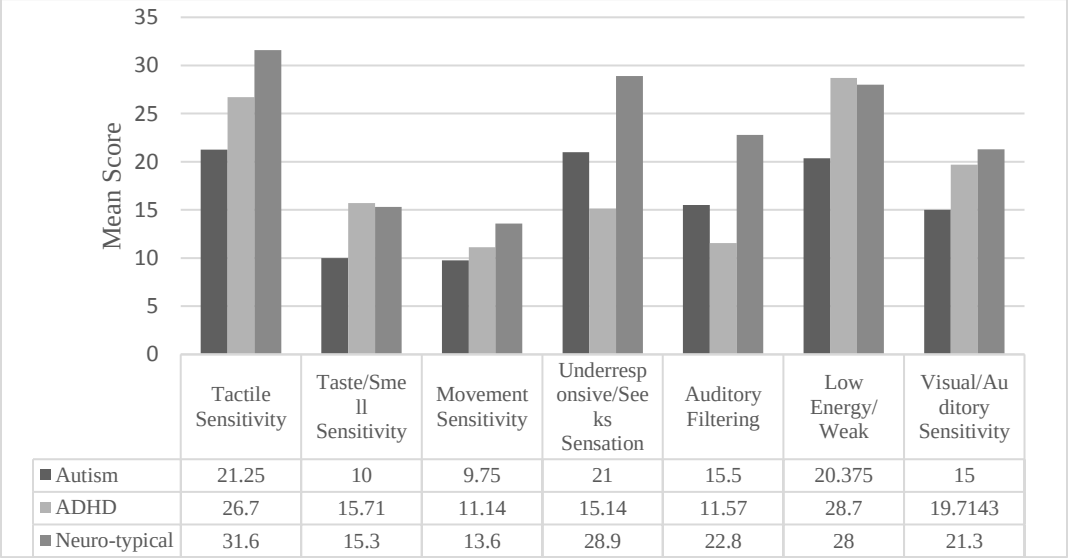

Figure 2 Short Sensory Profile Section Scores

Discussion

Autism is currently defined by the behavioral phenotype. The heterogeneous nature of this disorder presents a very serious complication for researchers in their search for other defining characteristics which could potentially serve to extend this definition to include all levels of analysis. The benefits to extending this definition are incalculable. Not only will the understanding autism be broadened, defining autism at all levels of analysis would make it possible to develop testing measures so that a critical early diagnosis and implementation of a treatment plan so critical for an optimal outcome. To extend the diagnosis of autism, it is necessary to identify characteristics that can differentiate this disorder from other disorders and from the neuro-typical population. A unique sensory processing modulation has been investigated as a possible differentiating factor as atypicalities have been observed in as many as 100% of individuals diagnosed with autism (Hilton et al., 2010). Previous studies have found atypicalities in several

sensory systems as shared by autistic participants (Ashburner, 2013; Baranek et al., 2006; Baranek et al., 2013; Blanche et al., 2012; Colligan et al., 2013; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Lane et al., 2010). While findings have been significant, past studies have been commonly limited in their selection of comparison groups. In order to definitively identify atypical sensory processing patterns as a defining characteristic of autism, it is necessary to study these patterns against the sensory processing patterns in disorders whose defining characteristics closely resemble those in autism. The present study was designed to address this limitation and verify the findings of previous research.

Hypothesis One The first hypothesis states that the autism group and the ADHD group could be differentiated from the neuro-typical group on the basis of sensory processing. This study confirmed that the two groups could be differentiated from the neuro-typical group on the basis of sensory processing as measured by The Short Sensory Profile in Total scores (p=.000), in the Tactile Sensitivity section scores (p=.001), in the Underresponsive/Seeks Sensation section scores (p=.001), and in the Auditory Filtering section scores (p=.000). This confirms that the sensory processing of participants in this study in the autism group and in the ADHD group were significantly different from the sensory processing of participants in the neuro-typical group. Additionally, both the ADHD group and the autism group had mean Total scores in the "Definite Difference" range (<141), the autism group and the ADHD group had mean Tactile Sensitivity section scores in the "Definite Difference" range (<26), in the Underresponsive/Seeks Sensation section, the autism group and the ADHD group scored again in the "Definite Difference" range (<23), finally, in the Auditory Filtering section, both the autism group and the ADHD group scored in the "Definite Difference" range (<19) as specified by The Short Sensory Profile. This finding indicates that both the participants in the autism group and the ADHD group display atypical sensory responsiveness patterns most significantly in these four areas. In comparing the three groups, there was no significant difference in the Taste/Smell Sensitivity, in Movement Sensitivity, in Low Energy/Weak, and in the Visual/Auditory Sensitivity section scores. This does not mean that the scores of these three groups were not in the "Definite" or "Probable" difference range individually, it only means that when comparing all three groups, there was no significant difference found between them in these mean section scores.

Hypothesis Two The second hypothesis stated that the autism group could be differentiated from the neuro-typical group on the basis of sensory processing as measured by The Short Sensory Profile. Between the autism group and the neuro-typical group significant differences were found in mean total scores (p=.000), mean Tactile Sensitivity section scores (p=.000), and mean Auditory Filtering section scores. While there were no significant differences found in the remaining section of The Short Sensory Profile (Taste/Smell Sensitivity, Movement Sensitivity, Underresponsive/Seeks Sensation, Low Energy/Weak, and Visual/Auditory Sensitivity) between these two groups, it is notable that mean scores of the autism group were in the "Definite Difference" range in all sections. Previous studies indicated that differences between autism participants and controls could be found in the proprioceptive sensory system, the multisensory system, and, most abundantly, in the auditory sensory system (Ashburner et

al., 2013; Baranek et al., 2006; Blanche et al. 2012; Colligan et al. 2013; Haswell et al., 2009; Lane et al., 2010; O'Riordan & Passetti, 2006; Tecchio et al., 2003). This study confirms that the autism group and the neuro-typical group can be differentiated by ability of auditory filtering. While the present study did not explicitly measure proprioceptive responsiveness or the ability of the multisensory system, the "Definite Difference" status of the mean scores in all sections measured by The Short Sensory Profile does not refute the findings of previous studies.

Hypothesis Three The third hypothesis stated that the ADHD group could be differentiated from the neuro-typical group on the basis of sensory processing as measured by The Short Sensory Profile. In comparing these two groups significant differences were found in Underresponsive/Seeks Sensation section scores (p=.000) and Auditory Filtering section scores (p=.000). Again, while no significant differences were found in comparing the mean scores of the ADHD group and the neuro-typical group in the remaining sections, mean scores of the ADHD group did fall in the "Definite Difference" range in Total, in the Tactile Sensitivity section, in the Underresponsive/Seeks Sensation, and in the Auditory Filtering section. Additionally, the mean scores of the ADHD group fell within the "Probable Difference" range of the Movement Sensitivity section.

The significant difference found in the Underresponsive/Seeks Sensation section reflects a core behavioral characteristic of ADHD, hyperactivity and impulsivity (APA, 2013; Dunn & Bennett, 2002). More specifically, an atypical sensory seeking responsiveness pattern, as seen in the ADHD group of the present study, is seen behaviorally as hyperactivity and impulsivity as the afflicted individual frantically seeks sensation from the environment. The significant difference found between the ADHD group and the neuro-typical group in the Auditory Filtering section reflects this group's difficulty in attending to relevant auditory stimuli while filtering out extraneous stimuli. One study by Dunn and Bennett (2002) used The Short Sensory Profile to compare a group of participants diagnosed with ADHD with a control group made up with age-matched neuro-typical individuals and also found significant differences in Auditory Filtering mean section scores. These authors concluded that this is the result of a unique cognitive style indicative of ADHD. While autism is characterized by a weak central coherence cognitive style, or the tendency to perceive parts over the whole, ADHD is characterized by a particularly strong central coherence, or the tendency to perceive the whole over the parts (Dunn & Bennett, 2002; Lord & Jones, 2012). Whereas the atypical auditory filtering ability seen in autism has been speculated to be the result of over attention given to pieces of auditory stimuli, the atypical auditory filtering seen in ADHD has been speculated to be the product of over attention given to the whole of auditory stimuli (Ashburner et al., 2013; Briskman, Happe, & Frith, 2001; Chen, Rodgers, & McConache, 2009; Dunn & Bennett, 2002; Frith & Happe, 1999; Happe, Briskman, & Frith, 2001; Lane et al., 2010; Riby, Janes, & Rodgers, 2013; Watson, Patten, Baranek, Poe, Boyd, Freuler, & Lorenz, 2011).

Hypothesis Four The fourth hypothesis stated that the autism group could be differentiated from the ADHD group on the basis of sensory responsiveness as measured by The Short Sensory Profile. The comparison between the autism group and the ADHD group was of the most interest in

the present study. To prove that atypical sensory processing can be a differentiating characteristic of autism, it is necessary to compare the sensory response patterns of individuals who have been diagnosed with autism with individuals who have been diagnosed with a similarly defined disorder. In the present study, an ADHD comparison group was chosen because of the similarities ADHD has in definition to autism (APA, 2013). Using The Short Sensory Profile, no significant differences were found in any section scores or the Total score when comparing the autism group with the ADHD group.

Previous studies have identified an atypical sensory profile in autistic participants characterized by difficulty with auditory filtering, in the proprioceptive sensory system, and in the multisensory system (Ashburner et al., 2013; Baranek et al., 2006; Blanche et al. 2012; Colligan et al. 2013; Haswell et al., 2009; Lane et al., 2010; O'Riordan & Passetti, 2006; Tecchio et al., 2003). The present study did not specifically examine the proprioceptive sensory system or the multisensory system so no conclusive statements can be made in regards of differences between these two groups in those sensory systems. Auditory Filtering was, however, examined and, being the most distinguishing sensory quality indicated by previous studies, it was expected to yield significant results when comparing the autism group with the ADHD group in the present study system (Ashburner et al., 2013; Baranek et al., 2006; Blanche et al. 2012; Colligan et al. 2013; Haswell et al., 2009; Lane et al., 2010; O'Riordan & Passetti, 2006; Tecchio et al., 2003). While the difference found in Auditory Filtering when comparing these two groups was not significant, it is interesting to note that mean scores in this section were lower in the ADHD group (m=11.57) than the autism group (m=15.5). This indicates that the strongest sensory characteristic of autism is a stronger sensory characteristic of ADHD, a quality that has significant implications for past research and must be taken into consideration in future research into sensory responsiveness patterns in autism.

Previous research findings indicate that the prevalence of atypical sensory response patterns in autism is 100% (Hilton et al., 2010). Moreover, a sensory response pattern in autism that can not only unite individuals on the spectrum, but also differentiate them from individuals diagnosed with other disorders and from the neuro-typical population has been identified. The sensory systems indicated by previous studies that are most significantly differentiated and universal, as indicated by previous research, are the auditory sensory system, the proprioceptive sensory system, and the multisensory system (Ashburner et al., 2013; Baranek et al., 2006; Blanche et al. 2012; Colligan et al. 2013; Haswell et al., 2009; Lane et al., 2010; O'Riordan & Passetti, 2006; Tecchio et al., 2003). While the present study did not examine the proprioceptive sensory system and the multisensory system, the results refute previous claims of a sensory response pattern in auditory filtering that can differentiate autism from other disorders.

Limitations

Some limitations of the present study include the limited capabilities of the measure chosen and the small sample sizes. As mentioned previously, the measure chosen, The Short Sensory Profile, is a shortened version of The Sensory Profile and includes seven sections, five of which measure only the extent to which an individual displays a hyperresponsive modulation pattern. If a seeking modulation pattern or a hyporesponsive modulation pattern exists it may be missed by the

limited capabilities of The Short Sensory Profile. Additionally, this is a parent/caregiver report measure and depends on the perception of the parent or caregiver of his/her child's sensory responsiveness pattern. Because of this, the questions are open to interpretation meaning they are not precise or objective. Future studies must use a combination of measures or a single measure designed to objectively detect any variation in sensory modulation patterns including hyperresponsiveness, hyporesponsiveness, and seeking. Another limitation possessed by the present study is in the limited sample sizes. The present study used three groups of participants including an autism group, an ADHD group, and a neuro-typical group. The autism group had eight participants, the ADHD group had seven participants, and the neuro-typical group had twenty participants (in order to more closely match sample sizes, ten participants in the neuro-typical group were randomly chosen for this study). To replicate the findings of the present study and to more concretely define the results of this study, future research must include larger sample sizes that can more accurately represent the population.

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