Differentiated Effects of Sensory Activities as Abolishing Operations via Non-contingent Reinforcement on Academic and Aberrant Behavior

G. Richmond Mancil
Louisiana Tech University

Todd Haydon
University of Cincinnati

Marty Boman
Western Kentucky University

Abstract: The purpose of the study was to evaluate the effectiveness of sensory activities used as antecedent interventions on the percentage correct on academic tasks and rate of aberrant behavior in three elementary aged children with Autism Spectrum Disorders (ASD). Study activities were conducted in an after school program for children with ASD where program personnel acted as change agents regarding strategy implementation. An alternating treatment design was used with each participant to evaluate the differentiated effects of three activities. Results varied across participants regarding the sensory related activity that had the greatest effects on producing correct academic responses and reduction in aberrant behavior. In addition, sensory activities had greater effects than control sessions across all participants. A discussion of limitations and future research directions is included.

Autism spectrum disorder (ASD) is a complex developmental disability affecting the lives of over 1.5 million Americans. According to the Centers for Disease Control and Prevention (2014), 1 in 68 children born today will eventually be diagnosed with ASD. In sum, the incidence and prevalence rates of ASD appear to be growing at high rates. Described first by Leo Kanner in 1943 through the case histories of 11 children, these individuals differed significantly from other children; therefore, he recommended that a separate diagnosis was necessary to describe their unique characteristics. Since Kanner’s first description of autism, the disorder has evolved into a spectrum disorder (i.e., ASD) with the percentage of diagnosed individuals increasing each year (Autism Society of America, 2007).

The essential features of ASD include significant impairments in social interaction, communication skills and a highly restricted area of activities and interests (American Psychiatric Association, 1994). The latter category may be more specifically analyzed in terms of restricted, repetitive, and stereotyped patterns of behavior, interests, and activities. Children with ASD often demonstrate a preoccupation with idiosyncratic interests to a level considered abnormal in intensity and focus (American Psychiatric Association, 1994). For example, a child may know about the makes and models of trains and sustain conversations related to this topic for hours, but remain unable to engage in conversations about other topics. Further, many children with ASD have stereotyped and repetitive motor mannerisms (e.g., hand flapping). For example, a child may engage in repeated hand flapping, for no apparent functional purpose such as attention or escape. Several researchers have hypothesized that the function of these stereotyped behaviors are due to difficulties in processing sensory information and may result in other aberrant behaviors which children engage in to regulate environmental stimulation (Baranek, Foster, & Berenson, 1997; Paluszny, 1979). Significant unusual reactions to various types of sensory experiences in individuals with ASD have been discussed in the literature for decades (Baranek, Wakefield, & David, 2008) and hypothesized to the result of differ-
ences in the brain structure and central nervous system of individuals with ASD. Researchers within the behavior analytic field have purported that behaviors related to these areas are automatically reinforced (Hanley, Iwata, & McCord, 2003; Iwata et al., 1994). When determining the function of these behaviors, social mediation (e.g., access to tangible, attention, escape from task demand) are ruled out (Querim, Iwata, Roscoe, Schlichenmeyer, Ortega, & Hurl, 2013). When this occurs, the function of the behavior is considered to be automatically reinforced either through automatic positive reinforcement (i.e., seeking sensory input) or automatic negative reinforcement (i.e., escaping sensory input).

Individuals with ASD demonstrate social participation challenges that involves functions that are associated with an atypical central nervous system (Bauman, & Kemper, 2003; Courchesne, Carper, & Akshoomoff, 2003). Increasingly, the literature describes the way in which the brain differentiates sensory integration and praxis dysfunction (Crane, Goddard, & Pring, 2009; Dawson & Lewy, 1989; Dawson & Watling, 2000; Smith & Bryson, 1994). Rogers & Ozonoff (1994) report significant incidences of sensory sensitivities and sensory perception deficits in a sample of individuals with autism, suggesting neurological abnormalities in higher cortical sensory perception. Using a meta-analysis of sensory modulation symptoms, Ben-Sasson et al. (2009) reported that 14 different studies have shown sensory differences between individuals with ASD and typically developing individuals with the greatest difference in under-responsivity, followed by over-responsivity and then sensation seeking. Researchers and clinicians have observed changes in persons who seem to react strongly to everyday sensory input, particularly individuals on the autism spectrum who generally have more frequent and intense reactions to external sensory stimuli. Some researchers and clinicians have hypothesized that a person with ASD typically has trouble processing information from the outside world because sensory problems make it difficult to understand what is being seen, heard, and touched. Although the severe reactions to various external sensory stimuli have been discussed in the literature for decades (Baranek, Wakefield, & David, 2008), a systematic process for identifying the precise sensory problems have not been identified and only a few cases of empirical evidence of effective interventions have been (Van Rie & Heflin, 2009).

One study evaluated antecedent exercise effect on behavior maintained by automatic reinforcement (Morrison, Roscoe, & Atwell, 2011). In the study problem behavior decreased during post intervention for three of the four participants; however, the effects could not be attributed to only exercise for one participant. In another study, Saylor and colleagues found that noncontingent auditory stimulation reduced vocal stereotypy in two children with autism (Saylor, Sidener, Reeve, Fetherston, & Progar, 2012). Further, only one study has examined the effects of sensory interventions on academic performance (Van Rie & Heflin, 2009). Van Rie and Heflin employed an alternating treatment design to access the effects of linear swinging, bouncing on a ball, and listening to a story on correct responding on academic tasks. The participants in their study engaged in the activities prior to performing their respective academic tasks. The results for the participants were mixed. For example, one participant’s results were undifferentiated, while others responded better to different sensory interventions. In addition to the mixed results, Van Rie and Heflin noted limitations such as time constraints (break in schedule such as holidays) and changing responses during the intervention. Thus, the purpose of the current study is to extend the research on sensory interventions with individuals with ASD by adding another activity and addressing the noted limitations. In addition, this study is designed to address the sensory issues from a behavior analytic perspective. Specifically, analyzing the access to sensory seeking activities via non-contingent reinforcement procedures to determine if they create an abative effect on off task and aberrant behavior. The current study is designed to determine the effects of specific sensory related interventions, such as linear swinging, and the effect on aberrant behavior and correct response percentages during academic related tasks.
Participants
Selection criteria for participants were based on academic difficulties and sensory challenges. Information on participants were collected by direct observations during instruction/academic work time. Academic samples and information on sensory challenges were collected by indirect interviews from parents and school staff.

Three male participants ranging in age from 8-10 years were recruited from an after-school autism program in central Kentucky that provided services for children and their families. These students were selected because of their difficulty completing academic tasks during instructional periods. They often did not complete and/or did poorly on assignments. Two of the students were in self-contained classrooms and one student was in a general education elementary classroom.

Each child had a diagnosis of Autism obtained independently from a physician or licensed psychologist. In addition, the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) and the Autism Diagnostic Interview-Revised (ADI-R; LeCouteur, Lord, & Rutter, 2003) was administered to obtain additional scores indicating a diagnosis of ASD. A doctorate level teacher educator and autism specialist trained to conduct the assessments for research purposes administered both instruments to all participants in the study (see Table 1).

Table 1

<table>
<thead>
<tr>
<th>Student</th>
<th>Diagnosis</th>
<th>Chronological Age</th>
<th>Reciprocal Communication:</th>
<th>Social Communication Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmar</td>
<td>Autistic Disorder</td>
<td>8.5</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Chuck</td>
<td>Autistic Disorder</td>
<td>10.6</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Hernando</td>
<td>Autistic Disorder</td>
<td>9</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Cadmar. Cadmar was a Caucasian male with a chronological age of 8.5 years. Diagnosed at the age of four, he received services from a psychologist (dosage not available), speech therapist (30 minutes a week) and occupational therapist (1 hour a week). Cadmar read at an 8.0 grade level, but struggled with his math skills. He often talked during instructional periods and individual work time. Parents, teachers, and the occupational therapist reported that he had several sensory integration and modulation issues, particularly at school when required to remain in his seat (e.g., bouncing up and down, falling out of his seat). This also was observed in the after-school autism program. He obsessed about special interests such as dinosaurs and cartoon characters to the extent that he had exhibited their characteristics, such as (e.g., walking around the room in a ‘dinosaur’ motion and ‘growling’ like a dinosaur).

Chuck. Chuck was a Caucasian male with a chronological age of 10.6 years. He was diagnosed with ASD at the age of two, and had been in therapy with a neurologist (no longer receiving), psychologist (dosage not available), speech pathologist (30 minutes a week) and occupational therapist (1 hour a week) within the past year. His verbal language was limited, but he was able to pronounce a several words to access tangible items such as toys.
or edibles. He was friendly (e.g., hugging everyone, trying to sit in the laps of others), but exhibited challenging behaviors (e.g., spitting) for access to preferred items or to escape task demands. He also had been diagnosed with seizures, which were controlled by medication (the exact medication name was not revealed in school records or from parents). His main sensory issues, according to the parents, occupational therapist, and observed in the afterschool autism program, was spinning in circles around the room.

**Hernando.** Hernando was a Caucasian male with a chronological age of 9.0 years. He was diagnosed with ASD at the age of three when he did not begin to speak. He had therapy with a speech pathologist (1 hour a week), occupational therapist (1 hour a week). He was quite verbal, but struggled with pragmatics and social situations (e.g., turn taking during board games, initiating conversations). His younger sister also had been diagnosed with ASD, and was non-verbal except for a few utterances. Hernando was very protective of his sister, which resulted in challenging behaviors at times (e.g., hitting other students when perceived to ‘pick’ on his sister). He also enjoyed a number of sporting activities such as soccer and Tae Kwon Do as well as quiet activities including music and movement (e.g., dance to slow music). According to parents and occupational therapists, his main sensory issues included spinning around, hopping up and down while running back and forth in the rooms.

All aberrant behaviors listed were confirmed during direct observations by two independent observers. The observations were compared and reliability of duration and frequency of aberrant behavior between observers was 98%.

**Settings**

Sessions were conducted at a local autism program at the same time and place every other day (twice a week: Tuesday and Thursday) for 15 total sessions. The sensory modulation interventions targeted in this study were implemented in a separate room in an attempt to prevent as little disruption to other students as possible. This classroom was adjacent to the home classroom that the corresponding students attended. The adjacent classroom was used by the participants for other group activities throughout the day; thus, decreasing the potential effects of novel environments on behaviors. The academic tasks were completed in the classroom of each respective student (no two students were in the same room for the academic tasks).

**Target Behaviors**

The target behaviors for the three participants were identified during observations, parent interviews, and analysis of academic permanent products (e.g., math sheets, other data sheets). These included: reading passages for Cadmar, shape and color identification for Chuck, and math equations for Hernando. These activities were of equal high interest for the respective participants, but required further practice for retention. Further, the academic tasks for participants were at the same response effort level across all sessions for respective participants. For example, each reading passage was of similar vocabulary and the same grade level across tasks for Cadmar, while math problems were of similar difficulty across tasks for Hernando.

The target aberrant behaviors differed in topography across participants. Cadmar’s aberrant behavior consisted of walking back and forth in rooms while growling and making ‘dinosaur’ sounds. Chucks aberrant behavior involved spinning in circles around the room. Hernando’s aberrant behavior entailed spinning around, hopping up and down while running back and forth in the rooms.

**Materials**

The materials required for the sensory interventions included a sit and spin, linear swing, and a Hippity hop© ball (i.e., exercise ball with a handle on top).

**Independent Variable**

The independent variable for this research was the sensory intervention/activity or control activity (i.e., no intervention), which was implemented for five minutes. The three sensory interventions included slow linear swinging, fast bouncing on the Hippity hop© ball,
and slow spinning on the sit and spin. Consistent with the Van Rie and Heflin study (2009), slow linear swinging was conducted with a sling-seat swing attached to the ceiling. The activities chosen were based on ones that may give the same input as the aberrant behaviors for the participants (e.g., spinning in circles-sit and spin, etc.) The research assistant pushed each participant in slow linear patterns for five minutes. For the bouncing ball, participants sat on a 65-centimeter Hippity hop® ball and held the hand on the ball while they bounced up and down for five minutes. Students sat on the sit and spin and used the circular handle in the middle to slowly spin around for five minutes both counterclockwise and clockwise (time for direction was not controlled). Consistent with the Van Rie and Heflin study, a control activity was used to contrast with the sensory interventions. Similar to their study, the participants in this study chose a story-book and listened to a reading by the research assistant (attempting to rule out effects of attention). The control activity was conducted in the same area as the swinging and bouncing activities.

**Dependent Variable**

The dependent variable was the percentage of correct responses on academic tasks (implemented immediately following the sensory intervention or control activity). As previously outlined under target behaviors, each participant completed his/her respective academic tasks. These academic tasks were selected based on participants’ skill development and what each were focusing on in the after school program (determined from review of educational records, parent interviews, and permanent work products).

Additional variables analyzed included off-task behavior and aberrant behavior. Off task behavior was recorded if the participant was not actively working on the assigned academic task for a period greater than 3 seconds. Each aberrant behavior for the respective participants are discussed in the target behavior section.

**Data Collection Procedures**

After the collection of baseline data, each participant was asked to implement the intervention for a five-minute interval session. This was followed by the completion of academic tasks including: a book with comprehension questions, activities with shapes and colors, and math equations.

Reliability checks were conducted by the graduate assistant who was trained to observe and record the occurrences of the target behaviors. Total calculations were completed for each agreement/disagreement for each session between the two observers. Finally, these occurrences were divided by the number of agreements plus disagreements multiplied by 100 (Kennedy, 2005). The mean IOA across all study phases was 95%, 93%, and 94% for Cadmar, Chuck, and Hernando, respectively.

Fidelity for the sessions was recorded by the researcher, who remained consistent for each sensory intervention. The mean treatment fidelity was 100% for Cadmar and Hernando for all three interventions, while Chuck scores were lower at 100% for only two of the interventions (’sit and spin’ and bouncing ball). During the data collection, he exhibited no change (0%) for the linear swing intervention, he often jumped from the swing and attempted to push the linear swing. Although he was redirected to sit in the swing, he would not remain in the swing for an entire 5 minutes and would engage in challenging behaviors (e.g., spitting, hitting) when redirected to sit in the swing. Thus, the authors determined that forcing him to sit in the swing was not ethically or clinically appropriate. Despite his modifications to one of the interventions, Chuck continued with the academic tasks correctly as outlined in the protocol as reflected by his scores in Figure 3. When Chuck was not provided with any sensory stimulation, he refused to perform any of the academic tasks, which are recorded on the graph.

**Experimental Design**

Prior to conducting the noncontingent reinforcement protocol, a functional analysis was conducted on each individual to determine the validity that the hypothesized automatic reinforcement function was accurate. The conditions included in the functional analysis were: contingent attention, contingent escape, contingent tangible, control (free play), and alone conditions.
Following the identification, an alternating treatment design was implemented to show a functional relationship to the identified intervention compared to the three other interventions (Kennedy, 2005). During the first three sessions, baseline data were collected followed by nine sessions where sensory stimulations was provided and two sessions during which no sensory stimulation was provided according to the research protocol. These final sessions of alternating treatment and withdrawal of stimulus occurred randomly so that the participants were unaware regarding which intervention was going to be implemented each day. All sessions were videotaped and then coded independently by a research assistant and subsequently coded by the first author to check for interobserver agreement (IOA) for 35% or greater of all sessions across all study phases.

**Data Analysis**

This study focused on direct observations of individuals with ASD interacting with various sensory stimuli, and included an alternating treatment design (ATD) with three participants. Baseline data was collected on the participants using behavioral coding of the child’s observed communication, social interaction, challenging behaviors, and academic behaviors during interactions with staff for three sessions. These data were collected during 10 minutes of observation per day, two times per week. For this paper only the academic behaviors are discussed. The staff implemented the various interventions, while graduate assistants collected data during the specified time sequences. During the review of the videotaped session, behaviors were coded using real time collection sheets. The data analysis was completed using Microsoft Excel. Further, permanent products of academic work were collected and checked for accuracy. Data lines were graphed for each intervention, and presented in time-series graphs for each participant. Data analysis was based on visual inspection of the trend of data lines, and magnitude and rate of behavior change between conditions (Kennedy, 2005). Summative data was reported on the fidelity of treatment data.

**Results**

In this study the research evaluated the effectiveness of three sensory activities as antecedent interventions on the percentage correct on aberrant behavior, off task behavior, and academic tasks with three elementary age children diagnosed with ASD.

Prior to implementing the intervention, a functional analysis was conducted on each participant. Results of the functional analysis for each participant were undifferentiated, which indicates the aberrant behaviors were likely
maintained by automatic reinforcement (Smith, Vollmer, & Pipkin, 2007), (see Figures 1, 2, 3).

For the intervention, researchers implemented an alternating treatment design to evaluate the differentiated effects of the sensory interventions. Although results varied across participants regarding particular sensory activities that had the greatest effects on the academic correct responses, all participants demonstrated a marked increase in their academic performance as compared to the baseline data after the introduction of the three stimuli (Figures 4, 5, 6). The degree of their performance varied among the participants as well as their preference for one stimulus as compared to another. Further, aberrant behavior for each participant decreased during intervention with the highest decrease corresponding to the same condition as the highest increase in correct responding (Figures 7, 8, 9).

Cadmer. Cadmer completed three sessions for his academic completion baseline until it was determined that the data were stabilized at 40% (Figure 1). This process was followed by three sessions for each of the three sensory interventions randomly administered. Although all three sensory interventions showed an increase in performance, the linear swing was most effective for Cadmer’s academic completion with 100% accurate responses during all three trials of this sensory stimulus. This was followed by an increase with

Figure 2. Chuck’s Functional Analysis.

Figure 3. Hernando’s Functional Analysis.
the sit and spin of 86.7% for these sessions. The Hippity hop© ball intervention demonstrated the least increase of 66.7% (Figure 4) as compared to the baseline although this was a marked increase from the baseline. During these sessions there were no overlapping data points with the baseline data. Further, the most effective intervention as indicated by the data did not overlap with any other intervention or the control. In conclusion, both the linear swing and the sit and spin resulted in academic scores at 80% or higher, which many educators consider acceptable performance.

Chuck. Chuck completed three sessions for his baseline with an average of 10% on his academic completion. The sit and spin intervention sessions were most effective with 100% completion of correct academic responses. Chuck had to be prompted often during the sensory interventions to continue to engage with the task as the protocol required. For example, he chose to walk around the sit and spin with his hands grasping the center turning device rather than sitting on the device with his legs crossed. Despite this modification, he demonstrated an increase in his performance as recorded on Figure 2, which would be classified as “highly effective” (Scruggs & Mastropieri, 1998). During the Hippity hop© ball interventions, Chuck increased to 46.7% from his baseline sessions, and again clas-
sified as “highly effective”. Chuck’s performance after the linear swing intervention remained at 16.7% and was considered consistent with the baseline data. This intervention did not show any deviation from the baseline recordings as recorded on Figure 5, and was not effective. Further, the most effective intervention as indicated by the data did not overlap with any other intervention or the control. In conclusion, only the sit and spin resulted in acceptable performance levels, all other sensory interventions resulted in ‘failing’ grades.

Hernando. Hernando’s baseline was established at 26.7% correct responding after three trials as displayed in Figure 3. His results from the implementation of the three sensory interventions demonstrated the most consistency among the data collected across all sensory activities: sit and spin at 90%, linear swing at 80% and Hippity hop© ball at 73.3% (Figure 6). All interventions were in the highly effective range, and indicated that all of the sensory interventions did impact the academic performance. However, only the sit and spin and linear swing resulted in performances considered acceptable for mastery (i.e., 80% or above). Further, the sit and spin was more effective, stable, and ended in an upward trend as compared to the other interventions, but did have one overlapping data point with each of
the other sensory interventions and magnitude in change between the sit and spin and the other two sensory interventions was small.

Discussion

Sensory activities were implemented regularly at the center where this research was conducted. The purpose of this study was to evaluate the effect of three activities (linear swinging, bouncing on a therapy ball and rotating on a ‘sit and spin’) on academic performance (reading comprehension, color and shape identification, solving math equations) and aberrant behavior. Results were somewhat varied as to which sensory stimulation impacted the academic outcomes for the participants. Cadmar had greatest gains in academic performance (100%) when the linear swing was implemented, followed by the sit and spin (86.7%) and the Hippity hop© ball (66.7%). Chuck increased his academic performance on the sit and spin (100%) followed by the Hippity hop© ball (44%). No change was ob-

Figure 8. Chuck’s Aberrant Behavior.

Figure 9. Hernando’s Aberrant Behavior.
served with the linear swing as he chose to reject the protocol of sitting on the swing and decided to push it linearly, therefore resulting in no change in academic performance. It should be noted that Chuck did not follow protocol with the Hippity hop© ball as he chose to run around the ball while he held onto the handle rather than sitting on the ball and bouncing. Hernando had greatest gains in academic performance on the sit and spin (100%), followed by the linear swing (80%) and the Hippity hop© ball (70%).

The present study adds to the current research regarding the use of sensory stimulating activities by using non-contingent reinforcement procedures to determine if they create an abative effect on off task and aberrant behavior on the academic performance for individuals diagnosed with ASD. Also, the data from this study give some support to the theory that different stimulation responses result in a variety of outcomes for individuals diagnosed with ASD. Two of the three participants were viewed by the staff of the center to be more excitable than other participants at the center. One participant (Hernando) tended to be hyposensitive to sensory stimulation except when this stimulation was presented in a manner as to impact his sister’s state of mind.

For targeted interventions, this information can be used to explore (a) whether an identified stimulus intervention is likely to succeed in order to increase academic performance and (b) whether minor modifications can be made to assist with other academic tasks. In this study, the results indicated an increase in academic performance; therefore, giving support that these sensory stimuli should be implemented prior to the introduction of new academic information so that individuals identified with ASD can have maximum outcomes.

A few limitations became apparent during this study. The autism program was staffed by individuals highly trained to work with children on the autism spectrum, which could effect overall performance and ease of new interventions being implemented.

Another limitation was the variety of the severity of the diagnosed ASD for the three participants (see Table 1). This was a representation of the heterogeneity of this population, which could have affected the different outcomes for each of the interventions. However, this was addressed somewhat by matching academic tasks to functioning level of respective participants. Also, it should be noted that some of the participants were comfortable with the interventions, while one struggled to follow the protocol for the variety of sensory activities.

Another limitation is the sensory interventions themselves. Each intervention required some level of physical activity; thus, the effects on academic performance could be attributed to engaging in physical activity before an academic task and not the sensory intervention itself. However, since the data indicated a difference between interventions, this may not be the case. Nonetheless, future research should include activities such as running around or some other type of physical activity to rule out these concerns and distinguish between the effects of typical physical activities and sensory interventions.

The current study focused on a targeted intervention that has demonstrated significant advantages for three participants. The simple sensory strategies have positive implications for staff and teachers who work with individuals identified with autism. These strategies can be modified according to the individual’s performance, and can be implemented for a low cost to schools. These results are tentative, but the strategies should be explored in different settings where participants are asked to focus for an extended period of time.

In conclusion, in this study, sensory stimulation suggested that academic performance could be increased dependent on the method implemented; however, the study was conducted with only three participants in one after school program. Further research is needed to determine if the results will be consistent in different settings such as schools. Also, a variety of different sensory stimulations should be presented according to the needs of the individuals to determine the overall impact on academic performance and other behaviors (i.e., challenging behaviors, social interactions).

References


Sensory Activities as Abolishing Operations / 103


Received: 19 March 2015
Initial Acceptance: 28 May 2015
Final Acceptance: 10 July 2015