Impact Of Tactile-Cued Self-Monitoring On Independent Biology Work For Secondary Students With Attention Deficit Hyperactivity Disorder

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ABSTRACT

Results from a multiple baseline with changing conditions design across high school students with Attention Deficit Hyperactivity Disorder (ADHD) indicated that the students increased the percentage of independent work they completed in their general education biology class after learning tactile-cued self-monitoring. Students maintained high percentages for completed work when the rate of tactile cues was faded from 1 per minute to 1 every 5 minutes, as well as when all tactile cues were withdrawn during a short-term maintenance phase. Moreover, the students increased their correctly completed work from percentages substantially lower than the mean of their classmates to percentages that matched and surpassed the mean of their classmates. Qualitative data indicated that the participants and their co-teachers approved of the tactile-cued self-monitoring procedures. Results confirm and extend prior research findings that students improve performance during independent tasks after learning how to use tactile-cued self-monitoring and that students maintain improvements when the tactile cues are systematically faded. Although this research was conducted in a secondary school setting, the method also could be applied to higher education. Postsecondary disability resource center personnel might consider MotivAider use for students with ADHD and other disabilities that affect the capacity to stay on task.

Keywords: Attention Deficit Hyperactivity Disorder; Independent; Self-Monitoring; Tactile-Cued

INTRODUCTION

Academic performance of students with Attention Deficit Hyperactivity Disorder (ADHD) on routine class work and homework typically lags behind the performance of peers who do not have ADHD (Harris, Friedlander, Saddler, Frizzelle, & Graham, 2005). Students with ADHD can be easily distracted and underperform while doing academic tasks in general education (GE) classrooms, setting the stage for detrimental short- and long-term outcomes (Sherman, Rasmussen, & Baydala, 2008). Compared to same-age peers without ADHD, individuals with ADHD are (a) at greater risk for lower reading and mathematics test scores; (b) have lower grade point averages; (c) have higher grade retention and more special education referrals; (d) are 2.7 times more likely to drop out of school; € have a lower level of college enrollment (Basch, 2011; DuPaul & Stoner, 2003); and (f) achieve less success occupationally (Biederman et al., 2008). Research about students with ADHD is more prevalent for younger children versus adolescents, leaving gaps in the evidence base from which educators can access interventions (Evans, Serpell, Schultz, & Pastor, 2007; Schultz, Evans, & Serpell, 2009). Becoming more independent on oneself and less reliant on others are important goals for students with ADHD in school settings.

Behavioral Self-Management

Managing one's own academic performance and social behaviors has long been recognized as an essential skill for success (Hogan & Prater, 1993; Rooney, Hallahan, & Lloyd, 1984), but many individuals with ADHD lack th1s skill (Barkley, 2006). Students with ADHD often exhibit inattentiveness, disorganization, off-task behavior, disruptive actions, and hurried and inaccurate responses, as well as messy, incomplete, or missing assignments (Fowler, 2010).

Managing behaviors is difficult not only for students with ADHD but also their teachers, particularly in GE classrooms of 20 to 30 students. Students with ADHD often need immediate attention or redirection from teachers, which can result in lost instructional time even during activities designed for students to complete independently (Rafferty, 2010). Overreliance on the teacher and excessive verbal redirection from the teacher can detract from classroom learning for all students and stigmatize students requiring frequent redirection.

Behavioral self-management (BSM) techniques help students learn how to better manage their own behaviors and free up time for teachers to plan and deliver instruction (Gureasko-Moore, DuPaul, & White, 2007). Students of various ages, abilities, and backgrounds, including students with ADHD can use BSM techniques (Reid, Trout, & Schartz, 2005). BSM techniques help students manage social and academic behaviors such as attention to task (Joseph & Eveleigh, 2011; Reid, 1996), academic productivity (Harris et al., 2005; Rock, 2005), and homework completion (Gureasko-Moore et al., 2007).

Self-Monitoring

Of various BSM techniques, such as self-evaluation, self-instruction, self-reinforcement, and self-graphing, self-monitoring (S-M) is the most prevalent (McDougall, Skouge, Farrell, & Hoff, 2006). S-M is based on the cognitive-behavioral principle of reactivity, whereby raising awareness of one's behavior helps trigger subsequent changes in that behavior (Meichenbaum, 1977). S-M consists of self-assessment followed by self-recording (Glynn, Thomas, & Shee, 1973). First, the individual covertly asks a question such as "Am I working quickly?" Then, the individual answers the self-assessed question, typically by marking a response or circling "yes" or "no" on a self-recording form. When students first learn to self-monitor, they are typically prompted by auditory or visual cues.

Benefits of self-monitoring. Three major benefits to using S-M techniques are as follow. First, S-M techniques are easily adaptable to meet the needs of a wide range of students (Rafferty, 2010), and the techniques are often less invasive and less stigmatizing than environmentally- or teacher-mediated strategies (Rock & Thead, 2007). Second, S-M promotes initiative, independence, and responsibility (Bialas & Boon, 2010; Blood, Johnson, Ridenour, Simmons, & Crouch, 2011) and reduces students' dependence on adults (McDougall, 1998). Third, S-M has been used successfully to increase students' self-control and improve academic performance (Graham-Day, Gardner, & Hsin, 2010; Joseph & Eveleigh, 2011; Rock, 2005).

Evidence base for self-monitoring. During the past 40 years, findings from descriptive, analytic, and meta-analytic reviews of the BSM literature indicate that individuals with various disabilities can be taught to self-monitor and that S-M has produced moderate to strong improvements in a wide range of social and academic behaviors, across various settings, for individuals ranging from preschoolers to adults (King-Sears, 2006; McDougall, 1998; Mooney, Ryan, Uhing, Reid, & Epstein, 2005). Although S-M is recognized as an evidence-based practice, most school-based S-M studies have been conducted in resource rooms and self-contained classrooms (McDougall et al., 2006). More recently, investigators have used S-M to improve academic, recreational, and social behaviors of students with disabilities in inclusive settings such as occupational health, auto mechanics, physical education, and the school cafeteria (Hughes et al., 2002; Hughes et al., 2004), as well as reading, math, language arts, social studies, and science (Bialas & Boon, 2010; Cihak, Wright, & Ayres, 2010; Farrell & McDougall, 2008; Harris et al., 2005; King-Sears, 2008).

Types of self-monitoring. The vast majority of school-based S-M interventions to date have utilized either audio cues, such as beeps or recorded phrases, or visual cues, such as reminder words, symbols, or pictures. Unfortunately, audio-cued and visually-cued S-M can be impractical if the cues disrupt the classroom or draw unwanted attention to students who use such cues (Amato-Zech, Hoff, & Doepke, 2006). Moreover, teacher and student acceptability of S-M can be limited when audio or visual cues distract students and adults who are within hearing range or eyesight of the cues (Reid, 1996).

*Tactile-cued self-monitoring***.** Tactile-cued self-monitoring (TCSM), a relatively recent variant of S-M, can be less intrusive than audio or visual cues, and is also underutilized in classroom settings (McDougall et al., 2006). In TCSM, instead of hearing or seeing cues that prompt S-M, the individual feels a vibration emitted by a pager-like device. TCSM emerged with development of a device called the MotivAider (Levinson, Kopari, & Fredstrom, 2002). Students can use TCSM in ways that do not disrupt the classroom environment (Amato-Zech et al., 2006; Legge, DeBar, & Alber-Morgan, 2010).

Although few in number, results of classroom-based TCSM studies show promise. Early TCSM studies targeted on-task and off-task behaviors of elementary students in special education settings. Amato-Zech et al. (2006) published the first TCSM study in which students with disabilities used the MotivAider in a classroom. After learning how to use the MotivAider to self-monitor their attention to task, the students increased their on-task behavior during class from a mean of 55% to a mean of 90%. Both students and teachers rated the MotivAider high for treatment acceptability. Based on a functional behavioral assessment and behavioral intervention plan, Lo and Cartledge (2006) applied a multi-component intervention package that included skill training, differential reinforcement, and TCSM via the MotivAider. Participants, including two students with ADHD, decreased their off-task behavior during classes in resource rooms. The students also increased appropriate recruitment and decreased inappropriate recruitment of teacher attention.

More recently, authors of classroom-based TCSM studies have targeted academic productivity and collected permanent product data instead of collecting observational data on on-task and off-task behaviors. In a study by Farrell and McDougall (2008), five 9th graders with various disabilities, including ADHD, used a multi-component BSM package consisting of TCSM, visual cues, goal setting, and self-graphing. After they learned to self-monitor their pace with the MotivAider, each student's math fluency increased from rates substantially less than classmates without disabilities to rates that matched classmates' math fluency. Students' treatment acceptability ratings were high, too. McDougall, Morrison, and Awana (2012) conducted two TCSM studies using the MotivAider combined with self-graphing. In study one, a 10th-grade male with ADHD tripled the percentage of algebra work completed during 10-minute, independent warm-up activities, in a GE class. In study two, a 7th grade male with emotional disturbance decreased the time needed to complete his daily English warm-up activity (i.e., vocabulary word task) in a self-contained classroom from a mean of 30 minutes to a mean of 11 minutes after he learned how to use TCSM. Although results of these two studies were favorable, both studies utilized an A-B design and, thus, did not permit conclusions about experimental control of the intervention over the target behaviors. In summary, the small but emerging research literature suggests that TCSM has the potential to produce moderate to strong improvements in students' performance similar to that produced via audio-cued and visually cued S-M.

Purpose of this Study and Research Questions

The primary purpose of this study was to investigate the impact of TCSM on the percentage of independent work completed by two 9th grade students with Attention Deficit Hyperactivity Disorder (ADHD), in a GE biology class, co-instructed by a GE teacher and a special education teacher. The primary, secondary, and tertiary research questions (RQ) were:

RQ 1: How will the percentage of independent biology work completed by the two participants change after they learn how to use TCSM?

RQ2: How will the percentage of independent biology work completed by the two participants be impacted when we systematically fade the rate of tactile cues from one per minute to one every 5 minutes?

RQ3: How will the percentage of independent biology work completed by the two participants be impacted during short-term maintenance probes when we remove the TCSM intervention?

We also evaluated social validity via the social comparison method (Kazdin, 1977) in which changes in the participants' independent biology work were compared to their peers' independent biology work. In addition, we examined teachers' and students' acceptability of the TCSM procedures.

METHOD

In this section, we describe the method of this intervention study, including participants and setting, materials, dependent and independent variables, research design and data analysis, and procedures.

Participants and Setting

Based on teachers' recommendations, we identified three students to participate in this study. Before we started this study, however, the parent of one student received orders to transfer to another military installation. Thus, that student did not participate in this study due to having to move. The remaining two participants, Matt and Casey (pseudonyms), were both Caucasian, 15-year-old 9th graders who qualified for special education services under the diagnostic category of Other Health Impairment, according to Hawai'i State Department of Education guidelines, via a pediatrician's diagnosis of ADHD. Full-scale, standard IQ scores on the Wechsler Intelligence Scale for Children-Fourth Edition (Wechsler, 2003) were 90 for Matt, and 103 for Casey. We selected Matt (a male) and Casey (a female) for this intervention study based on recommendations from both biology co-teachers. Each co-teacher reported that Casey and Matt had difficulty starting and completing assignments, including the daily warm-up assignment for biology class, which the teachers called "bellwork." The teachers intended bellwork to be a 10-minute, independent practice activity whereby students produced fluent responses to biology problems that required skills they had mastered recently. Both teachers reported that during bellwork, Casey and Matt typically (a) sat at their desks with pencil and paper on the desk, but with zero to few written responses; (b) tended to watch and talk to classmates, or stare at objects in the room; and (c) produced written responses when teachers verbally redirected or positioned themselves close to Casey and Matt. Casey's and Matt's behavioral habits, limited productivity, and need for teachers' reminders set them apart from their classmates. The biology co-teachers noted that, in contrast to Casey and Matt, classmates routinely and punctually produced accurate responses during daily bellwork in biology class.

The setting for this study was a GE biology class held every other school day during the final period of the day. The class had 24 students, seven of whom received special education services. A GE teacher and a special education teacher (first author) co-taught the class. The classroom was divided into two sections. One section had desks facing the board at the front of the room. The other section was a laboratory with eight tables. Preferential seating was noted on the Individualized Education Programs (IEPs) for Casey and Matt, both of whom sat in the front desk of their respective rows. The class was located at a high school with a total enrollment of approximately 750 students, on the island of Oahu, in the state of Hawai'i. Of the 750 students, 40% were White, 20% part-Hawaiian, 5% Filipino, 5% Hispanic, 4% Japanese, and 4% Black. The remaining students were Native American, Chinese, Hawaiian, Portuguese, and Samoan. Twenty-two percent of the students at the school received free or reduced lunch, 3% had limited English proficiency, and 12% received special education services.

Materials

Materials for use by Matt and Casey included daily worksheets and pens for use during baseline and intervention sessions, as well as the MotivAider and a S-M form for use during intervention sessions. Daily worksheets consisted of 5 to 10 questions typed on an 8.5 x 11 inch paper. The questions were based on recent biology lessons and designed to serve as independent practice. The questions required students to write responses for biology vocabulary terms or to complete Punnett squares (i.e., 2 x 2 tables that illustrate genotypes of an offspring produced by crossing the alleles the offspring's parents).

The MotivAider is a 6.35 x 6.03 x 1.59 cm plastic device that weighs about 0.1kg with one AA battery (Levinson et al., 2002). Users can attach the MotivAider to a belt or waistband by using a metal clip on the back of the device, or they can place the MotivAider in a pocket. The front of the device has a viewing screen and operating switches that can be set to emit vibrations of varying durations and intensity on fixed or variable interval schedules. The S-M form was a 8.5 x 5 inch paper with "Directions: Circle yes or no each time you feel the vibration from the

MotivAider" printed at the top, and a question-answer phrase, "Am I completing my bellwork? YES or NO," printed multiple times beneath the directions.

Materials used in the classroom by the first author included a timer, pencil, and procedural integrity checklists. Additional items included forms for collecting data on the target behavior of Matt and Casey, social comparison data from Matt's and Casey's classmates, and treatment acceptability data from Matt and Casey and their teachers.

Dependent Variable: Independent Biology Work—Measurement and Reliability

The dependent variable or target behavior was the percentage of independent biology work completed correctly by Matt and Casey. We operationally defined this target behavior as the percentage of correct written responses to questions printed on daily worksheets, during the first 10 minutes of biology class, during what teachers and students called bellwork. Using permanent product recording, we calculated the percentage of independent biology work that each student completed correctly during each session of this study. That is, we divided the number of correct written responses by the total number of responses required, then multiplied by 100%.

The first author served as the primary data collector. During approximately every third session of the baseline phase and intervention phases, the GE teacher served as the secondary data collector. The point-by-point formula for calculating reliability of measurement (i.e., inter-grader agreement) between the primary and secondary data collectors was number of agreements on worksheet responses completed by the student, divided by number of agreements and disagreements on responses completed, multiplied by 100%. Mean reliability between the primary and secondary data collectors equaled 85% for Matt (N = 7 sessions) and 89% for Casey (N = 9 sessions).

Independent Variable

The independent variable, or intervention, in this study was TCSM. Consistent with Glynn et al.'s (1973) BSM model, TCSM comprised two components—self-assessment plus self-recording. Each time the MotivAider emitted a vibration (tactile cue), Matt and Casey silently asked themselves the question printed on their S-M form, "Am I completing my bellwork?" and decided yes or no (self-assessment). Then Matt and Casey circled "Yes" or "No" on their S-M forms (self-recording).

Research Design and Data Analysis

We used a multiple baseline with changing conditions design across two students (Alberto & Troutman, 2009) with a baseline phase followed by an initial intervention phase (first condition), then three additional phases during which we faded the rate of tactile cues (second, third, and fourth conditions), and, finally, short-term maintenance probes. The changing conditions were changes in the rate of tactile cues. To analyze graphed data and to evaluate control of the TCSM intervention over the target behavior, we used six classic visual inspection criteria, including changes in means, levels, trends, and variability; latency; and overlap (Kazdin, 2011). We also reported descriptive statistics (means, standard deviations, and ranges), percentage of nonoverlapping data (PND; Scruggs, Mastropieri, & Castro, 1987), and percentage of data points exceeding the median (PEM; Ma, 2006). Finally, we calculated effect sizes (*d*, that is, standardized mean difference; Cohen, 1988), using the standard deviation of the baseline phase, to compare each participant's mean percentage of independent biology work for the baseline phase versus first condition, and for the baseline phase versus all conditions' phases combined.

Procedures

Approvals and consent. Before starting this study we obtained approval from the Institutional Review Board at the University of Hawai'i, and permission from the State of Hawai'i Department of Education. Then we obtained voluntary informed consent from the students' parent and the two co-teachers, as well as voluntary informed assent from Casey and Matt.

Baseline phase. During each session of the baseline phase, we used the following procedures. Teachers delivered worksheets to all students when the first bell rang to signal the start of the biology period. Students had 10 minutes to complete the assignment. Before students began their work, both teachers verbally prompted students to begin their work and to raise their hands if they needed help or had questions about the problems on the worksheet. If students asked questions, one of the teachers provided assistance. At the end of the 10-minute period, all students handed their worksheets to one of the teachers. Then one of the teachers reviewed the answers and steps required to complete each problem on the worksheet. For Matt and Casey, we stopped collecting baseline data and began initial training of TCSM when their graphed data indicated a flat or descending trend.

Initial training of TCSM. After the final session of the baseline phase but before the first session of the first S-M condition, the first author instructed Matt and Casey, separately, for approximately 30 minutes, how to self-monitor during bellwork by using the MotivAider and a S-M form. The first author adapted the following six training steps depicted in the video training packet produced by McDougall (2003). Within the following training steps, we have embedded some tips and explanations for teachers.

1. Teacher briefly explains to student the rationale for the intervention. In this study the rationale was to increase the percentage of bellwork completion, thus engaging students for the first 10 minutes of class. Completion of in-class assignments would result in overall grade improvement and acquisition of biology content skills. Explaining the rationale for an intervention (in this context, self-monitoring) alerts students about the "why?" for learning and using an intervention. The rationales for this study included specific benefits for Matt and Casey (e.g., increased grades; better learning), which was important to motivate them, and relating to Matt and Casey that the intervention we would be using had helped other students in the past improve their school work
2. Teacher models examples and nonexamples of the target behavior; student observes. Students may not realize how many or how long they are exhibiting off-task behaviors, and they may not realize what the replacement behaviors look like. In this study, the teacher modeled by talking aloud as she demonstrated staying on task and focusing on the problems in bellwork. She also modeled nonexamples of off-task behaviors, which were based on what Matt or Casey had been doing: doodling, staring into space, watching other students, and playing with hair or objects on the desk. By having students observe the on- and off-task behaviors, they begin to see the distinctions between the behaviors. Additionally, listening to the teacher talking aloud about her behaviors (e.g., what she is doing, why she is doing it) during this modeling step provided Matt and Casey exemplars of an internal dialogue that matched their external behaviors. Modeling clearly on-task behaviors informed the students what they should do and think; modeling off-task behaviors matches what they already do and adds the internal dialogue that students may not realize they were thinking.
3. Teacher models the S-M procedure while student observes. Student and teacher independently self-record occurrences of teacher doing and not doing the target behavior on their respective S-M sheets. At this point, the teacher introduced to Matt and Casey, individually, the MotivAider and self-monitoring form as the intervention that could help them increase their bellwork completion, leading to better learning and increased grades. The teacher showed the MotivAider and self-monitoring form to each student, and explained that these two items had helped other students in the past improve their school work. The teacher directed the student to, "Watch me carefully while I do my bellwork. Circle 'yes' if I am on-task when MotivAider vibrates. Circle 'no' if I am off-task when the MotivAider vibrates. Afterwards, we'll compare our self-recording forms to see if we agree about how many times I was on-task and off-task." The teacher gave a blank copy of the self-monitoring form to the student and positioned her own self-monitoring form such that the student could not see whether the teacher was circling 'yes' or 'no' during this step of the training procedure. The teacher also made sure that her own MotivAider and the student's MotivAider were set on the same cuing schedule, and that she and the student started their respective MotivAiders at the same time. Then the teacher played the role of student, that is, the teacher modeled the self-monitoring procedure while doing bellwork by using the vibrations emitted by the MotivAider as the cue for when to silently ask oneself "Am I completing my bellwork?" and circled "yes" or "no" on the self-monitoring form for each vibration emitted. The student watched and listened to the teacher as she intentionally mixed in examples (on-task behaviors) and nonexamples (off-task behaviors) to ensure that the students would

accurately discriminate between desirable and nondesirable behaviors. During this training step, the teacher and the observing student independently circled “yes” or ”no” on their respective self-monitoring forms.

4. Teacher and student compare their respective S-M sheets and check for agreement. After they independently completed their self-monitoring forms, the teacher and observing student compared their respective responses. For both Casey and Matt, their responses on the self-recording form during step 3 of training always matched the teacher’s responses. The initial training of self-monitoring does not need to be lengthy in order for students and the teacher to reach high agreement (at least 80% agreement) during this step 4. However, it is essential that agreement is high. The reason agreement should be high during step 4 is because the next step shifts from teacher modeling to the student practicing self-monitoring for the very first time. When agreement is high during step 4, students will likely be very accurate when using self-monitoring during step 5. Conversely, if agreement in not high, then students are less likely to be accurate when it is their turn to practice the self-monitoring procedure. High percentages of agreement, based on comparing the teacher’s and student’s independent responses on the self-recording forms, suggest that the student accurately discriminates between the desired and undesired behaviors. Thus, we eliminate lack of cognitive awareness (i.e., “not knowing” what or how to behave) as a plausible reason for inadequate performance.
5. Student practices the S-M procedure while teacher observes. Student and teacher independently self-record occurrences of student doing (or not doing) the target behavior on their respective S-M sheets. In this step, the student and teacher reverse their respective roles from step 4. By step 5, the student knows what behaviors are on- and off-task, has seen and heard the teacher model the thought process and corresponding behaviors expected during bellwork, and is familiar with how the MotivAider’s tactile cues work in conjunction with the S-M form. Thus, in step 5, the student practices using the S-M procedure for the first time, while the teacher observes and independently uses a self-monitoring form to check on the accuracy of the student’s self-recording. In step 5, the focus shifts from “someone else” (watching and monitoring the teacher’s behavior) to the student (self-monitoring one’s own behavior). Immediately before the student and teacher execute step 5, the teacher should remind the student to: (a) perform only on-task or desired behaviors, and to avoid off-tasks or undesired behaviors; (b) mark the self-recording form quickly, that is, immediately after the MotivAider vibrates, then get right back on-task; and (c) mark their self-recording form accurately or honestly; if and when an off-task behavior does occur, circle “No’ on the self-recording form, learn from that experience, and “get back on task.”
6. Teacher and student compare their respective S-M sheets and check for agreement. After they independently completed their self-monitoring forms during step 5, the student and observing teacher compared their respective responses. For both Casey and Matt, their responses on the self-recording form during step 5 of training always matched the teacher’s responses. Moreover, students’ and the teacher’s responses were always “yes,” which indicated that on-task behavior was very high during step 5. Thus, consistent with the 100% agreement verified previously in step 4, similar results for step 6 suggested that Casey and Matt were ready to begin using the MotivAider and self-recording form during actual bellwork periods. We did not adjust our initial training procedures, nor conduct additional training, as we would have had to do if (a) Casey or Matt had demonstrated instances of off-task behavior during step 5, or (b) agreement between the teacher and students had been anything less than high during step 4 or step 6. As we did with Casey and Matt, a student’s first opportunity to use TCSM with the actual task—biology bellwork in this case—could occur within 1 day of the time that initial training procedures verify that the student can use TCSM in an accurate and punctual manner.

Changing conditions 1 through 4. During each of four changing conditions of the TCSM intervention, procedures were the same as the baseline phase with the following exceptions. Upon entering the classroom, the MotivAider and S-M form were on Matt’s and Casey’s desks. Matt clipped the MotivAider to the waistline on his pants and Casey placed the MotivAider in one of her pockets. During bellwork, Matt and Casey used their MotivAider and self-monitoring form. After feeling each tactile cue (approximately 1 sec) emitted by the MotivAider, Matt and Casey circled “yes” or “no” on their respective S-M forms to indicate whether or not they were completing their bellwork, then resumed writing answers for their biology problems. During the first condition of the TCSM intervention, the MotivAider emitted one tactile cue every minute. During the second, third, and fourth conditions of the TCSM intervention, procedures were the same as the first condition except that the MotivAider emitted one tactile cue every 2 minutes, 3 minutes, and 5 minutes, respectively.

*Maintenance probes***.** In order to evaluate short-term maintenance of the target behavior, we used the same procedures used during the baseline phase. We conducted three maintenance probes during the week immediately after the final condition of the TCSM intervention.

Social validity. We used the social comparison method to assess social validity of changes in the target behavior (Kazdin, 1977). Kazdin noted that one of the ways to validate the importance of intervention outcomes is to compare performance of study participants to that of their peers. We compared Matt's and Casey's mean percentages of independent biology work completed during the baseline phase and each phase of intervention to mean percentages of independent biology work completed by their peers during those same times.

Procedural integrity. The first author constructed three checklists to promote co-teachers' and student-participants' adherence to procedures: one for the baseline phase and for maintenance probes, one for the initial training phase, and one for the intervention conditions.

Treatment acceptability. To assess the acceptability of the TCSM intervention, the special education teacher asked Matt and Casey these questions:

"Do you know why your teacher asked you to participate in this study with the MotivAider?"
"Did you like the MotivAider project?"
"What did you like about using the MotivAider?"
"Would you use the MotivAider in any of your other classes, if so, which ones?"

Treatment acceptability queries for the two co-teachers included: Do you think the TCSM intervention using the MotivAider was practical? Why or why not? Do you think the TCSM intervention was effective? Are you likely to use the TCSM intervention with the MotivAider again for students exhibiting similar characteristics as the participants in this study?

RESULTS

In this section, we present results that illustrate changes in independent work completed by the two participants, as well as results for social validity and treatment acceptability.

Percentage of Independent Biology Work Completed by Matt and Casey

Figure 1 displays percentages of independent biology work completed by Matt and Casey during baseline and intervention phases.

Figure 1

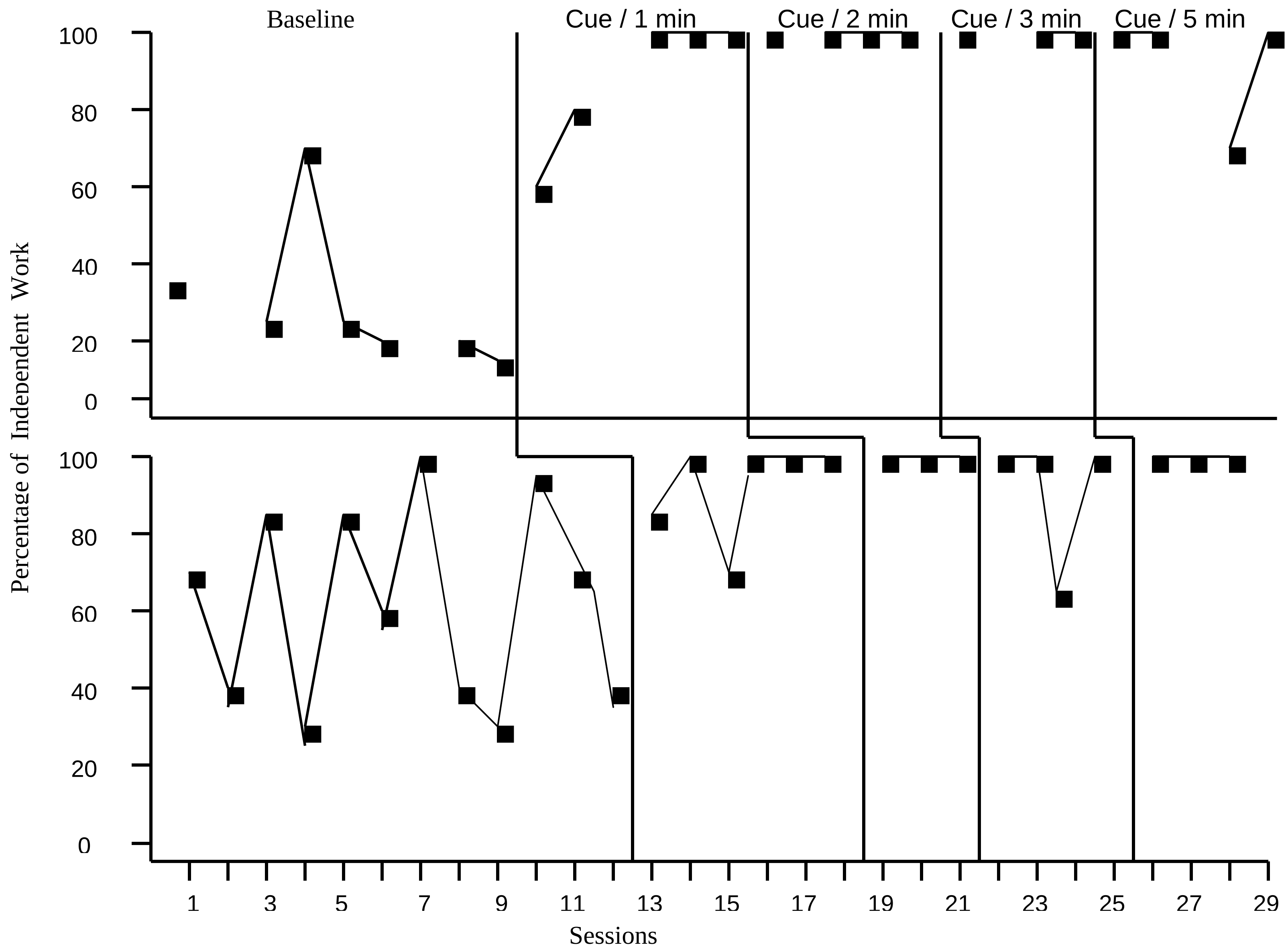
Baseline
Cue / 1 min
Cue / 2 min
Cue / 3 min
Cue / 5 min
Percentage of Independent Work
100
80
60
40
20
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Sessions

Figure 1 displays the percentage of independent biology work completed by Matt and Casey during baseline and TCSM intervention phases. During the initial TCSM phase, the MotivAider emitted one cue per minute (condition 1). During the remaining three phases, the MotivAider emitted one cue every two, three minutes, and five minutes, respectively (conditions 2, 3, and 4).

Matt. During the baseline phase, the mean percentage of independent biology work completed by Matt equaled 27% (*SD* = 19%; range = 11 to 67%; *N* = 7 sessions). During the first condition (one cue every 1 min), the percentage of independent biology work completed increased to a mean of 87% (*SD* = 19%; range = 57 to 100%; *N* = 5 sessions). The percentage of independent biology work Matt completed equaled a mean of 100% (*SD* = 0%; range = 0%; *N* = 4 sessions) for the second condition (one cue every 2 min), a mean of 100% (*SD* = 0%; range = 0%; *N* = 3 sessions) for the third condition (one cue every 3 min), and a mean of 92% (*SD* = 17%; range = 67 to 100%; *N* = 4 sessions) for the fourth condition (one cue every 5 min). PND between the baseline phase and all conditions combined equaled 88%. PEM between the baseline phase and the first condition equaled 100%. Effect size (*d*) for baseline versus the first condition equaled 3.14. Effect size (*d*) for baseline versus all four changing conditions combined equaled 3.50. For the three maintenance probes conducted during the week after Matt's final phase of intervention, the mean percentage of independent biology work equaled 93%.

Casey. During the baseline phase, the mean percentage of independent biology work completed by Casey equaled 61% (*SD* = 24%; range = 33 to 100%; *N* = 12 sessions). During the first condition (one cue every 1 min), the percentage of independent biology work completed increased to a mean of 92% (*SD* = 14%; range = 67 to 100%; *N* = 6 sessions). The percentage of independent biology work Casey completed equaled a mean of 100% (*SD* = 0%; range = 0%; *N* = 3 sessions) for the second condition (one cue every 2 min), a mean of 92% (*SD* = 17%; range = 67 to 100%; *N* = 4 sessions) for the third condition (one cue every 3 min), and a mean of 100% (*SD* = 0%; range = 0%; *N* = 3 sessions) for the fourth condition (one cue every 5 min). PND between the baseline phase and all conditions combined equaled 0%. PEM between the baseline phase and the first condition equaled 100%. Effect size (*d*) for baseline versus the first condition equaled 1.26. Effect size (*d*) for baseline versus all four changing conditions combined equaled 1.38. For the three maintenance probes conducted during the week after Casey's final phase of intervention, the mean percentage of independent biology work equaled 90%.

Social Validity

During the baseline phase, Matt (*M* = 27%) completed approximately one-third the amount of independent biology work as his peers (*M* = 82%). During each of the conditions of the TCSM intervention, however, Matt's independent biology work (means of 87%, 100%, 100%, and 92%, respectively) was comparable to his peers (means of 93%, 83%, 91%, and 93%, respectively). During the baseline phase, Casey (*M* = 61%) completed less independent biology work than her peers (*M* = 84%). During each of the four conditions of the TCSM intervention, however, Casey's independent biology work (means of 92%, 100%, 92%, and 100%, respectively) was comparable to her peers (means of 84%, 88%, 92%, and 94%, respectively).

Treatment Acceptability

Matt's and Casey's responses to the four questions on treatment acceptability were as follows. When asked why their teacher asked them to participate in the study, both students responded their bellwork grades were low and that their teacher thought it would help them pay attention better and improve their grades. Matt stated that he liked the MotivAider because it (a) was an easy way to pay attention without the teacher getting mad at him for not doing his work or for distracting other people, (b) was quiet and only classmates he had told knew he was using the MotivAider, and (c) helped him improve his biology grade. Casey stated that she liked the MotivAider because it was quiet and the vibration helped her "snap back to reality" when she was "spaced out or tired." Casey also said that the MotivAider helped her improve her bellwork grade. Casey asked if she could add the MotivAider to her IEP for the next school year. When asked if they wanted to use the MotivAider in other classes, Matt and Casey said yes and asked when they could start using the MotivAider in other classes.

Both co-teachers stated TCSM was a practical intervention for a GE setting. The GE teacher said TCSM freed up time for her to attend to other students. The GE teacher also noted that having the special education co-teacher train Matt and Casey was very helpful and that without a co-teacher, TCSM training might be problematic for GE teachers. The special education teacher reported that TCSM was an excellent way for the students to manage their own behaviors and become more independent learners. Finally, both teachers indicated they would be willing to use the intervention again for students exhibiting characteristics similar to Matt and Casey. The GE teacher suggested training all of the school's staff to use TCSM with any students who might benefit, regardless of special education or GE status.

DISCUSSION

Results of this study, as depicted in Figure 1, lend support for using TCSM to increase, stabilize, and maintain academic productivity of students who tend to produce too little or inconsistent amounts of work during independent practice tasks. For RQ1, we conclude that the TCSM intervention demonstrated moderate to strong functional control over the target behavior. For RQ2, we conclude that the TCSM intervention demonstrated strong functional control over the target behavior. For each of three intervention phases when we faded the cues, both participants' percentages for independent biology work matched or exceeded percentages they achieved during the initial phase of the TCSM intervention. Moreover, as evidenced in Figure 1 and by SDs we reported, both participants demonstrated very stable performance during the three phases when we faded TCSM cues (i.e., changing conditions), with Matt completing 100% of his work for 10 of 11 sessions and Casey completing 100% of her work for 9 of 10 sessions. This pattern is consistent with results from McDougall and Brady (1998), wherein students improved their performance after they learned to self-monitor, then continued to improve their performance during phases when elements of a multi-component BSM intervention were faded. In answer to RQ3, we conclude that Matt and Casey completed independent work at percentages similar to those they achieved during TCSM intervention phases, and substantially greater than those during baseline. It is possible that Matt and Casey covertly self-monitored during the maintenance probes, and that they no longer required the more explicit tactile-cued form of S-M. Without further data, however, we cannot definitely conclude that this was the case.

Results of our study also provide strong support for social validity via social comparison of the participants' work to that of their peers because the participants' means equaled or exceeded that of their peers. Additionally, both participants asked when they could start using the MotivAider in other classes. This suggests treatment acceptability from students' perspectives. Both co-teachers also were positive about the participants' use of TCSM. Finally, both co-teachers indicated that they were willing to use the TCSM intervention in the future.

Limitations

We acknowledge several important limitations of our study. First, we cannot claim that the TCSM intervention demonstrated experimental control over the target behavior. Contemporary standards for evaluating efficacy of results from studies that use single-case research designs (Horner et al., 2005), as well as evidence standards promulgated by the Institute for Education Sciences (2010), require at least three systematic changes in the target behavior within a study that uses a suitable research design. We included only two participants, as opposed to at least three participants, in our multiple baseline (with changing conditions) design, for the following reasons. Originally, there was a third participant recruited, but he needed to withdraw due to a family transfer. As for replacing this student with another one, the GE teacher and special education teacher verified that Casey and Matt were the only other students who needed to improve their performance during daily bellwork in biology class. Casey's and Matt's classmates routinely and punctually produced accurate responses during daily bellwork. Classmates' performance contrasted markedly with Casey's and Matt's behavioral patterns, limited productivity, need for teacher proximity, and need for reminders to stay on task during bellwork. We did not select a third participant, when the original third participant could no longer participate, simply to meet the "at least three" criterion for establishing experimental control in studies that use multiple baseline designs. Doing so would violate practical and ethical standards for single-case research and applied behavior analysis. That is, researchers and practitioners should intervene based on individual student needs, but avoid intervening when a student's performance indicates that the intervention is not warranted (Kazdin, 2011). We did demonstrate, however, that the target behavior increased markedly, for both Casey and Matt, after they started to use TCSM. Moreover, as we hypothesized, both students maintained gains in their target behavior during each of the changing conditions; that is, when we repeatedly thinned the cuing schedule from one cue per minute, to one cue per 2 minutes, to one cue per 3 minutes, and one cue per 5 minutes.

A second limitation is that we did not assign an independent observer to collect data that would have enabled us to calculate and evaluate S-M accuracy and S-M punctuality for each student. We did note, however, when reviewing self-recording forms, that Casey and Matt circled "yes" on their self-recording forms, for each opportunity, for every TCSM session throughout the study. Third, although the first author used procedural integrity checklists, we did not assign an independent observer to collect data, which would have enabled us to calculate and evaluate procedural integrity. Fourth, we would have liked to obtain higher percentages for reliability of measurement of the target behavior. Fifth, we did not conduct procedures to assess generalization across other tasks or settings. Finally, consistent with interventions that use single-case research designs, results are limited to the students in our study. Consistent with single-case research methodology, our goal was to demonstrate changes in the target behavior across time, via repeated measurement, for purposefully selected students likely to benefit from the intervention—not to conduct a large N, between-group, true-experimental study in which generalization takes the form of applying results from a sample to a population via random selection of participants.

Implications and Recommendations for Future Research and Practice

Based on our findings and the BSM literature, we recommend that practitioners consider the following items. First, use TCSM only for those students, behaviors, and contexts that are likely to benefit from TCSM. Select students who can perform a specific task, but who produce insufficient amounts of work or who produce that work inconsistently. Ensure that tactile cues do not simply become another environmental distraction for the user. For both students and teachers, initial success is important. Increase the probability of initial success with TCSM by ensuring that the task is brief and the behavior is already in the students' repertoire. Thus, avoid targeting an acquisition-level task, whether social or academic. After students produce more work when first using TCSM, gradually thin the cuing schedule. During this time, students should continue to produce as much work, or more work, and become more consistent (less variable) in producing that work. After thinning the cuing schedule, eliminate TCSM altogether and encourage students to cue themselves. Practitioners also should attend to procedural details, such as cuing schedules, which might impact the effectiveness of S-M. Axelrod, Zhe, Haugen, and Klein (2009) experimented with how frequently students needed to be cued to self-monitor and found similar results for students cued at 3 min and 10 min intervals. As such, practitioners should carefully select frequency of cues based on individual student characteristics. If a student initially needs a more frequent cuing schedule, then practitioners should gradually fade the cues, and be aware that less frequent cues may be as effective as more frequent cues in some cases. Practitioners also should consider the benefits and drawbacks of using fixed versus variable interval cuing schedules. We recommend that practitioners base initial cuing schedules on baseline observations that determine, on average, how long a student remains "on-task" or persists in producing answers, during independent tasks.

After students self-monitor effectively using devices like the MotivAider and a S-M form, practitioners should discuss with students options for subtler forms of self-monitoring. For example, students can ask themselves, occasionally, if they are working (self-assessment), then quickly write a tally directly on their worksheet (self-recording). Importantly, professionals who have invested time into teaching self-management to students should monitor to ensure students' productivity remains high, though it would not be unusual to observe slight decreases in the amount of work or in the consistency of that work. If productivity deteriorates more significantly, practitioners should reinstitute TCSM after having some sort of follow-up with students. King-Sears (2006) found that students whose behaviors deteriorated after intervention increased their performance after brief follow-up sessions with whomever taught them the intervention. Finally, practitioners can seek and utilize resources (i.e., colleagues and information) on how to apply S-M and other BSM techniques in school settings. Examples are provided in BSM training materials in books (Agran, King-Sears, Wehmeyer, & Copeland, 2003), practical guides (Dowrick, 1991), manuals (Koegel, Koegel, & Parks, 1992; Young, West, Smith, & Morgan, 1995), and DVDs (McDougall, 2003).

Our recommendations for researchers who investigate S-M are as follow. First, researchers should select behaviors that are already within students' repertoires, but which students are not consistently performing (Graham-Day et al., 2010; King-Sears, 2008). Second, because PND values can vary drastically based on a single data point

(Busk & Serlin, 1992; Scruggs et al., 1987), we recommend researchers consider the inherent baseline variability of S-M behaviors when interpreting effectiveness using PND. In our study, one discrepant data point from the baseline phase (session 4 for Matt, session 7 for Casey) had the effect of reducing PND from 100% to 88% for Matt, and from 81% to 0% for Casey. When reporting PND, we recommend that researchers also report other indices, such as PEM, or an effect size index, such as *d*. Effect size indices like *d* take into account each data point from the baseline and intervention phases, as well as the variability of those data points. Thus, unlike PND, *d* is not inflated or deflated by the presence or absence of a single data point or outlier. Visual inspection of graphed data remains the sine qua non for evaluating change in single-case research, but balanced use of summary indices and effect size indices can further illuminate analyses.

Third, when designing TCSM studies, researchers should build upon the extensive, predominantly favorable literature on audio-cued and visually-cued S-M, as well as other BSM techniques. We believe future TSCM studies are likely to replicate and extend findings obtained to date in the relatively few but promising classroom-based TCSM studies. In time, TCSM will likely prove efficacious, like audio- and visually-cued versions, across a wide range of settings, individuals, and behaviors. Fourth, researchers should evaluate long-term maintenance, generalization across settings, and generalization across tasks for TCSM. Fifth, widespread use of cell phones, smart phones, and personal digital assistants bodes well for TCSM. Such devices emit tactile cues and can be more practical to use compared to audio-cued and visually-cued versions of S-M. That is, TCSM devices blend in versus standing out when used in a variety of settings. Overall, the BSM literature suggests that individuals can use such a variety of devices to self-monitor their performance via video cues (Blood et al., 2011), picture prompts (Agran et al., 2003), recorded messages (King-Sears, 2006), and other technologies (Blood et al., 2011). Sixth, in our study, we took a cue from King-Sears (2008), who emphasized collaborative efforts between researchers and teachers. We relied heavily upon the special education co-teacher, who had prior experience in designing and implementing a TCSM intervention. Absent sufficient support or experience, it may not be practical for GE teachers to implement evidence-based interventions for specific students within a whole-class setting. Moreover, researchers should be attuned to professionals' job demands. Gureasko-Moore et al. (2007), who had school psychologists teach self-management interventions to the students in their study, noted that competing time demands could be too prohibitive for other school psychologists to deliver the intervention. However, it is important that school psychologists are aware of advances in self-management, such as the TCSM in our study, so that their repertoire of techniques when giving recommendations to classroom teachers expands. Sixth, researchers should be cognizant that the social comparison method appears to be underutilized in single-case research studies (Pierce, Reid, & Epstein, 2004). We recommend that researchers use, as appropriate, both the social comparison method and subjective evaluation method (i.e., personal perspectives of participants, such as student, and their teachers) to evaluate social validity of intervention outcomes. The two methods provide different but valuable information.

Although this research was conducted in a secondary school setting, the method could also be applied to college and university students, whether in the classroom or when studying outside of class, as long as the parameters previously discussed are met (e.g., specific directions are provided, students are monitored when learning how to self-regulate). Postsecondary disability resource center personnel might consider MotivAider use for students with ADHD and other disabilities that affect the capacity to stay on task, or help students use their own mobile device to assist in self-monitoring.

TCSM via the MotivAider and similar devices that emit tactile cues (e.g., cell phones, smart phones, or personal digital assistants) have the potential to become an evidence-based practice, like audio-cued and visually-cued versions of S-M. In our study, we found TCSM to be an effective, practical, nonintrusive intervention for increasing independent work of students with ADHD in a GE biology setting. We believe that students with ADHD can become more effective managers of their own behaviors when they are taught to use BSM techniques such as TCSM.

AUTHOR INFORMATION

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