A Comparison of the Effects of Tactile and Auditory Stimulation and Choice on the Problem Solving of Students with Attention Problems

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Abstract

Using a single-subject alternating treatments reversal design, the effects of three conditions, tactile stimulation, auditory stimulation, and choice of the two, were compared on the math story problem solving of elementary students with attention problems. Students attempted and solved slightly more problems and engaged in fewer off-task behaviors in the stimulation conditions than in baseline. Effects were very modest. Students chose stimulation conditions that were related to their behavior more than their accuracy.

Students with attention problems exhibit slower computation speed and attempt fewer math problems compared to control students (Barkley, Anastopoulos, Guevremeont, & Fletcher, 1991; Zentall & Ferkis, 1993). Their near average grades in computation in elementary school tend to decline in higher grades (Ackerman, Anhalt, & Dykman, 1986). For story problems, cognitive ability (including memory), sustained attention, and reading skills are needed to eliminate irrelevant information, handle multiple operations, and transform verbal information within problems (Zentall, Smith, Lee, & Wieczorek, 1994). Students with attention problems have significantly lower problem-solving scores in specific math concepts than students without attention problems (Zentall & Ferkis). Slow computation affects mathematical problem solving as it increases attention and memory demands and decreases students' ability to focus on the deeper structures of the problem (Zentall et al).

Students with attention disorders are challenged by the attention and working memory demands required to successfully solve math story problems. Their attentional differences can be understood through the optimal stimulation theory that suggests these students are biologically under-stimulated (Zentall, 2006). According to the optimal stimulation theory, each human has a biologically determined level of optimal stimulation and when insufficiently stimulated, will initiate stimulation-seeking activity to create a state of homeostasis, or a comfort zone of optimal stimulation (Hebb, 1955). Zentall (1983) applied this theory to students with attention disorders and provided an understanding of students' inability to sustain attention in lower stimulating environments. They attend to that which is immediately salient in the environment and not their tasks, resulting in difficulty with sustained attention (Zentall, 1995).

Students with attention difficulties can pay attention; their problems have to do with what they are paying attention to and for how long. Any strong stimulus can captivate their attention and distract them from their tasks. They selectively attend to novelty such as, color, changes in size, and movement (Copeland & Wisniewski, 1981; Radosh & Gittelman, 1981). When task success is dependent upon sustained attention, as in math problem solving, it becomes imperative for students to find their optimal level of stimulation required to sustain focus.

Methods used to increase stimulation to optimal levels include pharmacological interventions and procedures that embed higher levels of stimulation into tasks (Pelham, Wheeler, & Chronis, 1998; Zentall, 2006). These methods require parents and teachers to take actions to increase performance or decrease behavior. Students with attention problems need tools to regulate their own levels of stimulation. Self-talk, self instruction, self monitoring, and self-reinforcement have been used with some success as motivational strategies to develop self-control of attention and impulsive behavior (Ervin, Bankert, & Dupaul, 1996). But these methods may add additional demands on attention during a problem solving task.

Another child-driven strategy included physical movement. Physical movement has been used successfully to sustain attention in clinical experiments (Welsh & Labbe, 1994). Studies on large muscle motor activity, such as running, have demonstrated increases in sustained attention on clinical tasks and subsequently reduced excessive motor activity and impulsive behavior (Bass, 1983). Grskovic et al (2004) utilized a fine motor activity to improve behavior of students with attention problems in time out settings. In these studies, physical activity occurred prior to academic engagement. Kercood, Grskovic, Lee, & Emmert (2007) assessed the effects of a fine motor activity during math problem solving tasks on the performance and behavior of students with attention problems. They reported that with the fine-motor activity, students demonstrated more on-task behavior and increased performance and the activity provided students with a less obvious and less distracting means of movement.

Auditory stimulation has also been used successfully as a less distracting, child-driven method for reaching stimulation levels needed to sustain attention, although this research is limited. Abikoff, Courtney, Szeibel, and Koplewicz (1996) reported that students with attention disorders performed better than baseline on the number of math problems correct in the presence of auditory stimulation. The results are promising and suggest that auditory stimulation can be beneficial to the arithmetic performance of students with attention problems. However, students with attention problems made more errors under faster, than slower, music conditions when performing a precision motor task (Klien, 1981).

In summary, students with attention problems have difficultly with fast math calculations and solving complex story problems. Increased levels of stimulation may allow them to attend longer. Fine motor tasks and auditory stimulation have been used in classrooms because they are less distracting than some other methods for increasing stimulation and can be manipulated by children. It is not yet known if one of these procedures is more effective than the other. Therefore, the purpose of this study was to compare the effectiveness of tactile and auditory stimulation on the math problem solving performance of students with attention disorders. We hypothesized that tactile and auditory stimulation would promote gains in sustained attention and allow students with attention problems to focus longer on their tasks, leading to greater accuracy. A second question examined whether students with attention problems chose effective stimulation-generating methods.

Method

This study employed a single subject alternating treatments design with reversal and choice phases. Two instructional conditions, tactile stimulation and auditory stimulation, were alternated.

Participants

Three Caucasian participants, two fifth graders and one fourth grader, were invited to participate in this study. All three participants were middle class and nominated by their teachers as having attention problems. The inattention and hyperactivity status of participants was confirmed using ratings on the Conners' Teacher Rating Scale: Revised: Short Form (CTRS-R:S) and Conners' Parent Rating Scale-Revised (CPRS-R:S) (Conners, 1997). Students with a T-score of 60 or higher (1 or more SD above the mean) on either the (a) Cognitive/Inattention Index (b) Hyperkinesis Index or (c) the ADHD Index, on either the parent or the teacher ratings, were confirmed as students with problems with attention. All participants attended a general education classroom in an elementary school in a suburban community.

Bill's teacher rating on the Hyperkinesis Index was 68 and his ADHD Index was 62. Matt received a parent-rated Hyperkinesis Index of 66 and parent and teacher ratings on the ADHD Index of 68. Erin's T-scores on the Cognitive/Inattention Index were 68 (parent) and 70 (teacher). None of the participants were on medication for attention disorders.

Materials

Worksheets were created from a pool of over 300 math story problems taken from math textbooks used in the participants' school. Since the two fifth grade participants had failed the math portion of the state standardized test, problems were selected from fourth grade level texts. Thirty math story problems requiring addition, subtraction, and multiplication were printed on white paper with black ink (8-9 problems per page), stapled together, and placed in a manila folder. Teachers had not previously assigned the selected problems to the participants but the concepts had been taught. All the problems were at the 3rd to 4th grade reading level, determined with reading software offered by Microsoft Word. Blank answer sheets placed on clipboards, pencils, and erasers were also provided.

Experimental Design and Procedures

This study employed a single-subject alternating treatments design with an additional choice phase. All sessions lasted 20 min and were conducted in the mornings between 10:00 and 11:00 in an empty classroom in the participants' elementary school. A video camera was positioned in the room to tape all three participants during each session. Folders with math problems, empty answer sheets, pencils, and erasers were placed on worktables prior to students' arrival. Participants were escorted from their classrooms to the testing room by the examiner. The three participants were seated in different corners of the same room with their backs toward each other to reduce distraction and talking and to allow them to be videotaped at the same time.

For the tactile stimulation, students were given a Tangle Puzzle-Jr., a plastic circle-shaped toy with a series of 90-degree curves, connected, and able to pivot at each joint. The Tangle Puzzle-Jr. was chosen for tactile stimulation because it was flexible, easy to manipulate, twist, and swivel, and was not noisy. Additional description of the Tangle Puzzle-Jr. is available at www.tangletoys.com. For the auditory stimulation condition, students were provided with a personal compact disc player, headphones, and a music compact disc containing classical instrumental music.

For baseline, students were asked to complete as many math problems as they could. At the end of 20 min, students were told to stop and turn their materials in to the researcher. The researcher thanked them for participating and offered them a small reward, such as a pencil, notebook, or stickers.

During intervention, procedures were the same as in baseline except students were provided with tactile stimulation (i.e., the tangle puzzle toy), or auditory stimulation (the compact disc player and headphones with instrumental music). Before the first intervention session, students were shown how to manipulate the toy with one hand while working on the math problems. After the first session, the tangle toy was available on each student's desk for the Tactile Stimulation sessions. Before the Auditory Stimulation sessions, students were instructed on how to use the CD player and were told to keep the headphones and music on while completing the math problems. For the Choice phase, the CD player and music and the Tangle Toy were available and students were asked to choose which they wanted to use. Then that choice was provided each subsequent session in the Choice phase. A procedural check sheet was developed and followed to ensure integrity of the procedures.

Measures

The dependent variables examined in this study were (a) number of math problems completed correctly (calculated from the students' permanent product worksheets), and (b) number of off-task behaviors per 20–min session. Off-task behavior was operationally defined as looking away from the task by 90 degrees for more than 10 sec, rocking, talking out, leaving the seat, or lack of contact with academic material (e.g., manipulation of the writing instrument, reading). Inter-observer agreement for the behavioral data was scored from video tapes for more than 30% of the sessions and was calculated to be 95–100% (formula = intervals of agreement divided by total intervals times 100).

Results

All students performed somewhat better on math problems during at least one of the stimulation conditions than in baseline, although differences are modest. All students engaged in somewhat fewer off-task behaviors during the stimulation conditions. Mean number of problems attempted and correct, and the number of off-task behaviors for Erin, Matt, and Bill are presented in **Table 1** and **Figures 1-6**.

Discussion

The purpose of this study was to compare the effectiveness of tactile and auditory stimulation on the math problem solving and off-task behavior of students with attention disorders and to assess the effects of choice. This study lends modest support to the optimal stimulation theory in that all three students tended to perform and attend better with increased levels of stimulation. The results of this study also support the findings of Kercood, Grskovic, Lee, and Emmert (2007) who reported improvements in academic and behavioral performances with the inclusion of a fine motor tactile activity during academic engagement. When viewing the videotapes from this study, it was noted that students typically picked up the Tangle toy during, what appeared to be, mental computation, fidgeted with it while contemplating their answers, set it down, and immediately wrote their answers.

Students in the present study did not choose the stimulation method that was most related to their own increased problem solving. Erin's best performances were with tactile stimulation but when given choice, she chose auditory stimulation. Matt and Bill had their best days for problem accuracy with auditory stimulation but both chose tactile in the choice condition. It would appear that all three students chose the wrong type of stimulation. But examination of the off-task data shows that each student actually chose the type of stimulation related to fewer off-task behaviors for them. Students may have been aware of their increased level of on-task behavior with their selected stimulation method.

In the choice condition, students were asked to use their chosen type of stimulation for all three days. It is not clear what effects would have resulted if students had been allowed to vary their choices. Prior time series intervention research with students with attention disorders showed a decline in performance and increase in off-task behavior over time as students became acclimated to the intervention and its novelty decreased (e.g., Belfiore, Grskovic, Murphy, & Zentall, 1996). In the present study, this did not occur, possibly due to the variation in interventions. This supports the need for novelty and variety in the academic interventions of students with attention problems.

The results of this study are variable and will need to be confirmed through continued research and should be interpreted with caution. Another variable affecting results was the type of headphones used during the auditory activity; light weight headphones with a metal bar over the top were used. Students voiced their preference for heavier headphones that fit snuggly on the ears. Additionally, students asked if they could bring in their own music and expressed a dislike for classical music. It was noted that Erin, who choose auditory as her preferred type of stimulation, turned the volume up as high as it would go. This probably explains her reduced performances in the auditory condition as the loudness of the music served as a distraction. Future researcher may want to limit the volume control.

Future research should continue to explore strategies that help students attain their level of optimal stimulation through the use of relevant and self-selected strategies. Teachers have the ability to identify students who have difficulty staying on task and should allow these students to use strategies, such as fine motor activity, to enhance their performance and on-task behavior. Teachers can empower students to use strategies that increase their learning across various environments, instructors, and task conditions.

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To top

Table 1

Mean number of problems attempted and correct and number of off-task behaviors

Condition	Problems attempted			Problems correct			Off-task behaviors		
	Erin	Matt	Bill	Erin	Matt	Bill	Erin	Matt	Bill
Baseline	18.7	30.8	30.8	9.4	17.1	17.1	17.3	7.7	7.7
Tactile	19.5	29.8	29.8	9.8	17.16	17.16	17	6.3	6.3
Auditory	13	32.5	32.5	5.4	18.2	18.2	15.7	6.6	6.6
Choice	18 A	33.6 T	33.6 T	6.3 A	17.3 T	17.3 T	17 A	3 T	3 T

Note: A = Auditory, T = Tactile

Figure 1

Number of story problems correct for Erin

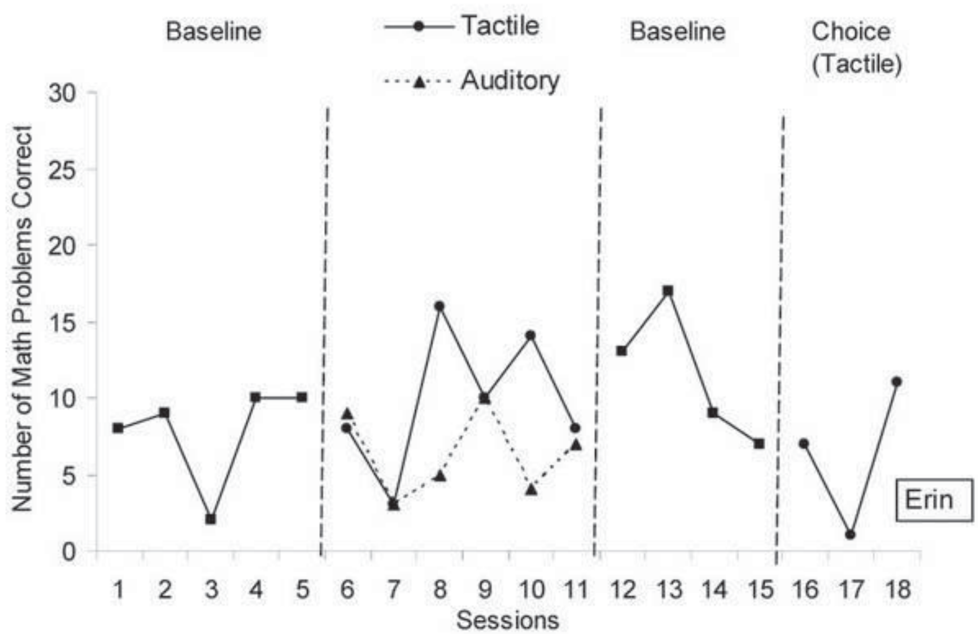

Figure 2

Number of story problems correct for Matt

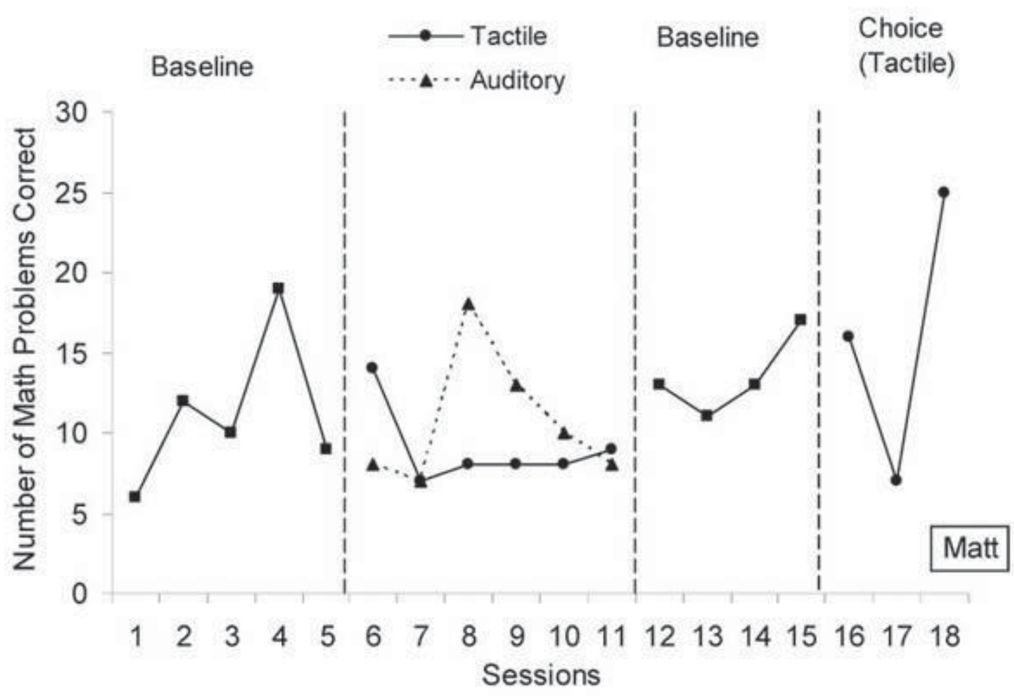

Figure 3

Number of story problems correct for Bill

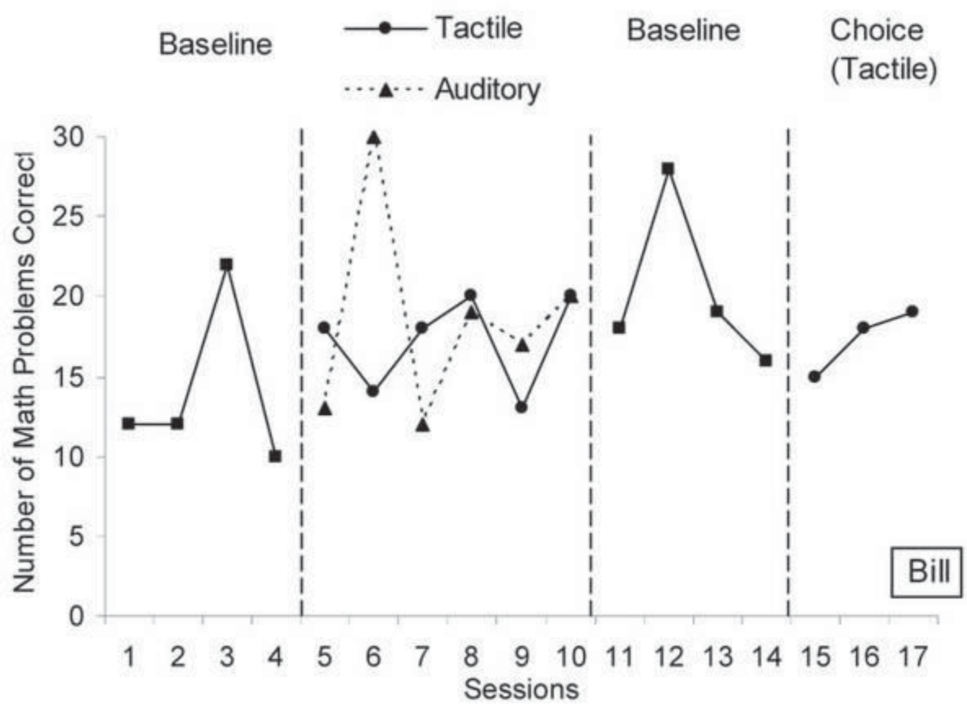

Figure 4

Number of off-task behaviors for Erin

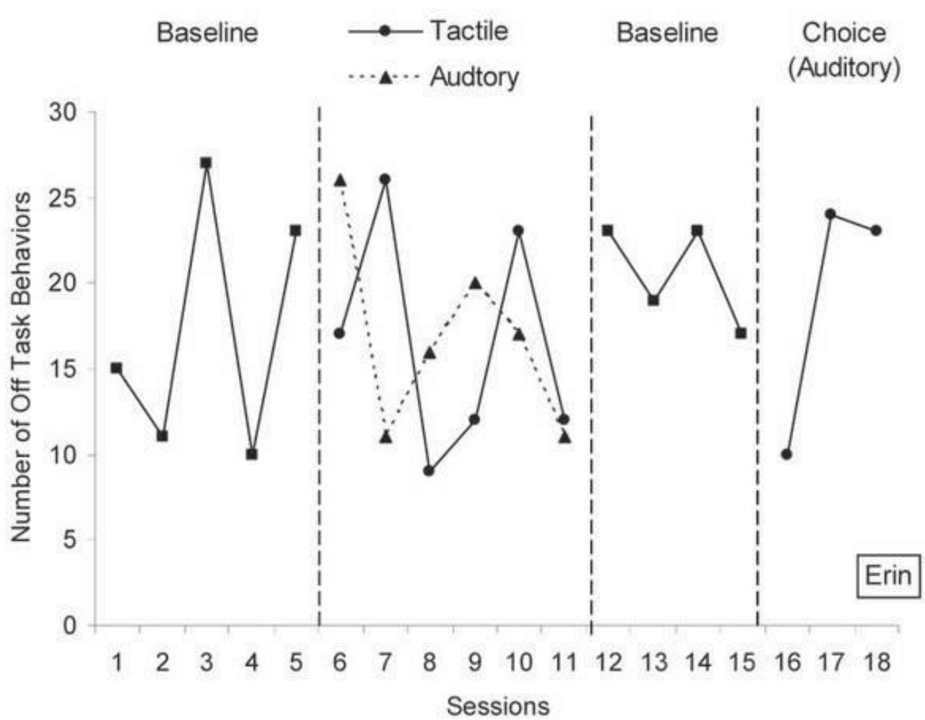

Figure 5

Number of off-task behaviors for Matt

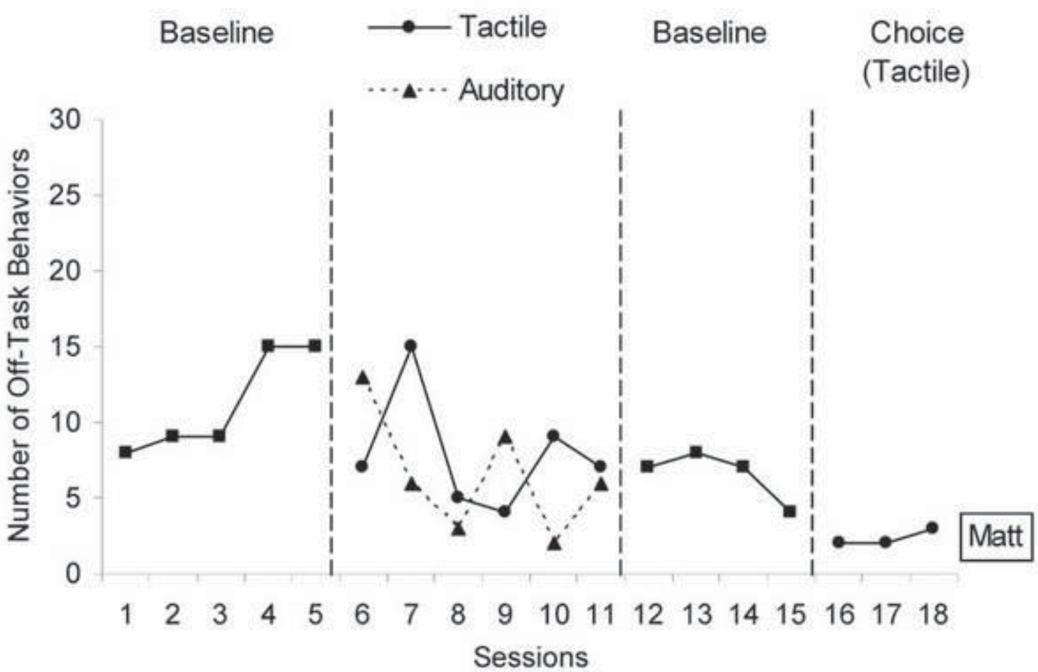

Figure 6

Number of off-task behaviors for Bill