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A Retrospective Pre-Post Treatment Study of Occupational Therapy Intervention for Children with Sensory Processing Challenges

Abstract

Background: This study investigated the impact of an intensive, short-term program that incorporates the principles of sensory integration and relationship-based therapies with extensive parent collaboration. The goals were to identify measures sensitive to change and explore the relation between sensory modulation characteristics and change in behavior after intervention.

Method: A retrospective chart review examined routine clinical data pre-post intervention from 179 children identified with sensory processing challenges without comorbid autism. Change in measures of adaptive behavior, emotional functioning, sensory-related behaviors, and motor functioning were evaluated. Relations between sensory modulation and behavior were explored.

Results: Improvements were noted from pretreatment to posttreatment on all measures of adaptive behavior, problem behaviors, sensory-related functions, and measures of motor function. Sensory craving symptoms were associated with a significant reduction in externalizing and behavior problems after intervention.

Conclusion: This study provides preliminary support for the effectiveness of a novel treatment approach.

Keywords

treatment effectiveness, occupational therapy, sensory-based intervention, relationship-based approach, parent coaching

Cover Page Footnote

We wish to thank the children and families who participated in this study and Jillian Sullivan, PhD, who consulted on this project. We would also like to thank Shannon Hampton, Andrea Valdez, and Aryanna Wiggins for their efforts on this paper.

Credentials Display and Country

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Evidence-based pediatric outcomes research is critical to developing better ways to improve the quality of care for children and their families. Pediatric occupational therapists who work with children with sensory processing challenges commonly use sensory-based treatments, relationship-based therapies, developmental skill-based programs, and parent coaching and education approaches (Case-Smith & Arbesman, 2008). However, little is known about the optimal intensity, the active ingredients of treatment, or the outcomes most sensitive to change based on occupational therapy treatment.

Retrospective research is a useful approach for answering questions encountered in day-to-day clinical practice. This methodology is often undervalued and underused, although there is evidence that retrospective studies can expand on outcomes of randomized controlled trials as well as inform randomized clinical trials (Gearing, Mian, Barber, & Ickowicz, 2006). These benefits include reduced costs of conducting the study, easier access to data, and hypotheses generation for prospective studies (Gearing et al., 2006). The following study describes a retrospective chart review of outcomes from an intensive, short-term intervention for children with sensory processing challenges.

Sensory Modulation Difficulties

Sensory processing challenges (often called sensory processing disorder [SPD]) are often characterized by using parent report and teacher report measures. Various measures exist that classify the large group of children identified with sensory processing challenges into homogenous subtypes. Although different frameworks are used to describe these subtypes, commonality exists in the description of the unusual behaviors associated with the typologies of SPD. Sensory modulation dysfunction, one pattern of SPD, usually includes (a) individuals who are overresponsive (i.e., hyperreactive, sensory sensitive, and sensory avoiding) and who experience sensations that most individuals perceive as aversive, uncomfortable, and/or painful; (b) individuals who are underresponsive (e.g., hyporeactive, low sensory registration) and who are slow to respond or have a muted response to sensory experiences of typical intensity; and (c) individuals who are sensory cravers (e.g., sensory seekers) and who have an insatiable need for sensation beyond what is observed in typically developing individuals (Miller, Coll, & Schoen, 2007). It is important to subtype individuals with sensory processing challenges because each subtype has unique symptom clusters that may respond differentially to treatment and the specific responses need further investigation.

Sensory processing challenges can negatively impact an individual's functioning in daily life, although little is known about the association between sensory subtypes and specific daily challenges. Previous studies demonstrate a relation between sensory modulation and participation in functional activities (e.g., daily care, academic activities, or play and leisure) (Bar-Shalita, Vatine, & Parush, 2008) but have small samples that are inadequate to research the differences and characteristics by subtype. The differential effect of interventions based on sensory subtype is also poorly understood, which is an important consideration when investigating the effectiveness of interventions on sensory processing challenges.

Components of the Occupational Therapy Intervention

The intervention used in this study combines principles from pediatric occupational therapy and mental health, including principles from sensory integration (Ayres, 1972) and DIR/ Floortime™ (Greenspan & Wieder, 2007). This intensive, short-term program, referred to as the STAR approach, includes extensive parent collaboration and education as an integral part of the intervention. Parent strategies are based on the clinical reasoning process described in *No Longer A SECRET* (Bailer & Miller, 2011).

The sensory component. Systematic reviews provide preliminary support for using a sensory integrative approach with gains on individualized goals (using goal attainment scaling) as the primary outcome of randomized controlled trials rather than improvements on standardized tests (May-Benson & Koomar, 2010). Conclusions suggest that treatment effectiveness can neither be confirmed nor denied and that additional studies are needed to corroborate previously obtained results. The more recent studies of this approach have focused on children with autism spectrum disorder (ASD) (Pfeiffer, Koenig, Kinnealey, Sheppard, & Henderson, 2011; Schaaf et al., 2014), while an older study was conducted on children without comorbid ASD (Miller et al., 2007).

The relationship component. Occupational therapists often use relationship-based interventions in combination with sensory-based methods. These relationship-based approaches focus on improving social engagement, social communication, and social-emotional development in children with ASD and other developmental conditions (Prizant, Wetherby, Rydell, Wetherby, & Prizant, 2000). One approach, known as DIR/Floortime™, promotes regulation of the child and his or her relationship with caregivers as the key to functional improvements. Elements of this intervention include increasing communicative intent and shared problem solving as a foundation for learning, growth, and development (Kasari, Freeman, & Paparella, 2006; Mahoney & Perales, 2005). Positive results are reported in studies of the effectiveness of these interventions, including increased social participation, social competence, and social engagement (Hwang & Hughes, 2000; Solomon, Nechels, Ferch, & Bruckman, 2007). The strategies that are used include following the child's lead, using contingent imitation and natural reinforcements, focusing on positive responsiveness (Hwang & Hughes, 2000), increasing peer interaction, and sharing problem solving (Solomon et al., 2007). The foundation of the approach is establishing mutually responsive, supportive relationships and bidirectional engagement (Greenspan & Wieder, 2007).

The parent component. An increasing emphasis in many pediatric programs is to use parent participation, coaching, and education (Dunn, Cox, Foster, Mische-Lawson, & Tanquary, 2012; Wilkes-Gillan, Bundy, Cordier, & Lincoln, 2014). This increases the family-centered nature of occupational therapy and highlights the role of parents as the primary supports to their child's growth and development. Parent involvement provides more contextually relevant intervention in daily routines and shows improvement in child outcomes, including increased participation in everyday life (Wilkes-Gillan et al., 2014). A recent meta-analysis demonstrated significant improvement in language outcomes when parent-directed interventions were combined with therapist-led approaches (Hampton & Kaiser, 2016).

Purpose of the Study

The debate about the effectiveness of many pediatric interventions continues for several reasons. The literature is rampant with jargon describing protocolized approaches or specific strategies that use a one-size-fits-all approach, which, though easier to research, are not reflective of the clinical reasoning used in pediatric occupational therapy. Previous studies have had additional challenges, including poorly defined, nonreplicable interventions, no method to ascertain fidelity to the intervention, and a lack of power (May-Benson & Koomar, 2010).

This present study addresses past problems by using a detailed manualized approach as well as a well-defined training procedure for delivery of the intervention (May-Benson & Koomar, 2010). One of the major challenges of conducting outcomes research is the significant time and cost needed for large clinical trials. Therefore, data collected from chart reviews that document the effectiveness of interventions are valuable additions to the literature.

The following retrospective chart review seeks to examine the effects of occupational therapy intervention for children with sensory processing challenges using standardized outcome measures. This intensive, short-term program uses direct treatment that incorporates the principles of sensory integration and relationship-based therapy with extensive parent collaboration, including direct coaching in treatment sessions and parent education provided during parent-only meetings.

Research Questions

The specific research questions addressed were:

1. What outcomes are most sensitive to change, suggesting their use in future prospective studies of treatment effectiveness?
2. What is the relation between sensory modulation characteristics and changes in behavior after intervention?
3. What are the adaptive behavior challenges and problem behaviors of children with specific sensory modulation subtypes?
4. Does intervention have a differential effect on adaptive behavior and problem behaviors based on the sensory modulation subtype?

Method

This study used a retrospective pretreatment and posttreatment design. Routine clinical data, collected before and after treatment, were accessed retrospectively. Charts from 216 children who had completed occupational therapy were reviewed. All of the children were enrolled in an intensive program at a private pediatric clinic in Greenwood Village, CO, from 2007 to 2013. The Rocky Mountain University of Health Professionals Institutional Review Board approved this study.

Participants

Referrals made between January 2007 and December 2013 were examined to determine which children met the inclusion criteria. Inclusion was based on confirmation of impairment in sensory processing defined by (a) the global clinical impression of an occupational therapist following standardized testing using the Miller Function and Participation scale (MFUN) (Miller, 2006) or the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) (Bruininks, 2005), and atypical performance on the Sensory Processing 3 Dimensions (SP3D) Assessment; (b) abnormal scores on the the Short Sensory Profile (SSP) (McIntosh, Miller, Shyu, & Dunn, 1999) ($< -2.5 SD$) and the SP3D Assessment; and (c) atypical structured and unstructured observation in the clinic. Only children who had both pretreatment and posttreatment test data on either the Adaptive Behavior Assessment System, second edition (ABAS-II) or the Behavior Assessment System for Children, second edition (BASC-2) were included.

In order to obtain a more homogenous sample, children were excluded if they had other known psychiatric, neurological, or physical disorders, such as autism, Down syndrome, Fragile X syndrome, Tourette's syndrome, drug or alcohol exposure, spina bifida, and orthopedic problems. Comorbid diagnoses of attention deficit hyperactivity disorder (ADHD) and anxiety were allowed. We reviewed 206 charts. Thirty-one charts were deleted due to exclusion criteria: children who had a diagnosis of ASD ($n = 25$), Tourette's syndrome ($n = 2$), injury/accident ($n = 2$), or cerebral palsy ($n = 2$). Five charts were deleted because of incomplete or missing information regarding the duration of treatment. One chart was deleted because the child was seen for only five treatment sessions.

One hundred and seventy-nine child records met the inclusion criteria. The children were ages 2 to 13 years (mean = 6.1 years, $SD = 2.3$); 40 (22%) were female and 139 (78%) were male; 87% of the

sample were Caucasian. Socioeconomic status, based on maternal and paternal education, demonstrated 94% with a college or graduate school degree. The majority of families who attend the clinic live in the state of Colorado (60%), but some do come from other areas of the United States (35%) and from around the world (5%). The parents of all children voluntarily sought out this intervention program because of concerns that sensory impairments were significantly interfering with their child's participation at home, at school, or in the community.

Description of the Intervention

This was an intensive, short-term program designed to address sensory symptoms affecting performance of daily life activities and routines. The intervention used a combined approach, including sensory integration therapy (Ayres, 1972) and DIR/Floortime™ (Greenspan & Wieder, 2007). Individualized treatment focused on regulation strategies to address arousal, relationship-based strategies to enhance interpersonal connections, sensory integration activities to address sensory and motor deficits, and social-emotional attunement to affect enjoyment and quality of life. Our theory of change is that parent-child interactions impact the play process, which supports a child's growth and development. Activities are used to enhance the process of engagement, but the goal is to engage the parent and child in increasingly complex processes of interactions that support the child's underlying sensory processing and relational challenges. In addition, some of the children in this study were exposed to Integrated Listening Systems™ (iLs™) (www.integratedlistening.com) during the intervention (complete information on the exact number was not available from the client charts). Occupational therapy sessions were 50 min in duration and scheduled for three to five times a week. The manual used for training clinicians in this approach appears in *Sensational Kids* (Miller, 2014). All of the clinicians had a master's degree in occupational therapy and a minimum of 5 years of experience. They also participated in Level 1 and Level 2 mentorship training in sensory integration, were certified in DIR/Floortime™, and had weekly individual supervision and team case review of all clients.

This approach is unique for its inclusion of a significant parent education (one in five sessions are parents only, no children participate), parent collaboration, and parent coaching component. Parent coaching takes place in each treatment session, and the parents participate in five to six parent-only education sessions. The parent education component focuses on the development of home and school strategies using the clinical reasoning model of *A SECRET* (Bailer & Miller, 2011).

All of the children were pre-post tested using standardized scales, parent report measures, individualized goals, and goal attainment scaling (data on goal attainment scaling not included or reported in this study). Posttreatment testing was conducted within 2 weeks of completing the program.

Training in the treatment approach was provided to therapists at the STAR Institute by the authors of this study following the principles outlined in *Sensational Kids* (Miller, 2014). Fidelity to the treatment model was attained through weekly, individual supervision and team meetings where videotaped sessions were reviewed and discussed.

Instruments and Assessment Measures

Bruininks-Oseretsky Test of Motor Proficiency, second edition. The BOT-2 (Bruininks, 2005) is a standardized norm-referenced, performance-based assessment of fine and gross motor abilities in children aged 4 to 21 years. The test assesses motor performance in four domains: fine manual control, manual coordination, body coordination, and strength and agility, each with two subtests. Because of missing data, only five subscales are reported in this study: (a) fine motor precision reflecting drawing, writing, folding, and cutting skills; (b) bilateral coordination; (c) balance reflecting

motor skills used in locomotion, sports-based, or recreational movement; (d) manual dexterity; and (e) upper limb coordination reflecting speed and accuracy of reaching, grasping, and bimanually coordinated movements. Internal consistency reliability and test-retest consistency of the total test are high: ~ .80 and .77 to .80, respectively. The content validity and construct validity of the scale has been demonstrated (Bruininks, 2005).

Miller Function and Participation Scale. The MFUN (Miller, 2006) is a performance-based assessment for children aged 2 years 6 months through 7 years 11 months. It is a standardized, norm-referenced test that assesses visual motor, fine motor, and gross motor abilities. Each test produces a separate normative scaled score. Support is provided for content validity and concurrent validity (Miller, 2006). Sensitivity and specificity of the scale is considered strong, particularly for children who score one standard deviation below the mean. Internal consistency for items in each domain is good (.85 to .92), test-retest reliability is moderately high (.77 to .82), and inter-rater reliability ranges from .91-.93 (Miller, 2006).

Adaptive Behavior Assessment Scale, second edition. The ABAS-II (Harrison & Oakland, 2003) is a norm-referenced parent or caregiver rating scale for individuals from birth to 21 years of age. The ABAS-II provides a comprehensive assessment of a child's adaptive behavior. Adaptive behavior is concerned with conceptual, social, and practical skills that contribute to one's ability to function in daily life. There are 10 adaptive skill areas of the ABAS-II: communication, community use, functional academics, school/home living, health and safety, leisure, self-care, self-direction, social, and work (the latter for older adolescents and adults). There are four composite scores: general adaptive, conceptual, social, and practical. Internal consistency reliability for the general adaptive behavior quotient and all adaptive skill areas was high for all age groups ($\alpha = .79 - .99$). There is strong convergent validity with the Vineland Adaptive Behavior Scale (Harrison & Oakland, 2003). Discriminant validity was demonstrated between multiple clinical groups and typical controls, including individuals with learning disorders, ADHD, ASD, mental retardation, and emotional/behavioral disorders.

Behavior Assessment System for Children, second edition. The BASC-2 (Reynolds & Kamphaus, 2003) is a norm-referenced, multidimensional measure of emotional and behavioral disorders for children aged 4 to 18 years. The parent rating scale assesses a child's behavior at home and in the community. The BASC-2 assists in the diagnosis of childhood disorders and includes a variety of symptoms described in a number of developmental and mental health disorders. There are four composite scores: externalizing problems, internalizing problems, adaptive skills, and behavioral symptoms index. All composites have high internal consistency reliability, with α ranging from .88-.94. Reliabilities average in the mid to upper .70s for all age levels. The factor structure was confirmed using principal-axis factor analysis. Support is proved for both convergent and discriminant validity. Psychometrics of the scale suggests that profiles of the clinical groups (including conduct disorder, depression, emotionally disturbed, ADHD, learning disability, mild mental retardation, and ASD) were significantly more impaired than typical controls.

Sensory Processing 3 Dimensions (SP3D) Assessment. The SP3D Assessment is an unpublished performance measure of sensory modulation, sensory-based motor disorder, and sensory discrimination disorder. It consists of activities similar to those encountered in daily life, specifically designed to elicit typical and atypical behavioral responses to sensation. The assessment provides structured opportunities and specific scoring criteria on which to base one's determination of sensory processing status. The activities on the assessment include those previously tested for reliability and

validity on the Sensory Overresponsivity scale (Schoen, Miller, & Green, 2008) as well as items that elicit sensory underresponsivity and sensory craving (Schoen et al., 2014) and new items tapping postural disorder, dyspraxia, and discrimination problems. Preliminary evidence supports the internal consistency reliability and discriminant validity of the scale as well as supporting the underlying structure of the behavioral scoring categories (Schoen et al., 2014).

Sensory Processing 3 Dimensions (SP3D) Parent Inventory. The SP3D Parent Inventory is an unpublished measure of sensory modulation and sensory-based motor disorder. It consists of five subscales: sensory overresponsivity (SOR), sensory underresponsivity (SUR), sensory craving (SC), postural disorder, and dyspraxia and sensory discrimination disorder. The items chosen for the inventory include those previously tested for reliability and validity on the SOR subscale (Schoen et al., 2008) as well as items that are based on behaviors usually observed in children with sensory underresponsivity or sensory craving (Schoen, Miller, & Sullivan, 2016) and new items reflecting postural, praxis, and discrimination problems. Scoring using a binary system, which requires the informant to indicate whether a behavioral description applies to his or her child (*applicable* = 1; *not applicable* = 0). The total SP3D Parent Inventory takes approximately 10 min to complete. The parent rates the child on the five subscales; total subtest scores reflect the summed number of items endorsed by the parent on each subscale. Subscales demonstrate good internal consistency reliability and significantly discriminate between typically developing children and those with sensory modulation challenges (Schoen et al., 2016). The internal structure of the scale is confirmed by principal axis factor analysis (Schoen et al., 2016).

The Short Sensory Profile. The SSP (McIntosh et al., 1999) is a 38-item parent report questionnaire. A child is scored using a 5-point Likert scale to quantify the occurrence of sensory-related behaviors in the following dimensions: tactile sensitivity, taste/smell sensitivity, visual/auditory sensitivity, auditory filtering, underresponsive/seeking sensation, and movement sensitivity. The reliability and validity of the measure is strong and it is frequently used to characterize sensory modulation challenges in children (McIntosh et al., 1999).

Data Analysis

Nonparametric tests were used for all analyses. Several criteria were examined to make this decision: Shapiro-Wilks test, skewness, kurtosis, and examination of the distribution using histograms and Q-Q plots. The majority of the pre-post measures were not normally distributed; Shapiro-Wilks tests with $p < .05$, skewness (0.32 to 33.47), and kurtosis (-1.07 to 163.06) ranging from moderate to severe and exceeding the acceptable range of ± 1.96 . The associated histograms and Q-Q plots had non-normal distributions and deviations from fit line. Based on these analyses, the data violates assumptions required to run parametric analyses (Abu-Bader, 2011).

Impact of intervention. Impact of intervention was evaluated using the Wilcoxon signed rank test, a non-parametric paired-samples test. Change in adaptive behavior on the ABAS-II, emotional functioning on the BASC-2, and sensory-related behaviors on the SP3D Parent Inventory were assessed.

A subset of the sample had pre-posttreatment testing of motor performance using either the MFUN ($n = 40-47$) or the BOT-2 ($n = 17-33$) performance measure. Wilcoxon signed rank tests were used to evaluate change on these measures.

A correction for multiple comparisons was made for p values for the parent report measures by dividing alpha ($\alpha = .05$) by the number of comparisons ($\alpha = .002$). A correction for multiple

comparisons was not made for the examiner-administered motor scales due to smaller n 's and the preliminary/exploratory nature of these analyses.

To explore the impact of varied lengths of treatment, Spearman ρ correlational analyses were computed between number of treatment sessions and change scores on the primary outcome measure variables. A correction for multiple comparisons was made for p values by dividing alpha ($\alpha = .05$) by the number of comparisons ($\alpha = .002$).

Sensory modulation characteristics. Relations between sensory modulation symptoms and behavior were explored using Spearman ρ . Pretreatment scores of the SP3D Parent Inventory SOR, SUR, and SC were correlated with the pretreatment scores of the ABAS-II and BASC-2 composite scores. Threshold levels of significance were adjusted for multiple comparisons ($p < .001$).

Relations between sensory modulation symptoms and outcomes following intervention were examined through Spearman ρ correlational analyses. Pretreatment scores of the SP3D Parent Inventory SOR, SUR, and SC were correlated with change scores on the ABAS-II and the BASC-2 composite scores. For these correlations, threshold levels of significance were not adjusted for multiple comparisons due to the preliminary and exploratory nature of these analyses.

Results

Eighty-four percent of this sample received a treatment program that consisted of 19 to 40 sessions ($M = 26.1$, $SD = 7.74$, range = 11 to 68). Fourteen percent received fewer than 19 sessions and 2% received greater than 40 sessions. The number of sessions varied due to parents' schedules.

Impact of Intervention

Significant improvements were demonstrated from pretreatment testing to posttreatment testing on all composite scores of the ABAS-II (see Table 1). Effect sizes were moderate to large ($r > .45$). Performance of the sample on all composites (general adaptive, conceptual, social, and practical) were at least one standard deviation or more below the mean at the start of therapy. Following the intervention, all of the scores, except for the practical domain, were within average range.

Table 1

Scores on the ABAS-II Pre-Posttreatment and Effect Sizes

ABAS-II	n	Before Treatment		After Treatment		Wilcoxon Signed Rank Test	p	Effect Size
		M	SD	M	SD			
General Adaptive	135	81.08	15.03	88.79	16.46	-6.43	<.001	0.55
Conceptual	141	85.25	14.50	92.23	15.72	-6.26	<.001	0.53
Social	146	85.84	15.77	91.77	17.29	-5.41	<.001	0.45
Practical	143	79.42	14.60	85.18	17.80	-5.33	<.001	0.45

Significant improvements were reported from pretreatment to posttreatment on all composite scores of the BASC-2 (see Table 2). Effect sizes were moderate to large ($r > .41$).

Table 2*Scores on the BASC-2 Pre-Posttreatment and Effect Sizes*

BASC-2	<i>n</i>	Before Treatment		After Treatment		Wilcoxon Signed Rank Test	<i>p</i>	Effect Size
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Externalizing	157	59.32	13.04	55.06	10.74	-5.15	<.001	0.41
Behavioral	157	62.62	12.67	57.17	10.69	-6.49	<.001	0.52
Internal	157	57.78	13.09	52.65	11.65	-5.88	<.001	0.47
Adaptive	156	40.93	8.74	45.22	8.59	-6.00	<.001	0.48

A post hoc analysis of pretreatment scores showed that before treatment approximately half of the sample had atypical externalizing ($n = 75$; $M = 70.40$), atypical internalizing ($n = 69$; $M = 69.41$), or atypical adaptive behaviors ($n = 71$; $M = 33.35$). Sixty-eight percent had an atypical behavioral index ($n = 96$; $M = 61.65$) score before intervention. Notably, the group average for scores on three of the four behavioral composites fell within the average range after intervention.

Improvements were noted from pretreatment to posttreatment for all subtests of the SP3D Parent Inventory (see Table 3) with an overall reduction in atypical sensory modulation behaviors. However, gains in posture and praxis were not significant after correcting for multiple comparisons. Subtests that were significant had moderate effect sizes ($r > .33$).

Table 3*Scores on the SP3D Pre-Posttreatment and Effect Sizes*

SP3D	<i>n</i>	Before Treatment		After Treatment		Wilcoxon Signed Rank Test	<i>p</i>	Effect Size
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
SUR	91	4.67	3.71	3.26	3.12	-4.19	<.001	0.44
SOR	119	9.05	5.16	7.44	5.13	-3.57	<.001	0.33
SC	116	7.63	6.40	4.75	5.10	-5.62	<.001	0.52
Posture	118	4.40	4.60	3.69	3.62	-2.10	.036	0.19
Praxis	118	10.07	7.56	7.36	6.01	-4.80	<.001	0.44
Discrimination	118	2.75	2.48	2.25	2.33	-1.94	.053	0.18

Data from a subset of charts had pre-post testing on either the MFUN or the BOT-2 (see Tables 4 and 5). Significant improvements were noted from pretreatment to posttreatment on all three subscales of the MFUN (e.g., visual motor [$n = 40$], fine motor [$n = 47$], and gross motor [$n = 40$]), all with large effect sizes ($r > .52$). Data from fine motor precision ($n = 17$), manual dexterity ($n = 23$), bilateral coordination ($n = 33$), and balance subtests ($n = 33$) of the BOT-2 also showed significant improvement from pretreatment to posttreatment with moderate to large effect sizes ($r > .45$). No change was noted in upper limb coordination ($n = 26$).

Table 4*Scores on the MFUN Pre-Posttreatment and Effect Sizes*

MFUN	<i>n</i>	Before Treatment		After Treatment		Wilcoxon Signed Ranked Test	<i>p</i>	Effect Size
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Visual Motor	40	6.25	2.86	7.63	2.95	-3.65	<.001	0.577
Fine Motor	40	5.36	2.18	6.92	2.83	-4.00	<.001	0.584
Gross Motor	40	5.63	2.34	7.00	3.07	-3.30	<.001	0.522

Table 5*Scores on the BOT-2 Pre-Posttreatment and Effect Sizes*

BOT-2 Composite	Subtest	Before Treatment		After Treatment		Wilcoxon Signed Ranked Test	<i>p</i>	Effect Size
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Fine manual control	Fine Motor Precision (<i>n</i> = 17)	9.53	4.11	11.65	4.68	-2.11	0.04	0.48
Manual Coordination	Manual Dexterity (<i>n</i> = 23)	9.61	3.04	11.26	4.15	-2.15	0.03	0.45
	Upper Limb Coordination	9.42	4.04	9.50	2.55	-0.67	0.50	0.13
Body Coordination	Bilateral Coordination (<i>n</i> = 33)	9.94	3.98	13.42	5.24	-3.51	0	0.61
	Balance (<i>n</i> = 33)	8.33	3.17	10.85	3.45	-3.63	0	0.63

Only one significant correlation was obtained between length of treatment and change in the primary outcome measure variables; change in the externalizing composite of the BASC-2 was correlated with the number of treatment sessions ($\rho = .262$; $p = .001$). None of the other 21 correlations computed were significant.

Sensory Modulation Characteristics

Significant correlations were obtained between the SP3D sensory modulation subtypes and impairments on the ABAS-II and BASC-2 prior to treatment. Sensory craving (SC) positively correlated with externalizing problems ($\rho = 0.447$; $p < 0.001$) and behavioral symptoms index composites of the BASC-2 ($\rho = 0.405$; $p < 0.001$). SC also correlated with the social domain of the ABAS-II ($\rho = -0.283$, $p = 0.004$) such that greater SC behaviors were associated with poorer social adaptive behavior. Sensory overresponsivity (SOR) was positively correlated with the internalizing problems composite of the BASC-2 ($\rho = 0.337$; $p = 0.001$) but not with any domains of the ABAS-II. Sensory underresponsivity (SUR) correlated with the conceptual domain ($\rho = -0.338$; $p = 0.002$) and practical domain ($\rho = -0.280$, $p = 0.010$) of the ABAS-II, with greater SUR behaviors associated with greater problems in conceptual and practical adaptive behavior. SUR did not correlate with any composite scores on the BASC-2.

Significant correlations were found between SC symptoms prior to treatment and changes in externalizing problems ($\rho = -0.23$, $p = 0.02$) following treatment as well as between SC symptoms and changes in the behavioral index composite ($\rho = -0.20$, $p = 0.04$). In other words, greater SC behaviors

pretreatment were associated with a greater reduction in externalizing and behavior problems after intervention. No other composite scores were correlated with sensory modulation symptoms.

Discussion

This pre-post treatment retrospective chart review addressed three primary research questions by (a) providing preliminary evidence that supports the effectiveness of a model of occupational therapy intervention for children with sensory processing challenges, (b) identifying measures that were sensitive to change and suggesting potential for use in future outcome studies, and (c) suggesting sensory modulation subtypes were associated with different adaptive behavior and emotional functioning impairments.

Impact of Intervention

These results suggest that an intensive, short-term intervention was effective in improving adaptive behavior, emotional functioning, and sensory processing as reported by parents as well as by examiner-assessed motor performance. These results support a combined approach of direct treatment that uses sensory integration and DIR/Floortime™ with active parent participation and collaboration, parent coaching, and extensive parent education.

More specifically, improvements were noted on all standardized scales included in this study, suggesting their usefulness in future investigations of treatment effectiveness. Gains in daily life functioning were reflected by adaptive behaviors, such as functional communication, self-direction, self-care, home living, health and safety, leisure, and social skills. There was a significant reduction in problematic behaviors associated with externalizing, internalizing, and other behavioral symptoms, such as hyperactivity, aggression, anxiety, depression, withdrawal, and inattention. In addition, there was a decrease in sensory symptoms, including less SOR, SUR, and SC. Last, motor skills improved in the areas of fine motor, gross motor, and visual motor abilities, with the exception of upper-limb coordination on the BOT-2. It is possible that changes related to timing and sequencing in ball play are not as evident immediately following therapy and may require a longer period of integration to become a part of the child's repertoire of motor skills.

Of interest is that length of treatment was not associated with improvement in outcomes except for externalizing as measured by the BASC-2. Since no other improvements were associated with the number of treatment sessions, the study suggests that length of treatment did not have a significant impact on postintervention changes. The impact of the duration of treatment needs to be explored in future studies under more controlled experimental conditions.

The sensory component. This study extends the treatment model developed by Ayres (1972) and provides partial support of the effectiveness of an occupational therapy intervention that incorporates the principles of a sensory integration approach. Like Ayres' sensory integration, this study used a clinic-based, child-centered approach that incorporates enhanced sensory opportunities that address the needs of the child and foster more adaptive and organized responses in the context of play. Several recent studies of sensory integration treatment showed positive gains in individualized goals (using Goal Attainment Scaling) compared to usual care (Schaaf et al., 2014), a fine motor group (Pfeiffer et al., 2011), and an active placebo or waitlist (no treatment) condition (Miller et al., 2007). In comparison, the strength of this study showed gains in standardized measures.

The relationship component. This study makes an important contribution by providing preliminary support for an approach to intervention that focuses on fostering the child's growth and development through parent-child interactions. The STAR approach is strongly rooted in relationship-

based approaches as a foundation for intervention and recognizes how critical relationships are to learning (Greenspan & Wieder, 2007; Prizant, Wetherby, Rubin, Laurent, & Rydell, 2005). While many relationship-based approaches exist, there are few large-scale studies supporting their effectiveness (Case-Smith & Arbesman, 2008).

The parent component. Findings from this study also support previous findings of the effectiveness of programs that emphasize parent participation/collaboration, parent coaching, and parent-delivered interventions (Dunn et al., 2012). Inclusion of parents in the therapeutic process is increasingly reported in the literature and is growing in popularity (Hanna & Rodger, 2002; Wilkes-Gillian et al., 2014). The results of this study are consistent with other models of coaching and training parents, which demonstrates significant improvements in child outcomes. Parent participation may indeed maximize the gains of a therapist-provided intervention (Hampton & Kaiser, 2016).

Sensory modulation characteristics. The relations of sensory modulation subtypes, adaptive behaviors, and emotional functioning impairments that emerged in this study are consistent with case examples from clinical observation (Miller et al., 2007). For example, children with SC behaviors are often driven to obtain excessive amounts of sensory stimuli to the point of being dysregulated. In this study, they also tended to have more externalizing behaviors and behavior problems as reflected on the BASC-2. It is not uncommon that clinicians refer to these kinds of children as being “always on the go,” “in your face,” and “in your space,” and other such labels consistent with the behavioral dimensions of externalizing (Miller, 2014). In this study, the children with SOR, who have adverse reactions to innocuous or even pleasant sensory stimuli, tended to display more internalizing behaviors, such as anxiety, withdrawal, and depression. These children are often wary of the unexpected and potentially uncomfortable and unpredictable sensory experiences that may produce unease, worry, and excessive concerns (Green, Ben-Sasson, Soto, & Carter, 2012). The children with SUR, who are slow to respond or tend not to notice even high intensity stimuli, did not show a particular pattern of behavior problems in this study, but rather showed greater problems in the conceptual and practical domain of the ABAS-II. These domains reflect problems in communication, academics, self-direction, community use, school living, health and safety, and self-care. If sensory experiences are missed because of SUR, then impairments to functioning in daily life are not unexpected. For example, SUR in children with ASD has been shown to be associated with impaired cognitive and academic performance as well as poorer social functioning (Ashburner, Ziviani, & Rodger, 2008).

A novel finding of this study was the relationship between SC and the change in social-emotional functioning after treatment. The children not only had greater amounts of externalizing and behavioral challenges pretreatment, but also had greater change in both of these dimensions following intervention (e.g., more than those with SOR or SUR). To our knowledge, this is the first study to examine the differential effects of intervention by sensory subtype characteristics. Our findings suggest that this would be an important characteristic to explore or control for in future studies of treatment efficacy in children with sensory processing differences.

Strengths and Limitations

This study used an observational research method to complement findings from previous randomized controlled trials. Limitations of this approach include the lack of a control group and non-randomization. This study also only included individuals who attended therapy at one private pediatric clinic, thus generalizability may be impacted. Nevertheless, this retrospective study included a large sample across several years and was thought to be representative of the population seen in a typical

pediatric occupational therapy practice that treats children with sensory processing challenges. Although randomized controlled trials have significant advantages, the results presented here may be more reflective of what happens in real world practices.

Future Directions

This is the first study to report changes using the STAR approach, an intensive, short-term model of occupational therapy for children with sensory processing challenges. Evidence supports the value of this approach to intervention that includes principles of sensory integration, relationship-based approaches (DIR/Floortime™), and parent involvement. Future studies should examine the impact of frequency, duration, and intensity by comparing treatment delivered three to five times a week as well as examining the impact of duration by including more equal groups of participants with similar numbers of treatment sessions. (Retrospective data were not specific enough to allow us to examine this question adequately). Measures of sensory processing, adaptive behavior, and social-emotional functioning, although sensitive to change, were all collected using parent report. Future studies should include examiner-administered tools that would provide a more objective measure of social interaction, engagement in activities, and participation of childhood occupations. Additional areas for future study should reflect caregiver satisfaction, family empowerment, and impact on quality of life. Information on the lasting effects of intervention and need for additional services following an intensive, short-term program would help to understand the benefits of this dosage.

Conclusion

This study suggests that sensory modulation subtypes are associated with different adaptive behavior and emotional functioning impairments. This study also provides preliminary support for the effectiveness of a novel treatment approach developed at the STAR Institute that combines intensive, short-term occupational therapy using principles from sensory integration and DIR/Floortime™, with extensive parent education, collaboration, and coaching. All children improved on standardized measures of adaptive behavior, emotional functioning, sensory processing, and motor skills, thus suggesting that these measures are sensitive to change and hold promise for use in prospective studies that employ more rigorous research designs.

Implications for Practice

This study contributes important information to guide evidence-based practice for children with sensory processing challenges. The findings of this study suggest:

- A short-term program of intensive treatment occurring three to five times a week may be effective in remediating motor, social-emotional, and adaptive behavior problems in children with sensory processing challenges.
- A combination of sensory-based treatment with a focus on engagement or relationship may be an effective and appropriate approach for addressing the sensory processing challenges in children.
- Parent education, collaboration, and coaching may be an important and integral part of pediatric occupational therapy intervention.

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