Multisensory environments, autism, and the parasympathetic nervous system

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This scholarly project reflects individualized, original research conducted in partial fulfillment of the requirements for the Occupational Therapy Doctorate Program, The University of Toledo.

Abstract

Objective: This study compared the use of a Multi-Sensory Environment (MSE) with children with Autism Spectrum Disorders (ASD) using a client-centered approach and a manualized approach. Activation of the Parasympathetic Nervous System (PNS) was utilized as the primary outcome measure. It was hypothesized that within the MSE, the client-centered approach would result in a greater PNS activation, as compared to the manualized approach.

Methods: Twenty children between the ages of four to seven years, who had been previously diagnosed with an ASD were included in this study. Each participant attended six MSE sessions: three sessions in the protocol-driven condition and three sessions in the individualized condition. In the protocol-driven sessions, the equipment was turned on in a slow, sequential manner. In the individualized sessions, participants were free to play and engage the MSE as desired. Heart rate variability (HRV), an indicator of PNS activation, was taken from the inter-beat heart (R-R) and was measured via the RS800cx Polar WearLink transmitter (New York, NY, UA).

Results: Though the magnitude of change in heart rate variability was greater in the manualized condition, as reflected by the effect size, the change was not statistically significant. The effect is in the opposite direction to the stated hypothesis. There was also a high degree of variance in the measure. Taken together, these factors lead to difficulty in interpreting whether there is an effect of the condition on sympathetic nervous system activity.

Conclusion: The amount of variability among the results indicates a need for therapists to apply their own clinical judgment when selecting the most appropriate approach within the MSE. In order to guide best practice use of MSEs, continued research is necessary.

Multisensory Environment, Autism and the Parasympathetic Nervous System

Autism and Preschoolers with Autism Spectrum Disorders

Developmental disorders characterized by impairments in social interaction, communication, and repetitive behaviors are known as Autism Spectrum Disorders (ASD) (American Psychiatric Association, 2000). Autism symptoms range on a spectrum from mild to severe. Typically, ASDs are diagnosed around age three (American Occupational Therapy Association [AOTA], 2011). Over the last decade, the incidence of autism has been on the rise. While the etiopathogenesis of autism is not very well understood, it is typically thought to be a multifactorial disorder, including genetic, environmental, neurochemical and developmental factors (American Academy of Childhood and Adolescent Psychiatry, 2010).

The ability to perceive sensory information and to generate an appropriate response to that sensory information is termed *sensory processing*. Sensory modulation is a component of sensory processing in which the intensity of the response to a sensory stimulus is proportional to the intensity of the stimulus. Sensory modulation influences the ability to regulate the state of arousal. Children with sensory modulation disorders (SMD) demonstrate difficulty in regulating responses to specific stimuli and sensations. Research suggests that sensory modulation disorders are common among children with ASDs, with the co-occurrence of SMDs ranging from 40% to 80% in children with autism (Pfeiffer, 2011).

Children with autism are often less engaged in childhood occupations than their typically developing peers. Children with ASDs may have more difficulty regulating their responses to sensory stimuli and social situations. To compensate, children may resort to self stimulation or avoidance behaviors (Pfeiffer, 2011). In turn, children often demonstrate disabilities in a range of activities including disturbances in skill development and limitations in daily routines and activities.

Autonomic Nervous System

The Autonomic Nervous System (ANS) coordinates functions of the cardiovascular system, respiratory system, digestive system, and the urinary system (Martini, 2009). The autonomic nervous system itself acts outside the realm of conscious control. The ANS is comprised of two branches: the Parasympathetic Nervous System (PNS) and the Sympathetic Nervous System (SNS). The SNS helps prepare the body for increased somatic activity, including producing the *fight or flight* response. Responses of the SNS include increased mental alertness, muscle abilities, metabolic rate, and activation of sweat glands (Martini, 2009). The PNS is known for its *rest and digest* functions because it stimulates visceral activity. When the PNS is activated, digestive organs are highly stimulated, skeletal muscles relax, heart rate slows, and blood pressure lowers (Martini, 2009, pp. 529-545). The PNS also plays a role in regulating recovery from exposure to a stressor or a challenge (Nance, 1996). Activation of this system conserves energy.

Activity of the PNS is inferred through measurements of heart rate variability (Boccia & Roberts, 2000; Malliani, 1995). Known as *vagal tone,* heart rate variability reflects PNS activity to maintain homeostasis and the capacity to effectively cope with a wide variety of changing physiological and sensory stimuli. Disturbances in ANS function, resulting in inability to maintain homeostasis and regulate responses to stressful stimuli, influence one’s ability to participate in everyday occupations (Malliani, 1995).

A preliminary study conducted by Shaaf and colleagues (2003) investigated the PNS in children with disturbances in sensory processing. This study had a total of 15 child participants, 9 children who had disturbances in sensory processing and 6 children who were typically developing. With this study, Schaaf and colleagues were seeking to 1) provide information about group differences in PNS functions, as measured by vagal tone index, 2) determine effect size and power needed for future studies, and 3) lay the groundwork for continued study of the relations of PNS functioning and behavior in children with disturbances in sensory processing. Throughout both a two-minute baseline period and a Sensory Challenge Protocol, heart rate data were measured continuously. The groups were compared on vagal tone using two-tailed, independent sample t-tests. The results of this study showed that participants with disturbances in sensory processing had significantly lower vagal tone as compared to participants who were of typical development. To achieve an adequate statistical power, future studies should use a sample size of 20 participants per group as indicated by a statistical power analysis.

Schaff and colleagues (2010) suggest that children who have severe SMDs may exhibit physiological activity that is different from children who do not have SMDs. Physiological differences in PNS functioning contribute to the difficulties in a child's ability to participate in the events of daily living. Providing support for the relationship between parasympathetic functioning and the behavioral adaptation to stimuli, low parasympathetic functions are associated with stress, vulnerability, developmental and cognitive delays, or emotional and behavioral over activity in adults and infants (Schaff, et al., 2010).

Use of Multisensory Environments

A multisensory environment (MSE) is a specially created room, aimed to provide a variety of sensory experiences. The interior of an MSE is isolated from outside sensory information such as noise, lighting, and temperature. Equipment that provides controlled stimulation of the sensory systems is brought in the MSE. A multisensory environment is often a room set up in such a way to encourage participants to make choices and interact with the equipment. MSEs are constructed as a therapeutic intervention tool meant to elicit responses such as engagement, relaxation, or a sense of energy (Messbauer, 2012). The therapeutic aim of using MSEs is to help individuals utilize their own potential to focus and, in turn, take action through an adaptive response to their environment. Messenbauer (2012) defines adaptive response as "the individual initiating and reacting in a meaningful, productive way to situations, things and people in their environment" (para. 1). The complement of equipment within the MSE can be tailored for use with individuals with a wide range of diagnosis and disorders.

Previous research looking at the impact of MSEs on individuals presents mixed results. Hulsegge and Verheul (2001) suggest that engagement in a MSE may lead to a reduction in distress, sterotypies, aggressive and self-injurious behaviors for individuals with ASDs. A study conducted by McKee and colleagues (2007) reported that, although clients appeared to enjoy the MSE during their 30-45 minutes of exposure, they did not produce lasting behavioral changes. The study included three participants, all of which were male and were diagnosed with autism. Using an ABAB reversal design, disruptive and prosocial behaviors were recorded for each participant while they were engaging in the Snoezelen environment, over the course of the study. The study was composed of four 28-day periods. At the conclusion the of the study the results indicated that the clients did not show a decrease in disruptive behavior, but they did show a slight tendency to engage in more prosocial behavior as compared to baseline measures. Much of the current research indicates a need for further research on MSEs, with a particular emphasis on studies with rigorous research design (Hog, 2001;McKee, 2007).

Occupational Therapy and the Client-Centered Approach

Facilitation of client participation in occupational therapy services is encouraged. The Canadian Association of Occupational Therapy defines client-centered practice as a "collaborative approach aimed at enabling occupation with clients" (Law, 1997, p. 1). Under this style of occupational therapy practice there is an emphasis on a partnership between the occupational therapist and the client. The aim of client-centered practice is to provide flexible and individualized treatments, where clients have the opportunity to engage in problem solving. This individualized approach to treatment contrasts with rigid manualized approaches. In the manualized approach treatment is based on strict step-by-step guidelines or *protocols*. Compared to manualized approaches, client-centered approaches are less represented in the literature. This may reflect the challenge of establishing and ensuring *fidelity*. The term fidelity is used to indicate that the independent variable in an experiment was administered as planned, including delivery, receipt and enactment (Nelson, 2006). When following an intervention protocol, researchers can assure fidelity with greater confidence.

Present Study

This study compared the use of a MSE with children with ASDs using a client-centered approach verses a protocol-driven approach. Activation of the PNS was utilized as the primary outcome measure. It was hypothesized that within the MSE, the client-centered approach would result in greater PNS activation, as compared to the manualized approach.

Methods

This study was conducted at the Sensory Playroom within ProMedica Toledo Children's Hospital Autism Center**.** The University of Toledo's Biomedical Institutional Review Board approved the study procedures. Consent was obtained by all parents and/or legal guardians prior to participation in this study.

Participant Characteristics

Twenty child participants were included in this study. To be included in this study, children male and female, were between the ages of four and seven, and had a diagnosis of an Autism Spectrum Disorder. Children who had primary sensory loss, history of seizures, complications that affect cardiac activity or other major medical diagnosis, such as Cerebral Palsy or Down Syndrome, were excluded from the study. Participants were recruited through the community, as well as, facilities and organizations that serve children with ASDs and their families. After each session, the participants were offered a small token of either a pencil or a sticker for their participation. Upon completion of the study, participants were compensated with a gift card in the amount of $100.

Study Design

This study utilized a counter balanced design. Each participant attended six MSE sessions: three sessions in the protocol-driven condition and three sessions in the individualized condition. Block randomization was used to randomize and counter balance sessions, across the participant pool. Sessions were scheduled and held at the convenience of parents/ guardians, but they did not span a period greater than four months.

Apparatus and Conditions of MSE

The MSE is located at the Children's Hospital of Toledo Autism Center. The dimensions of the room are approximately 18' X 18', featuring equipment arranged in various configurations, to include a variety of multi-sensory equipment. A detailed description is provided (see Appendix A).

Protocol-driven condition. In this condition, sensory equipment was activated in slow and sequential manner, in a clockwise direction around the MSE. The first piece of equipment was turned on immediately, with subsequent pieces being turned on at two–minute intervals thereafter. Once activated, sensory equipment was left on. Participants were to remain in the MSE for approximately 30 minutes.

Individualized condition. Participants were free to engage and play in the MSE for 30 minutes. Participants requested which MSE items/equipment they would like activated through their usual means of communication. Equipment was deactivated when participants ceased to engage with it.

Measures

Demographics Questionnaire. Parents completed an initial questionnaire in order to obtain demographic information. The questionnaire asked questions regarding the participants' age, gender, age of diagnosis, medical history, family structure, current therapies received and socioeconomic status (see Appendix B). It also assessed the families' socioeconomic status through marital status, employment status, educational attainment and occupational prestige.

Sensory Profile. Participants were assessed using the Sensory Profile (Dunn, 1999) which was administered at the beginning of the first session, to determine a baseline measure of sensory processing pattern. The Sensory Profile is a 125-question caregiver completed profile that documents the frequency of a child's response to a variety of sensory stimuli. The parent/guardian is asked to check a box to rate the frequency of a given behavior in which the child engages. The choices are rated on a Likert scale: (1) Always; (2) Frequently: (3) Occasionally; (4) Seldom; and (5) Never. This is an interval level of measurement and the lower scores denote greater symptoms. Items are classified by the sensory systems of touch, movement, body position, visual, auditory, and taste/smell, and by the behavioral categories of activity level and social/emotional.

Dunn (1999) described the psychometric properties of the Sensory Profile as follows: Cronbach's alpha for internal consistency ranged from 0.47 to 0.91 for a number of sections of the profile. Internal validity correlations ranged from 0.25 to 0.76, and construct validity showed a correlation ($p < 0.05$) when comparing the results of the Sensory Profile to electrodermal responses.

Child Autism Rating Scale (CARS). To describe the severity of the participants' ASD, we utilized the Child Autism Rating Scale (CARS, Schopler, et al. 1994). The CARS is a behavioral rating scale with 15 items developed to identify, describe and quantify the severity of the child's Autism. The evaluator rates the child on a scale from 1 to 4 (with midpoint scores) across the items. The scores are added up ranging from 15-60, placing the child within a category of severity of Autism. The CARS has been used in studies with children, adolescents and adults (Schopler, et al., 1994; Njardvik, et al., 1999; Elia, et al., 2000). Schopler and colleagues (1994) described the psychometric properties of the CARS as follows: coefficient alpha of 0.94 for internal consistency and inter rater reliability criterion related validity were established.

Outcomes. Parallel studies were conducted to assess the effect of the condition on multiple dependent variables.

Parasympathetic nervous system (PNS). The outcome measure for the present study was heart rate variability (HRV), an indicator of PNS activation. This was taken from the inter-beat heart (R-R) and was measured via the RS800cx Polar WearLink transmitter (New York, NY, UA). The transmitter was mounted on a moistened chest strap, placed around the participant's chest just below the pectoral muscles. The transmitter sent heart rate data to a wrist-worn hard drive and a local laptop via the propriety WindLink technology. The Polar RS800 wrist band did not need to be worn with the chest strap but only needed to be in the same room as the participant. Gamelin and colleagues(2008) described the validity of the Polar810 to measure R-R intervals in children. Results are reported here.

Sympathetic nervous system (SNS). Electrodermal responses (EDR), indicating SNS activation, were measured by an Affectiva Q Sensor (Waltham, MA, USA). The sensor is embedded in a lightweight, washable wrist band that measures EDR, temperature and acceleration. The sensor was placed on the participant's right or left wrist prior to entering the MSE. The participant's wrist was cleaned with a hypoallergenic wipe. Data was streamed via Bluetooth wireless communication to a Dell E 6430 computer and was logged on the internal USB drive on the sensor. EDR is reported as the Skin Conductance Level (SCL) measured each 500 milliseconds (Gilissen, et al., 2007). Results of this study have been reported by Grieger (2015).

Engagement. Panasonic high definition video recorders with audio capabilities were used to record each session, in an attempt to ensure data collection was accurate. Engagement was measured across four variables. The first variable was the number of requests/ initiations for an MSE item to be turned on/off in the individualized condition. Request and initiations are defined as: pointing toward an item or piece of equipment, positive vocalizations, smiling, laughing or immediately engaging/ playing with an item. The second variable was the duration of engagement/ play within the MSE, measured in minute increments. The third variable was affect, measured by identifying negative, neutral and positive affect. The affective signs could have ranged from extreme distress to extreme excitement. Negative affect includes signs of distress, ranging from frowns, grimacing, whining, insoluble crying and negative verbalizations. Neutral affect includes being somber during MSE engagement/play and flat affect. Positive affect includes smiling, laughing and positive vocalizations. The fourth variable was comprised of the top three desired and undesired behaviors as identified by the parents/ guardians. Results of this study have been reported by Smet (2014).

Parent/ Guardian Opinion. Parent/guardians were asked to give their opinion on the use of the MSE under the two conditions. Results of this study have been reported by Smet (2014).

Procedure

Participants attended seven sessions (one introductory session and six MSE sessions). In the first session, the research personnel obtained informed consent from the parent/legal guardians and assent from the participants. The parent/ legal guardians were asked to complete the Demographics Questionnaires and the Sensory Profile, while the research personnel conducted the CARS with the participants. The child participants and guardians were oriented to study protocol. The researcher demonstrated the use of the physiological measurement devices and asked that the parent/guardians assist in applying them on the participants. A doll or stuffed animal may have been used to demonstrate donning/doffing of the devices to the participants.

In subsequent sessions, the parent/guardians were asked to assist the research personnel in applying the physiological measurement devices. No coercion was used to encourage children to wear the devices, and some did remove them. The participants were then encouraged to rest quietly for two to 10 minutes. Afterwards, the child participant was led to the MSE to engage in a session for up to 30 minutes. Parents/legal guardians had the option to inconspicuously observe the sessions through closed circuit video or accompany the child. Research personnel remained with the participant in the MSE to ensure safety. If participants engaged in behaviors that were unsafe or destructive, they were redirected by research personnel. If unsafe or destructive behaviors persisted after three attempts to redirect, the parent/guardian was asked to intervene and the sessions were terminated.

During the final session, the parent/ guardians were asked to complete reflective questions, while the child participant was playing. After completion of all MSE sessions, parents/ guardians were asked to observe videotaped sessions and count incidents of desired and undesired behaviors, as they defined them. The parent/ guardians received a $100 give card and the child received a small token (not exceeding 25 cents per item) for completing participation in the study.

Data Analysis

Data was obtained from the video and digital recordings of each of the sessions. The first two minutes of each session was used to allow the ANS to adapt to the sensory challenges offered by the MSE.

The first session in each condition was excluded to remove effects of novelty. The second and third session were averaged to address individual variability. Data were included in analysis only for participants who were present for all sessions and wore the heart rate monitor for their sessions. Signals were imported to Matlab (MathWorks, Natick, MA, USA) for analysis. HRV is reported as the Root Mean Square of Successive Differences (RMSSD) of the beat-to-beat heart beat intervals (R-R intervals), which is a proxy for PNS activation (Vanderei, et al., 2009). The RMSSD was calculated for each 10 second epoch. The average RMSSD for the ten minute rest period before each session represents a baseline activity. Subsequent RMSSD have been compared to baseline as proportional change.

The mean proportional change under the two conditions was compared with a Wilcoxon Signed Rank Test using SPSS (IBM, Armonk, NY, USA). Effect size is reported as Cohen's d. Statistical significance was determined at the alpha level of $\alpha = 0.05$.

Results

A total of 20 children participated in this study. The children's age ranged from four years to seven years. Out of the 20 participants included in this study, 16 were identified as male and four were identified as female. See Table 1 for participant demographics. There were 14 of the participants that had a diagnosis of Autism and six with a diagnosis of PDD-NOS. See Table 2 for distribution of CARS scores. CARs scores indicated a range of Autism severity among participants. The CARs assessment was scored after viewing videotaped observations from the introductory session with each participant; one participant was not scored due to technical difficulties. Sensory Profile scores varied across participants, with no participants having typical scores in all four of the quadrants. See Table 3 for distribution of Sensory Profile scores.

To test the hypothesis that within the MSE, the client-centered approach would result in a greater PNS activation, as compared to the manualized approach this study compared heart rate variability under the two conditions. Of the 20 participants, 15 wore the heart rate monitors for all sessions. Heart rate variability during 10-minute epochs were compared to baseline measurements in both conditions, protocol and individual. The magnitude of change from baseline in heart rate variability was greater in the protocol condition, as reflected an effect size of -.90; however, the change was not statistically significant ($n=15$, $Z= -.852$, $p = .394$, See Table 4 for average heart rate variability, proportional change, and statistical results). The effect is in the opposite direction to the stated hypothesis. There was also a high degree of variance in the measure, see Table 4. Taken together, these factors lead to difficulty in interpreting whether there is an effect of the condition on parasympathetic nervous system activity.

Discussion

This study pursued the idea that a client-centered approach to engagement in a MSE would result in greater PNS activation, when compared to engagement within a MSE under protocol driven conditions. The hypothesis was not supported by data analysis. Data analysis revealed a high degree of variability among both conditions. An explanation for this may be due to variability among the participants themselves. Severity of Autism greatly affects an individual's ability to communicate interests and interact with elements within the multi-sensory environment, which greatly impacts the participant under the client-centered condition. It was observed that participants with severe, non-verbal forms of Autism had the most difficultly initiating use of the MSE equipment, especially if they experienced the client-centered condition first. Under this condition participants were observed to associate with a familiar item such as the ball pit or the stairs and not investigate novel equipment. Under the client-centered approached some participants appeared to be uninterested in the room and the equipment, to the extent of leaving the MSE before the completion of a 30-minute session. Apparent disinterest in the MSE may have been due to the communication errors between the researcher and the participant.

Under both conditions some participants were noted to fixate on certain pieces of equipment, these participants were observed to express undesirable behaviors when under a condition where the item was not able to be turned on, as in the protocol driven condition. When safety was a concern, participants were redirected, which may also have caused emotional changes and distress which could have had an impact on the participants' level of interest in the MSE.

The parasympathetic nervous system acts to maintain homeostasis, to aid in self-regulation, and to regulate recovery from a stressor/challenge. Typically PNS activity is associated with the ability to self-regulate and maintain homeostasis. There was high variability in PNS activation among participants in this study. In a study of healthy children aged six to eight years old, the range of heart rate variability, measured as RMSSD, from the 25^{th} to the 75^{th} percentile was 38 to 84 ms (Seppala, et al., 2014). These values are well above the RMSSD measured in this study (14.8 to 19.1 ms), suggesting that perhaps participants were exhibiting low PNS activation regardless of the condition. This is consistent with the findings of Daluwatte and colleagues (2013) who found evidence of decreased heart rate variability in children with autism. A compromised PNS may disturb one's ability to maintain that homeostasis and complete regulation.

Children with Autism Spectrum Disorders are faced with challenges predominantly in the areas of sensory processing, social interaction, and communication; because of this, these children often have a difficult time engaging in activities. When working with clients with ASDs, occupational therapists aim to promote occupational engagement and enhance occupational performance. Occupational therapists also have knowledge of sensory processing disorders and sensory integration principles. With this background knowledge, and with a focus on client- centered practice, occupational therapists understand that every child is unique, and such, have unique sensory experiences. Because of this, engagement in MSEs is an intervention technique to be explored by occupational therapists. The novelty of MSE can be quite difficult for children with an ASD, but the occupational therapist can provide the child with new sensory information in a way that is individualized.

This study can be used to provide insight to occupational therapy professionals, caregivers of children with ADS, and facilities that use MSEs with children with ASDs. With a high degree of variability among both conditions, results from this study suggest that clinicians should use clinical judgement when determining how to best engage a child with an ASD in a MSE, perhaps through combination of adult and child selection of MSE equipment.

Limitations

Generalizations from this study are limited. The study drew participants from the Greater Toledo Area, including middle class to lower middle class families. There was a small sample size, which only included 20 participants, with an original aim to include 25 participants.

Children varied in their severity of ASD. The participants varied in their ability to initiate use of the equipment, including verbal request, pointing, physical interaction, and iPad/speech device. On multiple occasions, participants left sessions or paused sessions to go to the bathroom. At times participants expressed disinterest in the sensory room and did not complete 30-minute sessions.

There were a number of technical difficulties that could have limited study results. Device malfunction resulted in lost physiological and video data. Children's adverse reactions to the equipment, especially with the heart rate monitor strap, also led to inability to obtain data. Variability among data collection methods may have also led to the variability found among the results. There were multiple researchers collecting data. Participants completed sessions at varied times of day and length between treatments, due to parents schedules.

Conclusion

This study indicates a need for further research to determine the best practice guidelines for use of MSEs with children with ASDs. Future studies should include a larger sample size. Furthermore children with ASDs find comfort in repetitive behaviors and routines, which could account for the slightly higher degree of change in HRV found within the protocol-driven approach. During this approach the room was turned on in an orderly predictable pattern. The transitions and unpredictability of the room under the indivudalized condition could have been a source of distress to participants, making it more difficult to maintain homeostasis.

Occupational therapists should aim to include interventions to promote/ maintain homeostasis and self-regulation among clients. When using MSEs therapists may want to consider introducing a protocol approach with clients with ASDs, but clinical judgment should be drawn upon to determine the course of treatment in each individual case.

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Table 1

Participant demographics (n = 20)

Gender (n)	Age (years, mean ± SD)	Age of Diagnosis (years, mean ± SD)	Therapies (n)	Race/Ethnicity (n)	Family structure (n) *	SES (Hollingshead, mean ± SD) *	Min/Max SES (Hollingshead)
Male: 16 Female: 4	5.5 ± 1.1 years	3.2 ± 1.1	OT: 16 Speech: 14 Psychology: 3 Other: 8	White: 15 African American: 2 Biracial: 2 Hispanic origin: 1	Married: 18 Single: 2 Only child: 4 One sibling: 7 Two or more siblings: 9	36.5 ± 12.6	Min SES: 15 Max SES: 59.5

Note: *One parent did not include complete SES questionnaire

Table 2

CARs Results (n=19)

Severity of Autism (Score Range)	Number of Participants
Typical (0-29)	5
Mild/Moderate (30-37)	10
Severe (38-60)	4

Note: One participant was not scored using the CARs assessment.

Table 3

Summary of Sensory Profile quadrant results for participants, number of participants whose scores fell into each range (n = 20)

	Low Registration	Sensory Seeking	Sensory Sensitivity	Sensory Avoiding
Probable Less	0	0	0	0
Typical	3	0	2	2
Probable Difference	3	4	6	7
Definite Difference	7	9	4	4

Table 4

Heart Rate Variability (RMSSD), n=15

	Baseline Epoch	Session Epoch	Proportional Change	Z	Effect size (d)
Protocol	15.89±13.3	17.51±19.2	1.15±3.2	-.852	-.90
				p=.394	
Individualized	19.06±15.97	14.81±13.9	.04±1.06		

Appendix A

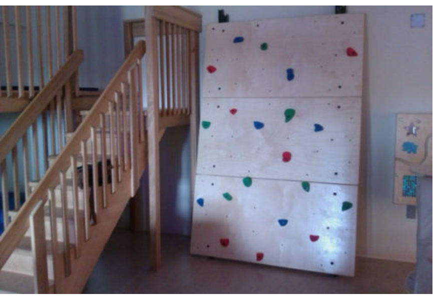
Community MSE Equipment Description and Content List

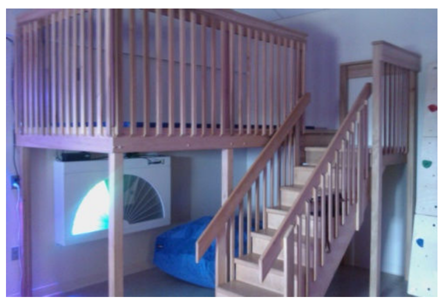
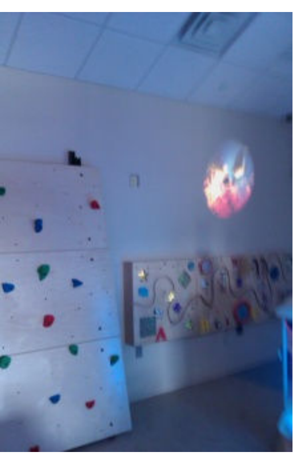
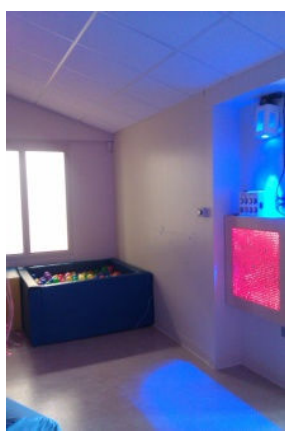
Equipment	Description
Bubble tube	Large clear tubes filled with water with streams of bubbles that float throughout. The tubes are illuminated and change color to allow for visual stimulation.
Vibrating bubble tube plinth	The vibrating seat surrounding the bubble tube provides added sensory stimulation. The intensity of the vibration can be adjusted using the remote control. The vibration has a calming effect for participant's seeking this input.
Fiber optic light wand	Long, smooth fiber optic cables with light travelling though the center for a glowing effect. The light wand is smooth to the touch and can be explored with the participant's hands (i.e. braiding it). The light can change colors as well as be draped over the child for further exploration. The light wand is great visual stimulus, a tool for visual tracking, and good for participants with low vision.
Ball pit/crash pit	A large pit that has 4" soft foam sides covered by safety approved (CPSC) vinyl square shaped unit with a soft foam pad cushion at the bottom. The pit can be filled with small plastic balls to arouse the senses or it can be filled with a large weighted blanket to create a soft, calming space.
Small climbing wall	A small, vertically mounted climbing wall comprised of three sturdy birch panels. Each panel measures 57" W by 29" H and comes with preinstalled handhold mounts. This is an excellent tool for motor planning skills, and bilateral hand movements.
4 multisensory wall panels (tactile, auditory and visual)	Interactive wall mounted panels, which allows for tactile, visual and sounds sensations. The moveable objects in the tracks allow for tactile input and development of motor skills. Clients with visual impairments enjoy the fiber optic lighting and mirrors.
Speakers and stereo for music	Music, particularly soothing music can enhance the MSE experience. A large selection of gentle melodies will be offered to

	promote relaxation.
Projector with varying wheels	Slowly rotating patterns and special effects are projected onto the walls around the room.
Vibrating rocker chair	A variety of oversized foam rocking chairs with built in speakers to provide vibration to arouse the senses.
Bean bag chairs (Including and excluding vibration and sound)	Large, brightly colored chairs filled with polystyrene beads. The chairs provide great proprioceptive input and relaxation.

The pictures below are of the Sensory Playroom with equipment installed





Appendix B

The following information is being asked in order for us to accurately describe the group of people who participated in our study. This information will be kept strictly confidential.

Please answer the following questions:

1. What is your child's age? _______ years

2. Date of Birth: _______________________

3. Gender: ____________________

4. Diagnosis:______________________ Age of initial diagnosis: _________________________

5. Medical history: ____

____

____

6. Family structure: ____

____

7. Current therapy received: ____

____

Indicate the race of the child participant. Please mark any of the following which apply: [¯] White [¯] Black or African American [¯] American Indian or Alaska Native [¯] Asian [¯] Native Hawaiian or other Pacific Islander [¯] Some Other Race	Please indicate whether the child participant is: [¯] Not of Hispanic, Latino, or Spanish origin [¯] Of Hispanic, Latino, or Spanish origin

Please provide responses about yourself in this column	Please provide responses about any other adult living in the home, such as your spouse or committed partner in this column
Level of school completed, select one: [¯] Less than seventh grade [¯] Junior high school (9th grade) [¯] Partial high school (10th or 11th grade) [¯] High school (private, parochial, trade, or public) [¯] Partial college or specialized training [¯] Standard college or university [¯] Graduate professional training	Level of school completed, select one [¯] N/A (i.e. you are single, widowed, divorced) [¯] Less than seventh grade [¯] Junior high school (9th grade) [¯] Partial high school (10th or 11th grade) [¯] High school (private, parochial, trade, or public) [¯] Partial college or specialized training [¯] Standard college or university [¯] Graduate professional training
If employed, please list current job title:	If employed, please list current job title:

Date:_____________ Participant # ____________