Effect of Classroom Modification on Attention and Engagement of Students With Autism or Dyspraxia

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Students with autism display sensory sensitivities to environmental stimuli that affect their attending and engagement in classroom learning activities. The purpose of the study was to determine whether attending of 4 male students, ages 13–20, increased after the installation of sound-absorbing walls and halogen lighting. The multiple single-subject, mixed-method design, AB(B+C), included a 2-wk baseline and two intervention phases: 2 wk after sound-absorbing wall installation using the Owens Corning Basement Finishing System™ (Owens Corning, Toledo, OH) and 2 wk after halogen light installation. We calculated nonattending frequencies from videotaped class sessions and used visual analysis to measure within-phase and between-phase characteristics. Results included increased frequency and stability of attending and engagement and improved classroom performance, comfort, and mood. Journaling provided students’ perspective on the modifications and reflected overall increased sensory comfort and themes of improved classroom environment, positive emotional response (mood), and improved classroom performance.


Autism is a lifelong neurodevelopmental disorder that affects social and communication skills. It is one of the most prevalent developmental disorders, occurring in 9.0 per 1,000 population, or 1 in every 110 children, according to the Autism and Developmental Disabilities Monitoring Network (Rice, 2006). This estimate, which is 10 times higher than before 1990, is in large part the result of a reclassification that combined three disorders as autism spectrum disorders (Rice, 2006). The increased prevalence has created a significant challenge to public education because many children with autism require intensive interventions to facilitate their participation and success in the educational setting.

People diagnosed with autism have common symptoms and characteristics that affect school participation (Altevogt, Hanson, & Leshner, 2008), including sensory processing difficulties, stereotyped behaviors, communication and language difficulties, low muscle tone, and sleep disturbances (Adams, Edelson, Grandin, & Rimland, 2008; O’Neill & Jones, 1997; Tomchek & Dunn, 2007).

The Individuals With Disabilities Education Improvement Act of 2004 mandates a free appropriate public education in the least restrictive environment for all students. Access to the general education curriculum and inclusion with peers without disabilities is the expected method of providing services for students with disabilities (Jimenez, Graf, & Rose, 2007). Individualized education plans document the modifications, accommodations, and related services required to enable a student to progress through the curriculum. The challenge...
for schools is to provide services for students with autism that will allow them to benefit from their educational placement (Godek, 2008).

Modifications to the educational environment and adaptations to facilitate learning are essential for many students to succeed in school as well as in college (VanBergeijk, Klin, & Volkmar, 2008). Universal design, an approach to making general education more accessible for children with disabilities, is the concept of simplifying life for everyone by making environments, products, and communication systems usable by more people (Jimenez et al., 2007). Universal design for learners (UDL) applies principles of universal design to curriculum instruction and addresses improving engagement through identification of distractions and threats and promoting self-regulation for learners (CAST, 2011).

Attention and engagement are interchangeable terms that are associated with successful learning and are common problems for people with autism. Poor attention is an identified impairment that could be a root cause (Ornitz, 1988) or could contribute to the core features of autism (Mundy, Neal, & Glidden, 2001). Various types of attention—orienting attention, sustained attention, shifting attention, social attention, and joint attention—have been studied in people with autism, as described by Patten and Watson (2011). Orienting attention is a person’s initial physical orientation to a stimulus, person, or event, and sustained attention is the ability to maintain the regard of an object or event. Shifting attention is the process required to disengage attention from one stimulus and to reorient and engage attention toward another. In contrast, social attention is a naturally occurring orientation to social stimuli such as voices and faces of others, and difficulty in this area is a core feature of autism. Finally, joint attention is shared attention between two or more people or between people and an object or event. Joint attention is particularly pertinent in the educational context; it involves all other components of attention and is a social behavior. All of these types of attention, except for sustained attention, are problematic for people with autism (Patten & Watson, 2011).

Students who have difficulty modulating the sensory information in their environment have difficulty attending to the stimuli relevant for learning (Liss, Saulnier, Fein, & Kinsbourne, 2006; Pfeiffer, Henry, Miller, & Withnell, 2008). Sensory processing and modulation issues are estimated to affect as many as 95% of people with autism (Baker, Lane, Angley, & Young, 2008). Sensory processing includes receiving, modulating, integrating, interpreting, and responding to sensory information, including visual, auditory, proprioceptive, vestibular, tactile, and olfactory stimuli (Baker et al., 2008; Miller, Coll, & Schoen, 2007). Sensory modulation disorder refers to an inability to appropriately adapt one’s response to sensory stimuli from one’s own body or the external environment, which can affect attention and behavior (Miller, Anzalone, Lane, Cermak, & Osten, 2007).

Sensory modulation disorders affecting the auditory system may result in hypersensitivity and over-responsiveness to pitch, volume, specific sounds, or multiple sounds such as gatherings of people or street sounds. Researchers have recognized the severity and frequency of auditory hypersensitivity (Minshew & Hobson, 2008) and its effect on attention and learning in people with autism (Ashburner, Ziviani, & Rodger, 2008) in spite of the lack of identified peripheral auditory differences (Gravel, Dunn, Lee, & Ellis, 2006). Avoidant behaviors are often associated with hypersensitivity to auditory stimuli. Routine classroom noise, especially when combined with verbal instruction, makes attending difficult for many students and especially for learners with autism (Ashburner et al., 2008). In fact, people with autism may have cognitive abilities similar to those of nonautistic or gifted people (Barnhill, Hagiwara, Myles, & Simpson, 2000), but interpersonal and sensory modulation difficulties, specifically auditory sensitivities, may negatively affect academic performance (VanBergeijk et al., 2008). Temple Grandin (2011), a person with autism and auditory sensitivities, has reported that her ears amplify sounds and she is unable to modify the stimulation. She asserted that people with autism should be “protected from sounds that hurt their ears” (p. 1).

Lighting also has a significant influence on learning. McCreery and Hill (2005) stated that the use of controlled illumination is a critical aspect of the learning environment and affects student achievement. The use of high-quality lighting in school environments has been linked to students’ improved mood, behavior, and concentration (Northeast Energy Efficiency Partnerships, 2002).

Classroom lighting can improve student comfort and attention. Fluorescent lights, although energy efficient, do not provide the best quality of light for learning. They have an unnatural color and a discontinuous spectrum, and they can be too bright for people who experience light sensitivity (Lorelei, 2003). Fluorescent lights have been associated with increased student stress and may negatively affect students’ learning, behavior, and comfort (Küller & Laike, 1998; Martel, 2003; Northeast Energy Efficiency Partnerships, 2002). Students in school environments that incorporate full-spectrum lighting experience less stress and anxiety and improved behavior,
Students with autism are often sensitive to light, and some lighting may be painful to them, especially bright and flickering lights. Research has suggested that children with autism exhibit increased repetitive behavior when exposed to fluorescent lights (Küller & Laike, 1998). Grandin (1995) suggested that some people with autism can see the 60-cycle flicker associated with fluorescent lighting, resulting in headaches, eyestrain, or the perception of a pulsating room. In contrast, halogen lighting is soft, producing a golden-white light with continuous spectral distribution that looks and feels like sunlight (Lorelei, 2003). Determining the effectiveness of sensory-based UDL modifications to improve classroom sound and lighting for students with autism can benefit educational programs.

Purpose and Research Questions

The purpose of our study was to determine whether students with autism demonstrate increased attention during learning activities in a classroom after the installation of sound-absorbing walls and halogen lighting and to explore how the modifications affect attending and learning from the students’ perspective. The research questions were as follows:
1. Will students diagnosed with autism or dyspraxia demonstrate increased attention for learning activities after the installation of sound-absorbing wall material? (The material used was the Owens Corning Basement Finishing System™; Owens Corning, Toledo, OH.)
2. Will students with autism or dyspraxia demonstrate increased attention for learning activities after the installation of halogen lighting?
3. From the students’ perspective, do sound and lighting modifications affect their ability to attend to classroom activities?

Method

Research Design

We used a mixed-method, multiple single-subject AB (B+C) design that provided systematic repeated measurements of behavioral responses over time, including baseline and intervention phases (Portney & Watkins, 2000). For this study, A was a 2-wk baseline (BL), B was 2 wk after the installation of sound-absorbing walls (wall phase, or WP), and C was installation of halogen lighting (lighting phase, or LP) in a sound-absorbing ceiling. The B+C segment included the installation of halogen lights and ceiling panels in addition to the sound-absorbing walls. We chose this design because it allowed us to quantify and compare behaviors across phases with participants functioning as their own controls. In addition, we interviewed each student 3 times in each phase with predetermined, open-ended questions about the student’s perceptions of the environmental modifications. Parents were requested not to change medications or diet during the study.

Setting

The study took place in a licensed, nonprofit, private academic school for prekindergarten through 12th-grade students with severe communication disorders, including students diagnosed with autism. Total school enrollment was 16–20 students. One classroom was modified for this study, and the 4 study participants were the students assigned to this classroom. The 11-mo academic curriculum uses a structured, multisensory, phonics-based curriculum for teaching speech, reading, language, writing, and literacy. Occupational therapy is integrated within the curriculum supplemented by individualized sessions.

Participants

The study was approved by Temple University’s institutional review board. A letter was sent from the school director to parents of students in the classroom targeted for modification. The letter described the classroom modifications, the study, and allowance for exclusion of student data on parental request. Parents contacted the school director in writing to permit their child to participate in the study. Participants were 4 male students ages 13–20 assigned to the classroom targeted for modification to improve the sensory environment. Participants needed to demonstrate classroom-ready behaviors as defined by the school and be free of special health concerns, cognitive impairment, or a psychiatric condition.

Instruments

A decibel (dB) is a unit of sound or loudness measurement. The weakest heard sound is 0 dB, a whisper is approximately 3 dB, and normal conversation is 60–70 dB. Death of hearing tissue occurs at 180 dB (Chasin, 2007).

We used a decibel meter to measure ambient classroom sound before and after the sound-absorbing walls and ceiling were installed. The meter recorded sound ranging from 50 dB to 126 dB. Sound <50 dB was displayed as low without a specific dB value.

The frequency of attending and nonattending behaviors was measured through analysis of 10-min videotaped segments on 4 days during four academic periods.
during each phase (A, B, and B+C) for a total of sixteen 10-min video segments of each child per phase. Videotaping is used regularly in the school and was a familiar routine for the students.

Before the study, the occupational therapist familiar with the students developed behavioral descriptors of nonattending behaviors specific to each student that were then corroborated by the teachers. For example, nonattending behaviors for Participant 4 included rubbing his eyes and face, covering his ears, vocalizing ≥ 3 s without visually attending, getting out of his chair, and requiring three or more teacher prompts for a response.

Journaling was used to record the subjective experience and opinions of the students responding to a set of questions about the environmental changes in BL, WP, and LP. Interviews took place in a familiar quiet room adjacent to the classroom and were conducted by the occupational therapist (author Rachel Shoener). Three students used spoken language to respond, and 1 typed the responses.

The Sensory Profile (Dunn, 1999), a standardized caregiver questionnaire, is completed by the parents annually and provides ongoing information about how a student processes information that in turn helps guide programming. The 125 items are categorized into three main groups: sensory processing, modulation, and behavioral and emotional responses. Content validity on item selection was 80%, Cronbach’s α ranged from .47 to .91, and the test was found to discriminate among groups without disability and diagnostic groups with autism and attention deficit hyperactivity disorder. Concurrent validity was completed with the School Function Assessment (Coster, Deeney, Haltiwanger, & Haley, 1998). In this study, we did not use the student’s Sensory Profile as either an inclusion criterion or a measure of change. Alternatively, we used it to provide insight into and context for behavioral changes. For example, insight into the students’ sensory makeup through his Sensory Profile helped explain why visual or auditory changes in the environment contributed to improved attention. Additionally, the students’ subjective responses, in light of his Sensory Profile, provided a more holistic understanding of the student–environment interaction.

Procedure
The study took place over 6 wk and included three phases: a 2-wk BL before the environmental changes, 2 wk after the installation of sound-absorbing walls (WP), and 2 wk after installation of halogen lighting (LP). Classroom physical layout, white walls, curriculum, routines, and activities were unchanged and uninterrupted during the course of the study. Installations were completed over non–school days (weekends). The materials and installation were donated to the school.

The intervention was the installation of the Owens Corning Basement Finishing System and included wall-covering material, installed in Phase 2, made of light-weight fiberglass panels, PVC lineal, and foam PVC trim moldings. Ceiling covering and halogen lights were installed in LP. The noise reduction coefficient of the sound-absorbing walls was 0.75 (Owens Corning, 2007).

Data Collection
To measure the reduction of sound levels in the classroom, decibel readings were taken in five locations in the classroom once per week during each phase of the study (1) in the empty classroom, (2) during class time when students were working quietly, and (3) during group sessions. Heat and air vents were open during each phase.

To measure attending, 10-min classroom segments were videotaped 2 days/wk during four academic periods in BL, WP, and LP, resulting in a total of sixteen 10-min video segments of each student for each phase. Videotaped sessions were analyzed to determine the rate of attending or nonattending behaviors.

To ascertain the student perspective, we interviewed students 3 times each in BL, WP, and LP, using predetermined questions about students’ perception of the environmental modifications. Their responses were transcribed as they answered questions, and 1 student typed his answers independently.

A Sensory Profile was completed by parents 6 wk before the study. We used it to provide insight into and a clinical explanation of behavioral response or changes. Consistently using the same form was valued by the school.

Two observers not familiar with the students and blinded to the phases independently viewed videotapes and scored the presence or absence of attending behaviors. Videos were scored at 15-s intervals within each 10-min segment for a total of 40 intervals. Decision rules were established for scoring behaviors specific to each student and consistent with the established targeted behaviors. If one or more nonattending behaviors were observed within a 15-s interval, a negative was scored for that interval. Interrater reliability (96%) was established using the interval-by-interval approach.

Data Analysis
Frequencies of nonattending behaviors were determined for each student in BL, WP, and LP. To determine the frequency of attending, we calculated the number of
negatives divided by the number of intervals times 100. The frequency and percentage of nonattending behaviors in each phase were compared for each student. The sum of negatives for each interval was plotted on a graph for each phase for each student for visual analysis.

The student interview transcripts were analyzed through theme identification across BL, WP, and LP for each student and then across students. Two independent reviewers established interrater reliability for the themes. This phenomenological methodology allowed us to explore the participants’ perspective and subjective experience with the modifications.

Results
The participants were 4 male students with language impairment ages 13–20 assigned to the classroom targeted for environmental modification. Three students were diagnosed with autism (Participants 1, 3, and 4 [P1, P3, and P4]), and 1 was diagnosed with dyspraxia (Participant 2 [P2]). Three participants were verbal, and 1 (P4) was nonverbal and communicated through typing. Participants were White, middle-class students who resided in the suburbs of a major metropolitan area.

Classroom Sound
To illustrate the reduction of classroom sound created by the wall installation, decibel readings are given in Table 1. Sound averages and ranges were lower, and the percentage of low readings increased after the installation of the sound-absorbing walls.

Attending and Nonattending Behaviors
Results demonstrated a reduction in the frequency of nonattending behaviors across the two intervention phases as well as increased stability of attending. Each student exhibited a decline in nonattending behaviors in the WP. Three of the 4 students (P1, P2, and P4) demonstrated a continued decline in nonattending behaviors in LP. P3, diagnosed with autism, showed an initial increase in nonattending behavior in LP followed by a reduction in nonattending behaviors.

P1 was diagnosed with autism. His Sensory Profile indicated that he had difficulty with sensory modulation related to endurance and tone and affecting emotional responses and behavioral outcomes. He had difficulty paying attention, was easily distracted by movement in the room, and preferred sedentary activities. The targeted nonattending behaviors, identified by the occupational therapist and teacher, included head down on desk, eyes closed, looking away from teacher or task, meltdown, and needing three or more teacher prompts.

Figure 1 depicts the frequency of P1’s nonattending behaviors (BL, 18.3%; WP, 18.1%; LP, 1.9%). During BL and WP, he was frequently observed with his head down on his desk and looking away from the teacher or task. After the installation of halogen lighting, P1 exhibited no occurrences with his head down on the desk or eyes closed. Journaling responses were not related to the question asked and did not capture his subjective responses to the modifications.

P2 was diagnosed with dyspraxia. His Sensory Profile revealed typical performance in all areas of sensory processing; however, specific item responses indicated distraction in a noisy environment, difficulty paying attention, and a tendency to look away from tasks to regard all activity in the room. Targeted behaviors included fidgeting in his chair without visually attending, hands in desk, shoes on and off, looking around the room, and requiring teacher prompts ≥3 times.

Although P2’s Sensory Profile indicated minimal difficulty with sensory processing, he exhibited improvements in attention after wall and light modifications. Figure 1 depicts the frequency of his nonattending behaviors (BL, 11.7%; WP, 5.6%; LP, 3.8%). The range of nonattending behavior also declined over the two intervention phases. During BL, 50% of the videotaped segments had five or more nonattending behaviors compared with 16% of the sessions in WP and LP combined. P2’s journaling responses in WP were

The noise level has really not [been] as loud as it’s been . . . when I am in my classroom it’s nice and quiet . . . my handwriting is much better than it was when we did not have the walls, much more focused in my work than when we did not have the walls.

In LP, he reported,

Yes I did [notice a difference]. Much more calmer than when the big lights shine . . . I could see my teacher better than before cause the lights are much more dimmer than before, they shined right in my eye . . . I’m

Table 1. Classroom Loudness: Averages for Individual Work and Group Work in Baseline, Wall Phase, and Light Phase

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<td>Light phase</td>
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Note. Meter measured 50–130 dB; <50 registered as low. For calculations, low = 49. dB = decibels.
really happy, very happy that I can finally come to a quiet room, finally I can concentrate. . . . I feel like it really has made a difference in the way I learn and the way I work.

P3 was diagnosed with autism. Scores on his Sensory Profile indicated typical processing in all areas except for auditory processing. He expressed occasional discomfort with or avoided bright lights but primarily had difficulty with auditory distractibility and sensitivity. He was reported to exhibit frequent difficulty completing tasks with the radio on and often held his hands over his ears in response to sound. The targeted nonattending behaviors included vocalizing or talking to self, requiring three or more teacher prompts, response time >3 s, and having a glazed look in his eyes. These behaviors are consistent with difficulty processing auditory stimulation.

Figure 1 depicts the frequency of nonattending behaviors for P3 (BL, 12.8%; WP, 3.3%; LP, 7.3%). The stability of behaviors increased from 37% of the videotaped sessions having 5–20 nonattending behaviors in BL to 100% having <5 nonattending behaviors in WP. In the first day of LP, 25% of the sessions showed 5–10 nonattending behaviors with a decrease to <5 for the remainder of LP. P3’s journaling reflected an awareness of the environmental changes, but most comments were not classroom related.

P4 was diagnosed with autism. Scores on his Sensory Profile indicated a high level of difficulty with sensory processing, including definite differences in auditory processing, vestibular processing, touch processing, and modulation of movement affecting activity level. Targeted nonattending behaviors included rubbing eyes or face, covering ears, fidgeting, turning sideways or getting out of the chair, head down on the desk, smelling or pulling on his shirt; vocalizing for >3 s, and requiring teacher prompts ≥3 times.

Figure 1 depicts the frequency of nonattending behaviors for P4 (BL, 17.2%; WP, 13.5%; LP, 12.2%). During BL, 40% of the sessions had ≥10 nonattending behaviors compared with 12% of the sessions in the WP and LP combined. P4, who was nonverbal and communicated through independent typing, expressed an appreciation of the environmental modifications through his journaling.

In WP, when asked whether he noticed a difference after the sound-absorbing walls were installed, P4 responded,

Better able to hear the teachers. Sounds identified easier. Keeps my sounds from travelling to distract me and everyone. Necessary in all rooms for autistics to listen easier without pain or fear.

In LP, P4 mentioned that the buzzing of the lights was gone and resulted in

less noise better freedom to think . . . great sound-absorbing walls and lights in class I love it. . . . Now less sound bothers me I can hear in class I’m not bombarded . . . free to think . . . less bothered and more focused. . . . Yes thanks to all I love to hear now very kind of you can enjoy voices without fear of pain in my head.

Cross-Student Themes

No cross-student themes were identified at BL. The WP and LP produced three cross-student themes: perception of environment improvement, positive emotional response to the changes, and self-assessment of improved classroom performance.
Classroom environmental improvements were described in both WP and LP. Journaling for WP indicated that 2 of 4 students provided positive comments about the sound in the room: “I noticed a lot more people a lot more quiet. Without the wall covering it was loud, plain old loud” (P2) and “better ability to hear teachers, sounds identified easier” (P4).

After halogen lighting installation, 3 of 4 students mentioned positive improvements, 1 of whom also mentioned light sounds (i.e., the absence of the buzzing of the fluorescent lights): “Much more calmer than when the big lights are on” (P2); “Yes, I really like the lights” (P3); and “New lights made calmer days” (P4).

A theme of positive emotional response to the environment after the installations was noted among 3 of 4 students: “I’m really happy, very happy that I have finally come in a nice quiet room” (P2); “Yes, I really like the lights” (P3); and “I love to hear now” (P4).

Discussion

This mixed-method, multiple single-subject study demonstrated a reduction in classroom sound as measured by a decibel meter in the classroom after the installation of the Owens Corning Basement Finishing System. Decibel readings indicated a decrease in sound levels in the empty classroom: BL, five of five areas >52 dB; WP, four of five areas low; and LP, five of five areas low. Fluorescent lights emit a low-level buzz that may explain the further reduction in sound after the light installation. Reductions in sound levels were reflected during individual and group classroom activities. Nonattending behaviors decreased in frequency and range for all 4 participants in WP, with a further decrease in LP. Participant journaling themes reflected that students perceived positive change in the classroom environment, generating a positive emotional response and improvement in classroom performance, including handwriting, hearing, and thinking.

A subsequent analysis of videotaped segments identified that 3 of 4 participants spontaneously and repeatedly initiated social interaction in Weeks 2 and 3 of LP, suggesting that a comfortable sensory environment freed them to interact socially, as supported by the contention in the literature (Greenspan, 2006; Greenspan & Weider, 1997; Ruble & Robson, 2007) that sensory hypersensitivities impede social interaction.

Study results provide evidence that the use of sound-absorbing walls and halogen lighting can benefit students with sensory hypersensitivity and improve their attention and engagement in the classroom. Results support the literature providing evidence that sensory-based adaptations can improve attention (Fertel-Daly, Bedell, & Hinojosa, 2001; Schilling & Schwartz, 2004). Classroom modifications using commercially available products and UDL principles could increase the accessibility of the general education curriculum for all students. The occupational therapists’ role in the school setting should include recommending UDL to reduce visual and auditory stimuli that impede learning.

Limitations of this explorative mixed-method study include the small sample size and single location. Case study and qualitative methodology, although appropriate for exploration, are weak designs for empirical research. The AB(B+C) design, although practical for this study, does not include a return to baseline condition as would an ABAB design, thereby strengthening the reliability of the results and providing increased confidence in the effectiveness of the interventions.

Further research that uses experimental research designs, varies the sequence of intervention, uses a larger sample, and randomizes participants or classrooms is recommended. A decibel meter that provides sound measurements at a lower decibel is also recommended.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- Occupational therapists’ role in school systems should include strategies incorporating universal designs for learning that address the sensory environment and contribute to student self-regulation.
- Installation of sound-absorbing walls can improve the classroom attention and engagement of students with auditory sensitivities.
- Use of nonfluorescent lighting can improve attention and engagement of students with visual hypersensitivity.
• Sensory comfort in a classroom improves attention as well as engagement, mood, and performance of students from the perspective of the students. ▲

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References


