
Behavioral Indexes of the Efficacy of Sensory Integration Therapy

Jane E. Roberts, Linda King-Thomas, Marcia L. Boccia

KEY WORDS

- behavior
- efficacy
- pediatric
- sensory integration

OBJECTIVE. The study examined behavioral treatment effects of classical sensory integration therapy.

METHOD. This study used a prospective longitudinal, single-subject ABAB design. The participant was a boy, age 3 years and 5 months, with average nonverbal intellectual skills, delayed communication skills, and sensory modulation disorder. Difficulties with modulating sensory input and delayed communication skills affected his occupational performance in preschool. Behavioral data were collected in the preschool by teachers who were blind to the type and timing of sensory integration therapy.

RESULTS. Improvement in behavior regulation was observed, including increased engagement and decreased aggression, less need for intense teacher direction, and decreased mouthing of objects.

CONCLUSION. Classical sensory integration therapy may be associated with improved self-regulatory behaviors.

Roberts, J. E., King-Thomas, L., & Boccia, M. L. (2007). Behavioral indexes of the efficacy of sensory integration therapy. *American Journal of Occupational Therapy, 61*, 555–562.

Jane E. Roberts, PhD, is Scientist, FPG Child Development Institute, University of North Carolina at Chapel Hill. Mailing address: 517 South Greensboro Street, Carrboro, NC 27510; jane_roberts@unc.edu.

Linda King-Thomas, MHS, is Director, Developmental Therapy Associates, Inc., Durham, NC.

Maria L. Boccia, PhD, is Scientist, FPG Child Development Institute, University of North Carolina at Chapel Hill.

Over the past decade, there has been an increase in research investigating physiological and behavioral indexes of self-regulation in young children. Self-regulation refers to a person's abilities to regulate his or her responses to specific stimuli and is purported to include physiological, emotional, and behavioral factors that are interdependent (Calkins & Dedmon, 2000). Although a fairly predictable pattern of self-regulation has been identified in early development, important individual differences exist in the abilities and expressions of these behaviors. Numerous studies have shown that poor self-regulation is related to disruptive and aggressive behaviors, poor attention, and lower scores on cognitive measures (Calkins & Dedmon, 2000; Davis, Bruce, & Gunnar, 2002; Richards, 1987).

The ability to integrate sensory information is one source of variation that accounts for individual differences in self-regulation. Although various definitions exist, sensory integration is generally described as a neurological process that reflects an individual's ability to organize internal and environmental sensations to regulate and function efficiently in the environment (Bundy & Murray, 2002; Dunn, 1997). Sensory modulation disorder (SMD) describes problems in regulating and organizing the degree, intensity, and nature of responses to sensory input in a graded manner that interferes with age-expected social, cognitive, or sensory functioning (Interdisciplinary Council on Developmental and Learning Disorders, 2005; Miller, Reisman, McIntosh, & Simon, 2001). Persons with SMD display overresponsivity, underresponsivity, or lability in response to sensory stimuli (Dunn, 1997; Miller et al., 2001). These processing abnormalities often are associated with concomitant sensory-seeking or sensory-avoidant behaviors that reflect a person's attempt to regulate the sensory input and achieve an optimal or

Reprinted from *The American Journal of Occupational Therapy* (Volume 61, Number 5) with permission from The American Occupational Therapy Association, Inc. (AOTA). Copyrighted 2003 by AOTA, 4720 Montgomery Lane, Bethesda, MD 20824. All rights reserved on products published by AOTA, please call 301-652-2682 or visit www.AOTA.org.

comfortable level of arousal (Ayres, 1979; Dunn, 1997). Functional problems associated with SMD include decreased social skills and participation in play; decreased frequency, duration, or complexity of adaptive responses; impaired self-confidence; and diminished fine motor, gross motor, and sensorimotor skill development (Bundy & Murray, 2002).

Few studies have investigated the prevalence and treatment efficacy of SMD. However, preliminary evidence suggests that 5% to 20% of children without disabilities display SMD (Ahn, Miller, Milberger, & McIntosh, 2004; Dunn & Westman, 1997). Other studies of children with neurodevelopmental disorders have shown that specific subgroups, such as children with autism or Fragile X syndrome (see Baranek, 2002, for a review), are at increased risk for SMD.

The evaluation of behavioral treatment effects of sensory integration therapy is critical for informing evidence-based practice. Few published studies have examined sensory integration treatment effects, and those studies have focused on persons with moderate to severe disabilities, with little attention to children who have average cognitive abilities. In addition, the studies have been limited by methodological flaws, including poor control over competing treatments, lack of baseline conditions, and potential bias. The current study was designed to investigate behavioral responses to classic sensory integration treatment. Two research questions guided this study. First, do self-regulatory behaviors increase in association with sensory integration therapy? Second, if self-regulatory behaviors increase in association with sensory integration therapy, are improvements seen in multiple domains?

Method

Participant

The participant was a boy, age 3 years and 5 months, with no history of gestational or birth complications. Gross motor milestones were within age expectation (e.g., walked at 10 months), but he had delayed speech and language. He had no current or prior history of medication use. Psychoeducational evaluation results at age 3 years, 3 months revealed average nonverbal intelligence with an IQ score of 104. However, a 10-month delay in receptive- and expressive-language skills was noted. He was diagnosed with SMD by a trained (PhD, OTR/L) occupational therapist using interviews, the Sensory Profile (Dunn, 1999), and the Sensory Experiences Questionnaire (Baranek, David, Poe, Stone, & Watson, 2005). The child's sensory profile was characterized by tactile sensitivity, poor auditory filtering, and sensory-seeking behaviors. These identi-

fied areas of difficulty (SMD and delayed communication) affected his ability to be successful in his occupation as a student in a preschool program due to poor self-regulation of his behavior.

The participant had no history of early intervention and had been in a part-time family day care program for 3 years. The participant took part in a Montessori program for 8 weeks before the onset of treatment. After the first 2 weeks in the Montessori program, his participation time was reduced from 210 min per day for 5 days a week to 90 min per day for 5 days a week due to poor behavior regulation that was affecting his and others' ability to learn and interact.

Intervention

The participant received occupational therapy using a sensory integration frame of reference from a therapist with 30 years of experience (the second author), who completed a work study program with A. Jean Ayres and is certified to administer and interpret the Sensory Integration and Praxis Tests (SIPT). Therapy sessions occurred one-on-one in an intensive model of 1-hr sessions three times a week during treatment cycles. Intervention was limited to clinic-based services. No consultation occurred with the Montessori program during this study to enable the teachers to remain blind to the treatment. The participant received therapy in treatment rooms with numerous ceiling hooks for suspended equipment and ropes, lofts, trampolines, slides, mats, and pillows on the floor. Intervention occurred within the occupation of play and followed the principles of sensory integration therapy, providing controlled sensory input to elicit an adaptive response, guiding the participant's self-direction within a structured environment, and facilitating active participation in exploring the environment.

Procedures

This study used a prospective longitudinal, single-subject ABAB design. The protocol was restricted to an 11-week period because the child was scheduled to enter an early intervention program at that time, which would introduce treatment confounds. The research procedure included alternating no-treatment (A) and treatment conditions (B) in the following order: (a) 2 weeks of no treatment, (b) 5 weeks of treatment, (c) 2 weeks of no treatment, and (d) 2 weeks of treatment. This schedule was selected to maximize the amount of data for each condition while minimizing the potential effects of maturation that can occur with young children over long periods. All procedures were reviewed and approved by the university's institutional review board.

Measures

Observational teacher ratings of behavioral regulation were chosen to evaluate the overt manifestations of SMD as they relate to typical occupations of childhood, such as engaging in meaningful cognitive and social interactions. The behavior ratings took place in the context of a typical day at the Montessori preschool. Note that although the teachers were aware that a research study was being conducted and willingly collected behavioral data, they were blind to the nature and schedule of treatment being provided. Thus, they did not know what type of intervention the participant received nor the day or weeks during which he received treatment.

A range of behaviors that reflected the child's maladaptive and adaptive behaviors was selected as well as a measure of the intensity of teacher input needed to manage his behavior. The behaviors that were measured included throwing, verbal aggression, physical aggression, touching other children's materials, mouthing objects, time spent in purposeful engagement, teacher time spent redirecting his behavior, and intensity of teacher input to manage his behavior (see Appendix for a detailed description of behavior codes). We obtained independent ratings of the child's behavior in three contexts: outside play; circle time, during which the children sat in a circle and discussions were facilitated by the teacher(s); and activity/work time. The daily routine for the first 90 min of the Montessori classroom was 30 min of outdoor play, 30 min of circle time, and 30 min of activity/work time. Thus, the study participant's behavior was measured in these three equal interval contexts (Outside, Circle, and Work) for a total of 90 min per day for 35 days.

Although we intended to collect behavioral data every day ($n = 55$), data were not collected for various reasons (e.g., teacher or child sick), resulting in a total sample of 35 days of behavior ratings. Behavioral observations were evenly distributed across all four treatment conditions (ABAB). To ensure reliability of the behavioral data, the assistant teacher independently completed ratings of the child's behavior on all behavioral variables for 46% (16 out of 35) of the same days as the lead teacher.

Data Analysis

Behavioral data were entered into an Excel spreadsheet, and 20% were checked for accuracy. Behaviors were combined across the contexts of Circle and Work (there were insufficient reliable data for Outside to include in the analysis). For Teacher Intensity, there were sufficient data only from Circle. Throwing, Verbal Aggression, and Physical Aggression were combined into one Total Aggression category, given the conceptual overlap among these three behaviors

and because insufficient data due to low frequencies of these three behaviors did not support keeping them independent. Four behavioral variables resulted: Aggression, Engagement, Mouthing Objects, and Teacher Intensity. Intraclass correlation coefficients (ICCs) between teacher ratings (exact agreement) support that each of these variables was reliable: Aggression ICC = .78, $p < .001$; Engagement ICC = .79, $p < .001$; Mouthing Objects ICC = .94, $p < .001$; and Teacher Intensity ICC = .66, $p < .05$.

These four dependent variables were statistically analyzed using the split-middle technique (Kazdin, 1984), which provides estimates of level (intercept) and rate of change (slope) for each experimental phase. In addition, phases can be compared statistically using a binomial test in this technique. For experimental phases where the number of sample points was greater than 25, the large N estimate of the binomial test was used. Use of the large N estimate is optimal because it allows the use of inferential statistical techniques to determine whether the relationship is beyond a reasonable estimate of chance using 95% confidence intervals (confident that 95 times out of 100 the result would be the same).

Results

Overall, visual analysis and statistical results suggest a significant reduction in aggressive acts, mouthing objects, and intensity of teacher input and an increase in engagement associated with the treatment phases. Intercepts and slopes are statistically derived values that estimate change (see Tables 1 and 2). Reported probability estimates (i.e., p values) reflect comparison to the initial no-treatment phase.

Total Aggression

Estimates of the level of aggression suggest a decrease across phases ($Z = 3.48$, $p < .001$; see Figure 1). This change was produced primarily by the rate of change in the first intervention phase that was greater than all subsequent phases. Aggression scores for the first intervention phase ($p = .0003$), second no-treatment phase ($p = .0039$), and second intervention phase ($p = .015$) were all significantly lower than the first no-treatment phase. In terms of the frequency of aggressive acts, there was an average of 2.9 aggressive acts per day during the first no-treatment phase, 1.0 aggressive acts per day during the first treatment phase, and 0 aggressive acts during the second treatment and second no-treatment phases.

Mouthing Objects

Estimates of the level of mouthing objects suggest a decrease across phases ($Z = 6.48$, $p < .001$; see Figure 2). Mouthing

Table 1. Intercept/Level of Behavioral Measures by Phase

Condition Behavior	A	B	A	B
	No Treatment 1	Treatment 1	No Treatment 2	Treatment 2
Mouthing objects*	6.0	4.5	0.5	1.0
Total aggression*	2.0	1.8	0	0
Intensity*	4.0	3.4	—	2.8
Engagement*	3.0	4.0	6.2	6.0

*Refer to Appendix for detailed descriptions of behaviors.

Note. — = insufficient data.

objects for the first intervention phase ($p < .001$), second no-treatment phase ($p = .01$), and second intervention phase ($p = .01$) were all significantly lower than in the first no-treatment phase. The percentage of time the participant spent mouthing objects decreased from 90% during the first no-treatment phase to 60% during the first intervention phase, to 10% during the second no-treatment phase, and to less than 10% during the second treatment phase.

Teacher Intensity

The degree of teacher intensity needed to manage the participant's behavior during the first intervention phase ($p < .001$) and second no-treatment phase ($p = .04$) was significantly lower than the first no-treatment phase (see Figure 3). There were insufficient data to analyze the second treatment phase. During the first no-treatment phase, the participant required either low-level or high-level physical input 100% of the time compared with 50% of the time during the first treatment phase and 25% of the time during the second no-treatment phase.

Engagement

Estimates of the level of engagement suggest an increase across phases ($Z = 3.783$, $p < .001$; see Figure 4). Engagement for the first intervention phase ($p = .01$), second no-treatment phase ($p = .01$), and second intervention phase ($p = .01$) was all significantly higher than the first no-treatment phase. The percentage of time spent engaged in classroom activities increased from 30% during the first no-treatment phase to 70% during the first intervention phase to 85% during the second no-treatment phase to more than 90% during the second treatment phase.

Discussion

This study examined behavioral effects of occupational therapy with a preschool-age boy of average nonverbal intel-

ligence, communication delays, and SMD. These results provide support that classic sensory integration therapy is associated with improved self-regulatory behaviors as reflected in improved engagement, lower aggression, reduced mouthing, and less intensity of teacher direction.

Our results are similar to those of other studies reporting clear improvement in behavioral outcomes in response to sensory integration therapy. Our finding of reduced aggression is similar to studies showing decreased self-injury (Larrington, 1987) and improved social interactions (Linderman & Stewart, 1999), although some studies show no improvement in peer interactions (Case-Smith & Bryan, 1999). Similar to studies of increased engagement and improved adult interaction (Case-Smith & Bryan, 1999; Linderman & Stewart, 1999), we found increased engagement in classroom activities and decreased need for teacher input or direction as treatment effects. Other studies that included mouthing objects as an outcome variable were not found, so our results that a decrease in mouthing objects was associated with treatment appear novel but consistent with expectations for self-regulation.

Interestingly, the challenging behaviors did not increase during the second no-treatment phase. In fact, the reduction of challenging behaviors and increase in adaptive behaviors remained constant after the first treatment phase. Two possible explanations of this seem plausible. First, the initial treatment program could have been sufficiently powerful to effect these changes in the child despite the removal of treatment for the second no-treatment phase. Theoretical support for this hypothesis includes assumptions that a child's behavior interacts with individuals and systems surrounding him or her. Thus, a child whose behavior improves often gets reinforced by caregivers and peers in ways that would sustain and encourage those improvements, which, in turn, reinforces the child's behavior to improve further. A second explanation for the lack of

Table 2. Slope/Rate of Behavioral Measures by Phase

Behavior	No Treatment 1	Treatment 1	No Treatment 2	Treatment 2
Mouthing objects*	1.0	1.0	8.0	4.0
Total aggression*	2.0	1.6	1.0	1.0
Intensity*	1.0	-1.3	-2.2	1.0
Engagement*	1.0	1.2	1.2	1.0

*Refer to Appendix for detailed descriptions of behaviors.

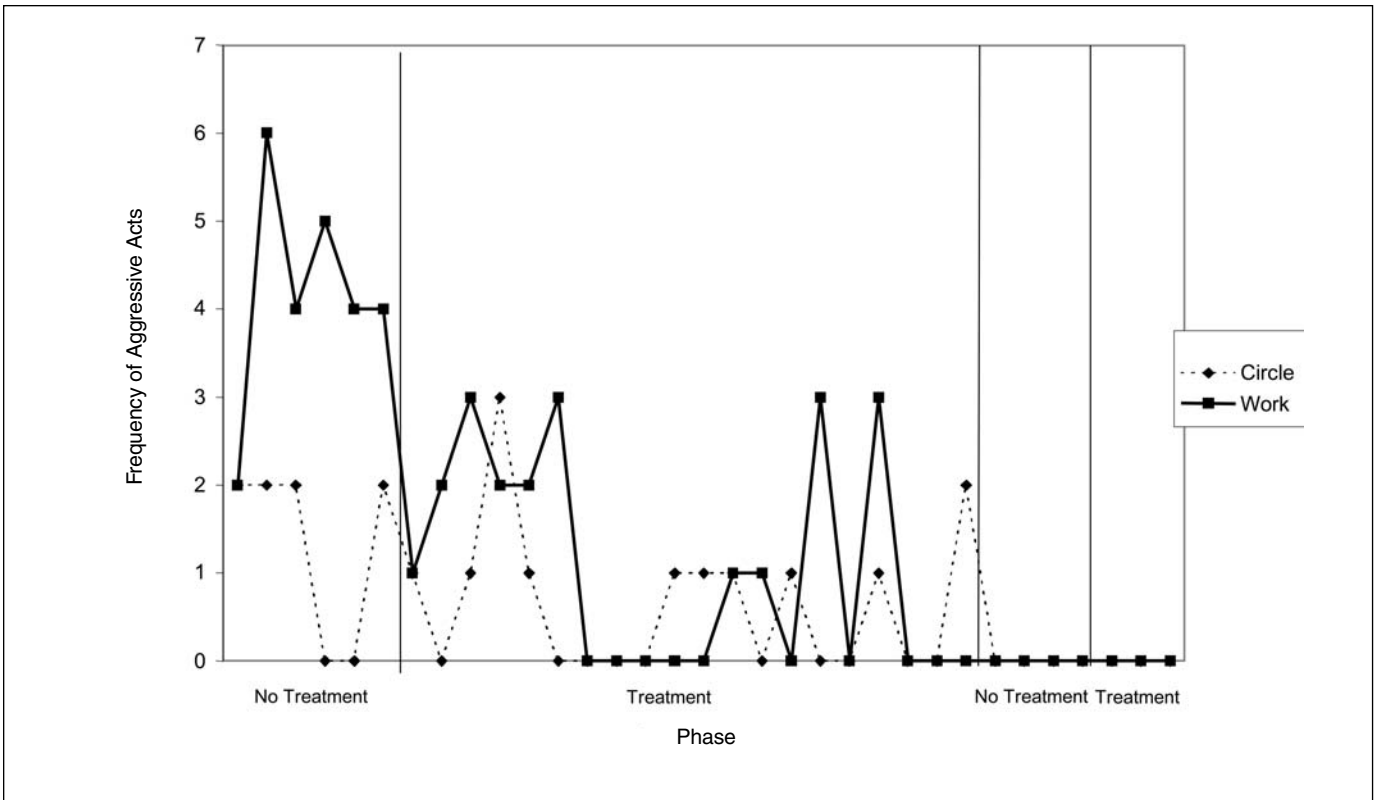


Figure 1. Aggression treatment effects by phase.

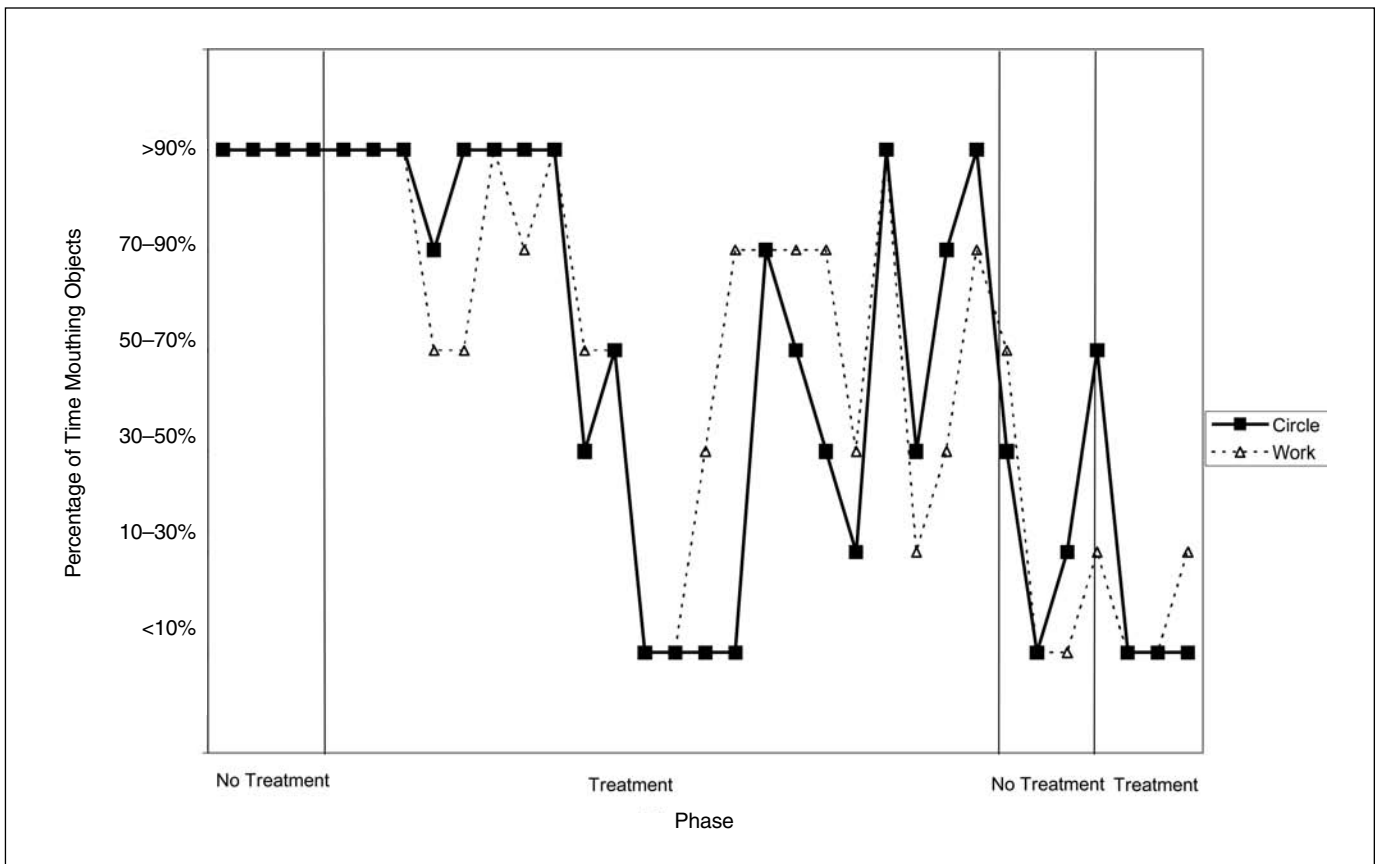


Figure 2. Mouthing objects treatment effects by phase.

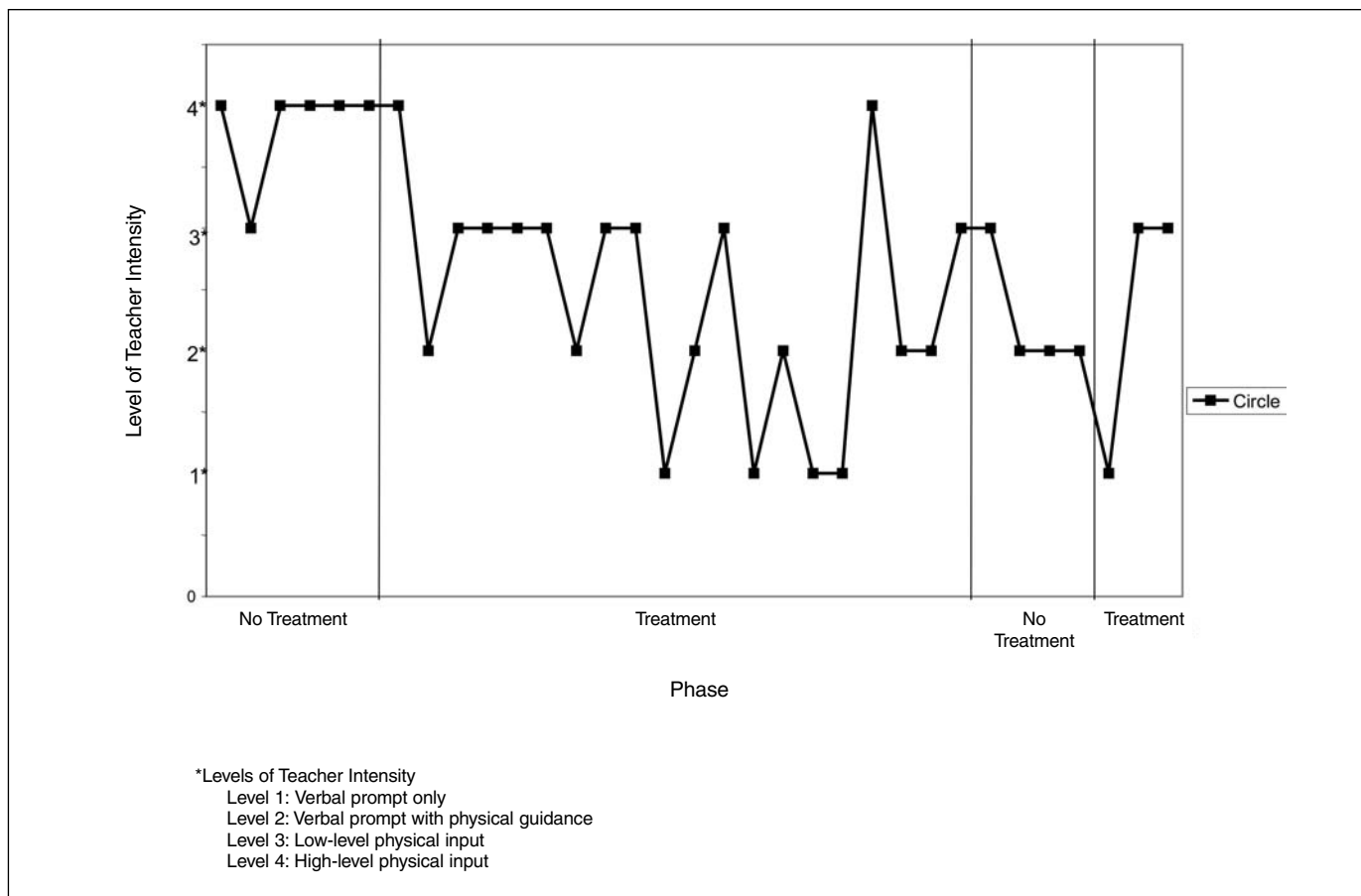


Figure 3. Teacher intensity treatment effects by phase.

behavioral change in the second no-treatment phase is that the phase was too short to allow a return of the problem behaviors.

As with all single-subject designs, this study is limited by restricted analytic strategies and poor generalizability associated with small sample size. Also, we were restricted in the length of the study, which resulted in multiple short duration phases, which limited our ability to test the treatment effects. In addition, measures of long-term follow-up were not included, so we do not know how long the treatment effects were sustained, and only one measure of efficacy, teacher observations, was included. Furthermore, the design of the study required the teachers to record their observations as part of their ongoing teaching responsibilities. Although this design may be viewed as an ecological strength in that the behaviors were observed in the child's natural setting by persons responsible for daily interactions, it also can be seen as a limitation in that the teachers likely missed observation of some behaviors because they could not focus solely on the research subject. However, to account for this limitation, we instituted multiple raters and confirmed reliability among the raters before analyzing the data. Despite these limitations, these results are strengthened by the use of an ABAB design, control over competing

treatments, blind assessment during all phases, and use of visual and statistical analyses with a conservative alpha level.

Conclusion and Clinical Implications

In summary, this study provides preliminary evidence that intensive (3 times a week) sensory integration therapy provided in a clinic setting results in improved behavior regulation in the classroom environment. This finding implies that a model of intensive clinic-based treatment without classroom and home-based interventions may be sufficient to produce behavioral changes. Although both teachers and the family did not implement treatment strategies, both were aware that treatment was being provided and the parent(s) observed the majority of treatment sessions. Thus, the teachers and parent(s) likely anticipated improvements and may have made overt or subtle changes in their behavior that could have affected the participant's behavior which, in turn, affected their responses to the child in a transactional manner that could have influenced our results. Future research should compare the effects of intensive versus traditional therapy models, include multiple single-subject designs or longitudinal studies to document the developmental progressions of unusual sensory processing features to behavioral and learning outcomes, integrate

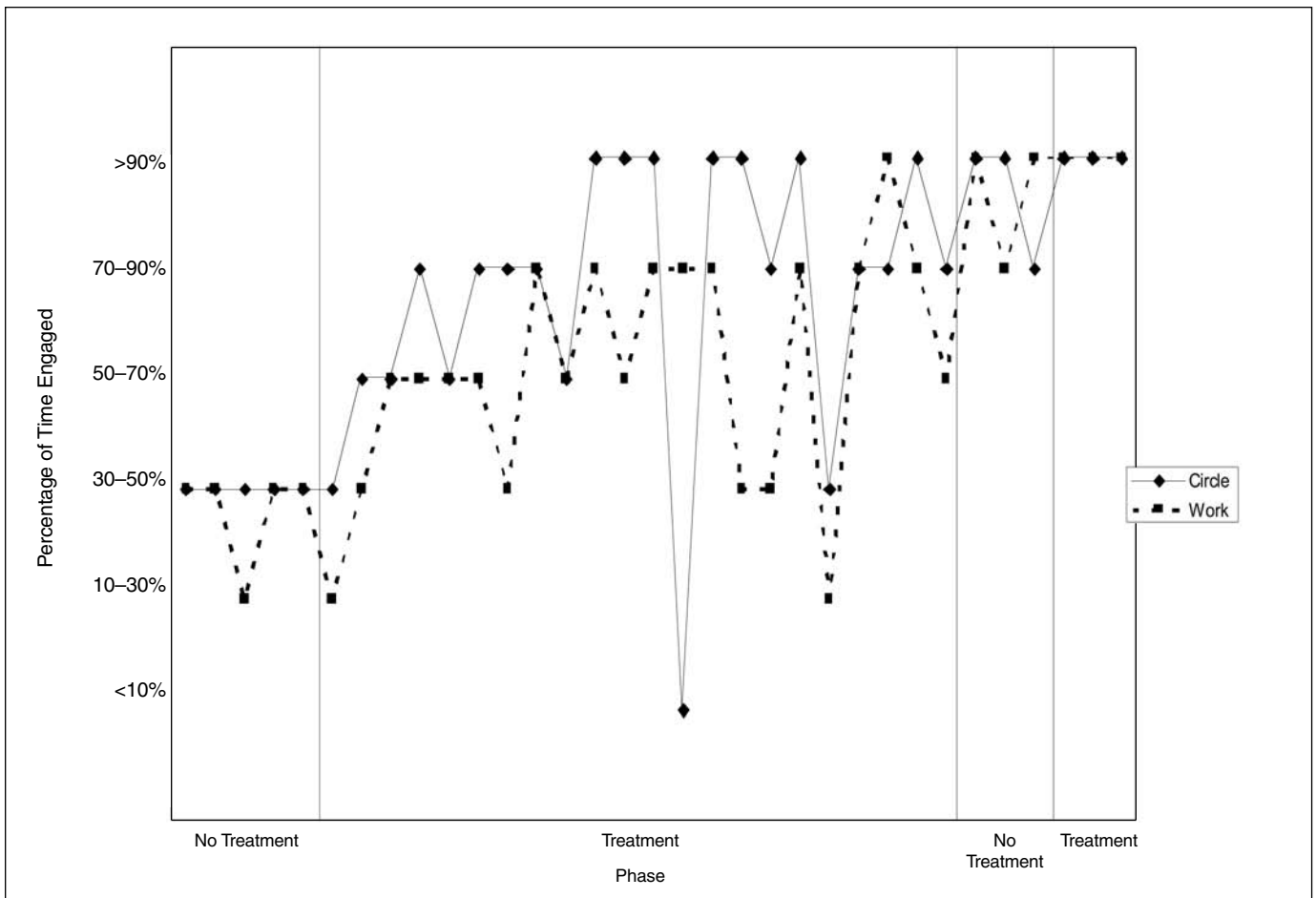


Figure 4. Engagement treatment effects by phase.

physiological and behavioral measures to differentiate responders from nonresponders to specific treatments, and document the relative contributions of sensory interventions within comprehensive educational curricula to determine whether educational goals are facilitated or inhibited by the interventions (Baranek, 2002). ▲

Acknowledgment

We thank Grace Baranek, PhD, for her consultation in the design of this study and for her feedback on an earlier draft of this manuscript. We also thank Christine Lowry and Amy Fitzgerald for their efforts in collecting the behavioral data. The participant in this study is the biological child of the first author, which could have introduced bias. Efforts to minimize bias included exclusion of data from the parent's perspective (e.g., rating forms) and no involvement of the parent in the data analysis or treatment (e.g., no home treatment activities). The parent did design the study and contribute to the written article.

At age 6, the participant was diagnosed with attention deficit hyperactivity disorder by a developmental pediatrician. In addition, a neuropsychological evaluation docu-

mented early signs of a reading disability. The child continued to receive clinic-based sensory integration therapy provided by the second author, although the intensity gradually lessened from once weekly to once monthly across a 3-year span. On entering public school kindergarten, he was placed in a regular classroom and provided with both school-based occupational and speech-language therapy twice a week for 30-min sessions. He also was treated with guanfacine, an alpha agonist used to reduce generalized physiological arousal as reflected in lowered heart rate.

References

- Ahn, R. R., Miller, L. J., Milberger, S., & McIntosh, D. N. (2004). Prevalence of parents' perceptions of sensory processing disorders among kindergarten children. *American Journal of Occupational Therapy, 58*, 287-293.
- Ayres, A. J. (1979). *Sensory integration and the child*. Los Angeles: Western Psychological Services.
- Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders, 32*, 397-422.
- Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2005). The sensory experiences questionnaire:

Appendix: Behavior Codes

I. Frequency codes (record the number of occurrences):

- a. *Throwing* = throwing an object that is not directed at another person (if so, code as Physical Aggression)
This behavior is seen as the result of “sensory overload”/frustration and not as destructive or aggressive per se
- b. *Physical aggression* = pushing, hitting, kicking, or throwing something at someone
- c. *Verbal aggression* = yelling, screaming
- d. *Touching others' work*

II. Duration codes (record the percentage of time that behavior occurs):

- a. *Mouthing objects* = the % of time spent with an object in his mouth (a chewy toy or any other object, such as a work item).
- b. *Purposeful engagement* = the % of time spent engaging in purposeful activity. This includes doing his own work, choosing a work activity, helping others, interacting with peers appropriately.
- c. *Need for teacher input* = the % of time teachers spend directing his behavior. This includes modifications like preferential seating (on lap, near teacher), verbal prompts, physical prompts, and so forth.

The percentage of time that each behavior occurred was categorized as follows:

1. < 10% of the time
2. 10%–30% of the time
3. 30%–50% of the time
4. 50%–70% of the time
5. 70%–90% of the time
6. > 90% of the time

III. Intensity of Teacher Input

- a. *Verbal prompt* (e.g., “put that where it belongs”)
- b. *Verbal prompt with physical guidance* (e.g., “You need to find something to do”—then holding his hand to take him to a shelf to choose an activity or telling him “you need to clean that up,” then following up by cleaning it up with him)
- c. *Low-level physical input* (e.g., back rub, big hugs, sitting beside him at circle)
- d. *High-level physical input* (e.g., roughhouse play, lifting up and down)

Discriminating response patterns in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry*. Retrieved January 17, 2006, from <http://www.blackwell-synergy.com/doi/full/10.1111/j.1469-7610.2005.01546.x>

- Bundy, A. C., & Murray, E. A. (2002). Sensory integration: A Jean Ayres' theory revisited. In A. C. Bundy, S. J. Lane, & E. A. Murray (Eds.), *Sensory integration theory and practice* (2nd ed., pp. 3–33). Philadelphia: F. A. Davis.
- Calkins, S. D., & Dedmon, S. A. (2000). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology*, 28, 34–46.
- Case-Smith, J., & Bryan, T. (1999). The effects of occupational therapy with sensory integration emphasis on preschool-age children with autism. *American Journal of Occupational Therapy*, 53, 489–497.
- Davis, E. P., Bruce, J., & Gunnar, M. R. (2002). The anterior attention network: Associations with temperament and neuroendocrine activity in 6-year-old children. *Developmental Psychobiology*, 40, 43–56.
- Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants and Young Children*, 9(4), 23–35.
- Dunn, W. (1999). *Sensory profile: User's manual*. San Antonio, TX: Psychological Corporation.

- Dunn, W., & Westman, K. (1997). The Sensory Profile: The performance of a national sample of children without disabilities. *American Journal of Occupational Therapy*, 51, 25–34.
- Interdisciplinary Council on Developmental and Learning Disorders. (2005). *Diagnostic manual for infancy and early childhood*. Bethesda, MD: Author.
- Kazdin, A. E. (1984). Statistical analysis for single-case experimental designs. In D. H. Barlow, & M. Hersen (Eds.), *Single case experimental designs: Strategies for studying behavior change* (2nd ed., pp. 285–324). Elmsford, NY: Pergamon.
- Larrington, G. G. (1987). A sensory integration based program with a severely retarded/autistic teenager: An occupational therapy case report. In Z. Mailloux (Ed.), *Sensory integration approaches* (pp. 101–117). New York: Hawthorn Press.
- Linderman, T. M., & Stewart, K. B. (1999). Sensory integrative-based occupational therapy and functional outcomes in young children with pervasive developmental disorders: A single subject study. *American Journal of Occupational Therapy*, 53, 207–213.
- Miller, L. J., Reisman, J. E., McIntosh, D. N., & Simon, J. (2001). An ecological model of sensory modulation. In S. Smith Roley, E. Blanche, & R. C. Schaaf (Eds.), *Understanding the nature of sensory integration with diverse populations* (pp. 57–82). San Antonio, TX: Therapy Skill Builders.
- Richards, J. E. (1987). Infant visual sustained attention and respiratory sinus arrhythmia. *Child Development*, 58, 488–496.