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EFFECTS OF ELECTRONIC TACTILE AWARENESS PROMPTING WITH SELF-MONITORING ON TEACHERS' USE OF BEHAVIOR SPECIFIC PRAISE

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Andrew Markelz

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The dissertation of Andrew Markelz was reviewed and approved* by the following:

Paul J. Riccomini
Associate Professor of Special Education
Dissertation Co-Adviser
Co-Chair of Committee

Jonte C. Taylor
Assistant Professor of Special Education
Dissertation Co-Adviser
Co-Chair of Committee

Mary Catherine Scheeler
Associate Professor of Special Education
Professor in Charge

David B. McNaughton
Professor of Special Education

David S. Guthrie
Associate Professor of Education

*Signatures are on file in the Graduate School.

ABSTRACT

Effectively managing a classroom is critical in promoting positive student outcomes. Regardless of research suggesting a correlation between the two, teachers report feeling unprepared to deal with challenging behaviors. As a result, teachers resort to reactive classroom management rather than proactive and preventative strategies. Behavior specific praise (BSP) is an empirically supported, proactive strategy to reinforce desirable student behaviors. Following a review of the literature, we identified tactile prompting and self-monitoring as effective methods to increase teachers' use of BSP while sustaining intervention long enough until teachers contacted natural maintaining contingencies. We created electronic tactile awareness prompting with self-monitoring (eTAPS) by combining two applications on Apple Watch™. This study primarily investigated the effects of eTAPS on special education teachers' use of BSP. Secondarily, this study investigated the impact that BSP would have on the on-task behaviors of targeted students with disabilities demonstrating frequent off-task behaviors. Results indicated that eTAPS was effective in increasing and maintaining BSP rates. Furthermore, significant increases in student on-task behavior occurred. Implications of results and future research are discussed.

Keywords: educational technology, teacher preparation, classroom management, tactile prompting, self-monitoring, behavior specific praise

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INTRODUCTION

Effectively managing a classroom is critical in promoting positive student outcomes as evidence suggests academics and behaviors are inextricably linked (Korpershoek, Harms, de Boer, van Kuijk, & Doolaard, 2016; Najaka, Gottfredson, & Wilson, 2001; Siperstein, Wiley, & Forness, 2011). Unfortunately, teachers consistently report student behaviors as one of the most challenging issues (Westling, 2010). Student behaviors can range in difficulty, however misbehaviors such as student disengagement (i.e., off-task) and simple disruptions (e.g., out of seat, calling out) are most common and can even consume as much as 80% of a teacher's instructional time (Simonsen, Britton, & Young, 2010). Alarmingly, special educators and faculty of teacher preparation programs report behavior management as the set of skills in which educators are least prepared (Begeny & Martens, 2006; Hemmeter, Santos, & Ostrosky, 2008; Oliver & Reschly, 2010).

Not only are novice teachers entering classrooms without fluent behavior management skills, but once in classrooms, pedagogical skills, classroom management, and curricular content often consume most of a teacher's working memory resources (Swanson, O'Connor, & Cooney, 1990). Research suggests working memory resources are limited to consciously thinking about a maximum of five to nine ideas or chunks at once (Miller, 1956). Classroom environments and the teaching profession create a multitude of competing stimuli. In fact, it is estimated that teachers make between 1000 and 1500 educational decisions daily (Good & Brophy, 2008). Feldon (2007) contends teachers are susceptible to cognitive overload in classrooms due to many competing stimuli. When competing cognitive demands such as academic instruction, social/emotional relationships, and sensory stimuli are consuming all of a teacher's cognitive resources, additional tasks are likely forgotten due to cognitive overload (Sweller, Van

Merrienboerer, & Paas, 1998). Because of cognitive overload, teachers are often reactionary in classroom management issues rather than proactive (Maag, 2001). Reactionary classroom management is when teachers mostly apply strategies (i.e., punishment) following undesirable behavioral occurrences. Proactive classroom management is when teachers remember to perform strategies that either a) curb undesirable behaviors before their occurrence, or b) promote desirable behaviors.

One particularly effective, proactive classroom management strategy not implemented—especially for students with emotional and behavioral disabilities—is behavior specific praise (BSP; Kern & Clemens, 2007; Markelz & Taylor, 2016). BSP is the use of positive statements intended to reinforce the desired behavior of an individual by acknowledging the individual by name (or in a manner in which he/she knows who is being praised) and specifically identifying the individual's behavior (Praising Effectively, 2017); for example, "Great job raising your hand, Ashley." In this example, the student (Ashley) is praised for a specific behavior (raising her hand). Grounded in the principles of positive reinforcement, Ashley is more likely to engage in that behavior in the future because a desired consequence (i.e., praise) immediately followed the behavior (Hester, Hendrickson, & Gable, 2009). Research suggests BSP is associated with increases in numerous desirable behaviors including on-task behavior (Luiselli & Downing, 1980; Sutherland, Wehby, & Copeland; 2000) as well as decreases in disruptive behaviors (Dufrene, Lestremau, & Zoder-Martell, 2014). In fact, Rose and Church (1998) identified BSP as one of the most consistently effective teacher behaviors associated with improved student behaviors.

Despite research findings on efficacies of BSP to promote desirable student behaviors, teachers continue to use low rates of BSP (Jenkins, Floress, & Reinke, 2015). Furthermore, reactionary classroom management is evidenced by high ratios of reprimands to praise. Although a suggested ratio of praise statements to reprimands is 4:1 (Walker, Colvin, & Ramsey, 1995), classroom observation literature reports inverse ratios of 4:1 in favor of reprimands (Sutherland & Wehby, 2001). In other words, rather than praising students' positive behaviors to encourage future positive behaviors, teachers are excessively reprimanding misbehaviors. For example, a student who is out of his seat will get the teacher's attention and likely lead to a reprimand (e.g., "Jeremy, go sit down!"). However, the student who is working quietly at his desk will often go unnoticed by the teacher, especially if the teacher is cognitively overloaded and reacting to undesirable behaviors in the classroom. Unfortunately, in this example, the opportunity to praise and reinforce the student for working quietly at his desk is lost due to reactionary classroom management.

Researchers have explored interventions to increase teachers' use of BSP to counter reactionary classroom management (e.g., Dufrene et al., 2014; Hawkins & Heflin, 2010; Kalis, Vannest, & Parker, 2007; Simonsen, Myers, & DeLuca, 2010). This introduction will present relevant research on such interventions, identify the efficacies of the intervention of the present study, and outline how the present study contributes to the literature.

Previous Interventions to Increase BSP

In a review of literature, Markelz, Scheeler, Taylor, and Riccomini (in press) identified training, performance feedback, self-monitoring, and tactile prompting as interventions used by researchers to increase teachers' use of BSP. Of the 20 studies included in the review, all studies demonstrated large effects using Non-overlap of All Pairs (NAP; Vannest, Parker, & Gonen, 2011) single-case effects sizes (*M* = 0.91, *range* = .71-1.0). Most studies (75%) used a combination of interventions (e.g., training + performance feedback) as opposed to a single independent variable.

Many interventions consisted of packages requiring intensive resources. For example, Reinke, Lewis-Palmer, and Merrell (2008) conducted a study using a class-wide teacher consultation model for increasing praise and decreasing disruptive behavior. The initial intervention involved a series of steps: (1) assess the classroom, (2) provide the teacher with feedback, (3) develop a menu of interventions, (4) choose the intervention collaboratively with the teacher, and (5) have the teacher self-monitor implementation of the intervention. Following the components of initial intervention, teachers received daily visual performance feedback (as a line graph) from the consultant. Although results were positive with increases in specific praise and decreases in disruptive behaviors across participants, multiple components of intervention along with extensive time and expertise requirements of consultees may limit the practicality and adoptability by practitioners (Riley-Tillman & Chafouleas, 2003).

In contrast to multi-component intervention packages, a more simplistic method to increase BSP is tactile prompting. Tactile prompting is when a worn device produces a vibratory signal on a time schedule prompting the user to perform a specific behavior. In two studies, electronic devices were set to vibrate on interval time schedules and prompt participants to deliver BSP (Haydon & Musti-Rao, 2011; McDonald, Reeve, & Sparacio, 2014). Immediate level jumps in participants' BSP rates during intervention with 100% response rates to vibratory prompts (meaning participants delivered BSP following every prompt) suggested the intervention was effective in reminding participants to deliver BSP.

Previous Interventions Using Tactile Prompting

The effectiveness of tactile prompting is based on research about external aids to compensate for limitations of working memory (Baddeley & Hitch, 1974). The repetitious reminder of the tactile prompting device allows users to perform a behavior (when prompted) without having to remember to perform the behavior. Given this benefit, researchers have explored the ability of tactile prompting to increase desirable teaching behaviors (McDonald et al., 2014; Petscher & Bailey, 2006; Rivera, Mason, Jabeen, & Johnson, 2015). Based on the growing number of studies using tactile prompting, Markelz, Taylor, Scheeler, and Riccomini (2017) reviewed the literature on the role of tactile prompting in teacher preparation (see Appendix A). The authors' findings suggested tactile prompting is an emerging technology in teacher preparation, yet for half of included studies ($n = 4$), tactile prompting was added as an additional component to intervention packages when participants were not meeting intervention goals. For example, in a study by Thompson, Marchant, Anderson, Prater, and Gibb (2012), a tiered intervention package was implemented to increase general educators' use of BSP. Out of three participants that did not meet BSP goals following tier one intervention (school-wide training on BSP) and tier two intervention (video self-monitoring), two participants entered tier three (coaching and tactile prompting). Both participants increased BSP rates during tier three intervention, however, multiple independent variables confound the ability to identify which independent variable contributed to level increases. Nonetheless, tactile prompting was assigned as a tier three (i.e., intensive intervention) to achieve intervention success.

Out of eight studies included in the review by Markelz et al. (2017), five used simplistic tactile prompting devices (e.g., MotivAider®; Behavioral Dynamics, 2010) that consisted of turning the device on, setting an interval schedule (e.g., 3-minutes), and initiating the intervention (Charlton, 2016; Haydon & Musti-Rao, 2011; Labrot, Pasqua, Dufrene, Brewer, & Goff, 2016; McDonald et al., 2014; Thompson, Marchant, Anderson, Prater, & Gibb, 2012). Technological barriers to adopting tactile prompting in teacher education is lowered with simplistic devices that require minimal training for participants, as well as preparation program personnel, yet innovations in technology, such as wearables, may allow for more comprehensive prompting devices. In a study by Markelz, Taylor, Scheeler, Riccomini, and McNaughton (in press), the researchers used Apple Watch™ to deliver tactile and visual prompts to a preservice special education teacher to increase BSP, active student questioning, and classroom scanning. Rather than a simplistic device that only targets one teaching behavior, the authors targeted three proactive classroom management teaching behaviors. During instruction, tactile prompting alerted the participant to reference her Apple Watch to see which behavior to deliver (i.e., practice). Behaviors were sent to the participant via text message from a researcher present in the classroom. Following immediate level jumps in targeted behaviors, and a social validity survey that demonstrated multiple-behavior prompting was unobtrusive, the authors concluded that prompting with wearable technology is a promising intervention for practicing multiple teaching behaviors.

Noted in the study by Markelz et al. (in press) was a return to baseline levels following intervention cessation for one behavior (BSP)—the other two behaviors did not enter maintenance due to time constraints. The authors hypothesized that the return to baseline suggested the behavior was solely influenced by the tactile and visual prompt and that the participant did not maintain the behavior due to insufficient practice opportunities. Apart from these limited data no other study has systematically examined the maintenance of behaviors following a tactile prompting intervention. If an intervention must be withdrawn at some point in time, the question arises; is tactile prompting by itself a sufficient intervention to maintain teaching behaviors following intervention withdrawal?

Previous Interventions Using Self-Monitoring

Self-monitoring is the capacity to regulate one's own behavior and includes techniques such as goal setting, self-evaluation and reflection, and self-reinforcement (Alberto & Troutman, 2013). Self-monitoring has been implemented to increase teachers' use of BSP (Markelz et al., in press). Out of nine studies that used self-monitoring, whether solely or in combination with other independent variables, two studies used clickers to self-monitor increases in teachers' use of BSP (Briere, Simonsen, Sugai, & Myers, 2015; Kalis et al., 2007). Kalis et al. examined self-monitoring to increase praise rates of a novice high school math teacher of students having emotional and behavioral difficulties. Prior to each session, the participant identified a number goal of praise statements. During each session, the participant self-recorded each praise statement using a hand-held clicker; meaning every time the participant delivered BSP she pressed a button to keep count. Following each session, the participant checked whether the daily goal was met. Visual analysis of results indicated an effective intervention with stable maintenance levels of BSP. The participant also indicated through a follow-up interview that the intervention positively affected student behaviors. The authors suggested that part of the efficacy of self-monitoring was that the participant received positive reinforcement through meeting daily goals. The authors' statement coincides with Markelz et al. (in press) who also state that self-monitoring may create positive reinforcement for participants to continue the targeted behavior because being aware of one's success is considered a reinforcer (Vargas, 2013).

An additional benefit of self-monitoring is that it allows interventions to run in duration until the participant contacts natural maintaining reinforcement (Alberto & Troutman, 2013). For example, Kalis et al. (2007) noted that the participant, over time, realized that the positive change in student behavior was a result of the intervention (i.e., increased praise rates). Although self-monitoring and achieving daily success was an artificially introduced reinforcement contingency, the change in student behavior was a natural maintaining reinforcement contingency that would likely persist following intervention withdrawal. Self-monitoring may be an intervention that allows for more immediate reinforcement until natural maintaining reinforcement contingencies are realized.

Electronic Tactile Awareness Prompting with Self-monitoring (eTAPS)

Building upon previous research on tactile prompting, self-monitoring, and wearable technology, the current study used two software applications (apps) on Apple Watch to combine tactile prompting and self-monitoring into one device. A repeat-timer app produced a looping tactile prompt capable of being programmed on different schedules (e.g., 90 seconds, 120-seconds). A clicker app allowed users to self-record behavior occurrences and monitor progress. The combination of these two apps on Apple Watch is henceforth called electronic tactile awareness prompting with self-monitoring (eTAPS).

We propose the efficacy of eTAPS is supported by two principles of behavior analysis: a) increased opportunities to practice and b) positive reinforcement through self-monitoring. In addition, artificial reinforcement from self-monitoring is sustainable by the ease and longevity of implementation which allows users to contact natural maintaining contingencies. In combination, eTAPS serves as a bridge to overcome cognitive overload by eliminating the need for teachers to remember to implement proactive classroom management (see Figure 1).

Imagine a novice emotional support teacher leading a new lesson in a subject she is unfamiliar with, there are high rates of student disruptions taking place, and the principal is calling to inquire about a fight that occurred during lunch between one of her students. It is understandable how the teacher may become reactionary to all the events competing for her attention and not remember to praise her student Emma—one of her most disruptive students—for being on-task at the moment. The repetitive reminders of tactile prompting on an interval timer do not require additional cognitive resources. Whenever the device prompts, no matter what is happening in the classroom, that is the teacher's cue to perform the target behavior.

Second, eTAPS increases opportunities to practice a target behavior with repetitive prompting. Increased practice may result in more automatic delivery of the behavior in the future due to repeated mapping of stimuli to responses (Blessing & Anderson, 1996; Schneider & Shiffrin, 1977). Additionally, the more practice one has delivering a behavior in various contexts (i.e., repeated processing in working memory), the more likely a behavior will transfer to long-term storage which is needed for automaticity (Tulving & Thomson, 1973; Godden & Baddeley, 1975).

Third, eTAPS utilizes daily self-monitoring for the user to check whether his or her daily goal was met. As previously described, self-monitoring introduces positive reinforcement by being aware of one's success (Vargas, 2013). Positive reinforcement will encourage the user to continue using eTAPS and delivering the target behavior.

Lastly, individualization and ease of implementation of eTAPS promotes sustained use during artificial reinforcement (i.e., reinforcement from self-monitoring) until contact with natural maintaining contingencies. Many interventions require external personnel (e.g., training and performance feedback) which limits the longevity of intervention duration due to resource limitations. For example, teacher preparation program personnel are limited in their availability to be in the field providing feedback to student teachers. Following initial set-up and training, however, eTAPS is solely operated by the user. As a result, the user can implement eTAPS for days, weeks, or months. Furthermore, student behaviors often do not change immediately following teacher intervention. For example, a student that displays frequent disruptive behaviors to seek attention will probably not remain on-task for the remainder of the school year following one delivery of BSP for being on-task. The teacher should not be discouraged, however, and quit praising the student. The teacher will need to deliver BSP repeatedly, over time, until the student associates receiving positive attention for being on-task and behavioral changes occur. How long that process takes is individualized, which is why eTAPS may act as a bridge of delivering daily reinforcement to the teacher until natural maintaining reinforcement (i.e., change in student behavior) is realized. After contact with natural maintaining reinforcement, daily self-monitoring reinforcement (i.e., artificial reinforcement) may no longer be needed to maintain the teacher's behavior.

The Present Study

Reactionary classroom management is problematic in that teachers are attempting to reduce undesirable behaviors following their occurrence. Kounin's (1970) landmark study on group management concluded that proactive classroom management effectively elicits student cooperation and involvement, thereby preventing undesirable behaviors from occurring. As emerging technologies are providing opportunities for more robust teacher behavior practicing devices, eTAPS attempts to achieve the qualities of an ideal intervention by being appropriate, effective, and efficient (Killu, 2008). The present study aims to promote the practice of proactive classroom management (e.g., BSP) while overcoming cognitive overload. This study attempts to contribute to the field by exploring innovative technologies in teacher preparation that may assist in the development of effective classroom managers. It is desirable that researchers provide proof of concept and evidence of efficacy for novel interventions (Cook & Campbell, 1979). Based on the novelty and prototype status of eTAPS, the efficacy and social validity of eTAPS was assessed. The following research questions guided our analysis:

1. What are the effects of eTAPS on teachers' use of behavior specific praise?
2. What are the effects of teachers' use of eTAPS on students' on-task behaviors?
3. Do teachers find eTAPS to be an acceptable and practical intervention in the classroom while teaching?

METHOD

Participants and Setting

This study took place in an urban elementary school in the northeastern United States. Prior to study initiation, approval was obtained from university and district review boards. Four teachers volunteered to participate in the study and self-identified a target student from their classrooms to complete a teacher/student dyad. Consent from each teacher and student was obtained. Following excessive student absences during baseline, the fourth dyad was removed from the study. All names have been changed to protect the identities of the participants.

Dyad 1 was a second and third grade self-contained emotional support classroom, led by Ms. Shannon, a certified special educator with one year of learning support experience and 10 years of emotional support experience (see Table 1 for dyad demographic information). Jamar was an 8-year old boy in the second grade, diagnosed with an emotional and behavioral disability. Ms. Shannon reported that Jamar frequently demonstrated off-task behaviors such as not paying attention to the assigned task, arguing with other students, and wandering around the classroom. Ms. Shannon completed a Functional Analysis Screening Tool (FAST; Iwata, DeLeon, & Roscoe, 2013), which indicated Jamar's off-task behaviors as attention maintained.

Observations for dyad 1 took place during phonics/reading where students sat at their individual desks and participated in teacher led activities.

Dyad 2 was a fourth and fifth grade self-contained emotional support classroom, led by Ms. Amy, a certified special educator with one year of experience as a general educator and two years of experience in an emotional support classroom. Dylan was a 10-year old boy in the fourth grade diagnosed with an intellectual disability. Ms. Amy selected Dylan as the target student for intervention due to excessive off-task behaviors such as not completing assignments and arguing with other students. Ms. Amy completed a FAST which indicated Dylan's off-task behaviors as attention maintained. Observations for dyad 2 took place during small-group math instruction where 3-4 students sat around a table with the teacher, or during science/social studies where students sat at individual desks and participated in teacher led activities.

Dyad 3 was a third through fifth grade self-contained autistic support classroom led by Ms. Katie, a certified special educator with two years of experience as behavior specialist consultant, half a year of experience as an emotional support teacher, and three years of experience as an autistic support teacher. Nate was an 8-year old boy in the third grade diagnosed with Autism. Ms. Katie selected Nate as the target student for intervention due to his frequent off-task behavior such as "zoning out" and taking an excessive amount of time to complete academic tasks. Observations for dyad 3 took place during individual folder-work time where students sat at individual desks and independently completed daily calendar or writing activities.

Data Collection Procedures

Dependent variables. The primary dependent variable was teachers' use of BSP towards the target student. Data were collected via frequency count based on observations. BSP was defined as a positive statement intended to reinforce the desired behavior of an individual that acknowledges the individual by name (or in a manner in which he/she knows who is being praised) and specifically identifies the individual's behavior (Praising Effectively, 2017). Examples of BSP by teachers were, "Dylan, nice job waiting patiently at your seat" and "Good job focusing on your assignment, Jamar."

The secondary dependent variable was student on-task behavior. Student behaviors were measured as a percentage using momentary time sampling (Johnston & Pennypacker, 2009). *On-task behavior* was defined as: Student is participating in lesson or activity; student is focused on and/or attending to speaker or activity (Simpson, 1979).

Data recording. The first and/or third authors collected data during each session. A session was defined as a 20-minute duration where the teacher/student dyad was present and engaged in academic tasks. Teacher data were collected in several ways. First, data collectors observed each session and kept a live frequency count of BSP. Second, teachers self-recorded through eTAPS each time he or she delivered a BSP statement. Third, teachers wore an audio recording device to document as a permanent product the quantity and quality of BSP. Observed BSP, self-recorded data, and audio recordings were cross referenced following each session to ensure the accuracy and frequency of BSP.

Student behaviors were measured using momentary time sampling at 20-second intervals. Data collectors used a repeat timer app on their smartphones or Apple Watch which prompted them with a tactile cue (i.e., short vibration) to score each 20-second interval (see Appendix B for data collection form). Data collectors scored a "+" for each interval that the student was on-task and a "-" for each interval the student was off-task. The number of on-task intervals was divided by the total number of intervals to obtain a percentage of on-task behavior for the session.

Reliability and inter-observer agreement. Each session was observed by a data collector conducting a frequency count, and teacher audio recordings were captured. Those two data sets were compared to produce reliable and accurate BSP data. A separate researcher, naïve to the study, listened and recorded accurate BSP statements for at least 20% of audio recordings across each participant and phase. Time stamps of BSP statements were recorded and cross-referenced with primary data collectors' frequency of BSP statements. Agreement was recorded if both time-stamps matched within a 5-second span. Mean agreement across all phases for dyad 1 was 96% (range = 91% - 100%), dyad 2 was 97% (range = 88% - 100%), and dyad 3 was 94% (range = 86% - 100%).

Inter-observer agreement for student data was obtained by two data collectors, conducting live observations, using an interval agreement approach (Johnston & Pennypacker, 2009). To calculate an interval agreement score; Total agreements ÷ Total number of intervals x 100 = % agreement. Prior to data collection, the two data collectors trained using video simulations. Following the first video training, data collectors obtained 83% interval agreement. Upon further training and a second video simulation, data collectors obtained 100% agreement. Inter-observer agreement was collected across at least 20% of all sessions in every phase. Mean agreement across all phases for dyad 1 was 95% (range = 93% - 98%), dyad 2 was 94% (range = 87% - 100%), and dyad 3 was 90% (range 83% - 92%).

Social validity. Teachers completed a 9-item questionnaire after the study (post intervention collection) to assess the third research question; perceived acceptability and practicality of eTAPS in the classroom while teaching (see Appendix B). Teachers were emailed a link to a secure online survey platform. Questions were adapted from the modified intervention rating profile (IRP-15; Martens, Witt, Elliott, & Darveaux, 1985).

Materials

For eTAPS intervention, each teacher received an Apple Watch (series 1) with two preprogrammed apps. Teachers did not need to own an iPhone to sync with the Apple Watch as the apps were independently operated on Apple Watch. The first app was an interval timer called Periodic Timer (Kelin, 2017). The app allowed teachers to set a specific interval of time in which the watch would emit a vibratory prompt. The interval timer operated on a continuous loop. The second app was a frequency counter app called Clicker (The Iconfactory, 2017). This app allowed teachers to self-monitor how many BSP statements were delivered. Once initiated at the beginning of a session, the app would continuously operate. To record a BSP statement, the teacher would turn her wrist to look at the Apple Watch face, this would awaken the device, and the teacher would tap the watch face to record. If a mistake occurred, for example, the teacher tapped the watch face twice and accidently recorded two BSP statements, simply pressing firmly on the watch face would allow the teacher to subtract from the total count. Both apps are free to download from the iTunes store.

For audio recording, teachers received a lapel microphone and the data collector's smartphone that had a recording app called Simple Mic (Atlantic Software, 2017). Teachers clipped-on the lapel microphone and put the phone in their pocket at the beginning of each session. Following each session, teachers gave the lapel microphone and smartphone back to the data collector who then uploaded audio files to cloud storage.

Experimental Design

A single-case, multiple baseline across teacher participants, design was used to measure functional relations between independent and dependent variables (Johnston & Pennypacker, 2009). A multiple baseline design is a rigorous scientific method used to establish evidence-based practices and is relevant for defining educational practices at the individual level (Horner et al., 2005). Additionally, single-case designs are ideal for exploratory analyses of innovative technologies due to the ability of researchers to maintain internal validity while allowing for potential intervention adjustments with phase changes. According to The What Works Clearinghouse standards for single-case design (Kratochwill et al., 2010), the present study met evidence standards by satisfying the four criteria: (a) the independent variable was systematically manipulated; (b) outcome variables were measured systematically over time by more than one assessor, and inter-assessor agreement was collected for at least 20% of all sessions across all phases; (c) the study included at least three attempts to demonstrate an intervention effect at three different points in time; and (d) each phase had a minimum of five data points.

Data Analysis

Data were collected for a minimum of five data points across all phases to establish a sufficient trend for visual analysis (Horner et al., 2005). Systematic visual analysis was conducted using Lane and Gast's (2014) steps to identify with-in condition and between condition level, trend, and stability (see figure 2). Level changes were calculated by comparing means for each condition, split middle procedures determined trend, and a stability envelope criterion of 80% of data within 25% of the median (rounded to the nearest whole number) was considered stable.

In addition to visual analysis, researchers in single-case design are trending towards the inclusion of statistical analyses so that evidence-based reviews can integrate findings across multiple studies (Shadish, Hedges, Horner, & Odom, 2015). Therefore, Tau-U was used to calculate effect size and demonstrate improvement of data between phases (Parker, Vannest, Davis, & Sauber, 2011). Tau-U calculations combine four AB indices and use regressive statistics for trending data as well as a dominance-based (non-overlap) model. An online Tau-U calculator (Vannest, Parker, Gonen, & Adiguzel, 2016) was used to compute effect sizes between baseline and intervention phases. Tau-U scores can be interpreted with the following criteria: 0.65 or lower = small effect; between 0.66 and 0.92 = medium to high effect; and 0.93 to 1.0 = very high effect (Parker & Vannest, 2009; Rakap, 2015).

Procedure

Pre-baseline. One week prior to baseline data collection, teachers received Apple Watches with eTAPS preprogrammed. Teachers were instructed to wear the Apple Watches during instruction without turning them on to become comfortable wearing the device. Additionally, no information was given about eTAPS and the dependent variable (i.e., BSP). Teachers were told that the intervention would assist one of their most off-task students. The first author and teachers met individually and identified a target student participant based on the teacher's observation of off-task behavior. A FAST was conducted for dyad 1 and 2 student participants to ensure off-task/disruptive behaviors were attention maintained. The third dyad teacher participant did not have any students with excessive disruptive behaviors, however, wanted to keep her target student (Nate) on-task more.

Baseline. Other than wearing the Apple Watch and audio recording microphone, teachers were told to conduct their class per business as usual. At the start of each observation, the data collector(s) started a repeat timer to provide a prompt at 20-second intervals to record on-task student data on a momentary time sample schedule. Simultaneously, data collectors recorded frequency counts of BSP. At the end of each session, student data were converted to percentages by dividing the number of on-task intervals by the total number of intervals recorded. Audio recordings were uploaded to cloud storage and BSP statements were cross referenced with frequency counts. Participants remained in baseline until BSP data were stable based on the stability envelope criterion.

Intervention. The first teacher participant entered intervention following a stable baseline and at least five data points. The criterion for staggering the introduction of the intervention to subsequent participants was a stable baseline and after three data points of the previous teacher participant (Gast & Ledford, 2014). Prior to intervention phase with each participant, the first author trained teachers on BSP and how to use eTAPS (see Figure 3). Individual trainings were in person, lasted no more than 20-minutes, and followed an explicit instruction model (Archer & Hughes, 2011). First, the trainer modeled accurate BSP statements and how to use eTAPS. Then the teacher practiced using eTAPS to deliver BSP on an expedited schedule (e.g., 10-seconds) with feedback from the trainer. Lastly, the teacher independently demonstrated proficiency in using eTAPS and delivering BSP. Teachers were instructed to provide BSP statements to the target student contingent upon on-task behavior. If the student was not on-task at the time of a prompt, teachers were instructed to ignore the off-task behavior and use corrective procedures to remind the student of appropriate on-task behaviors.

Based on previous research recommendations of 6-10 praise statements per 15-minutes (Sutherland, Wehby, & Yoder, 2002), each teacher had a daily goal of 12 BSP statements per 20-minute session. Tactile prompting was set to deliver 12 prompts (i.e., every 90 seconds).

Teachers were instructed to self-monitor data every time BSP was delivered, whether prompted or not. The following is a description of an intervention session:

1. Teacher clips on microphone, starts audio recording app and puts smartphone in pocket.
2. Teacher puts on Apple Watch, sets repeat timer schedule based on the number of desired prompts (e.g., every 90-seconds to deliver 12 BSP statements during a 20-minute session).
3. Teacher initiates clicker app on Apple Watch to self-monitor.
4. Lesson begins. Teacher delivers BSP and self-monitors, whether prompted by Apple Watch or not.
5. At the end of the lesson, teacher turns off repeat timer and audio app. Teacher checks clicker app to see whether daily goal of BSP statements was achieved.

Tactile prompt fading. Prompts are useful in helping display new, desirable behaviors, however, new skills are only mastered if prompts are eventually removed and the desired behavior continues (MacDuff, Krantz, & McClannahan, 2001). Therefore, a delayed prompting procedure systematically faded tactile prompts by increasing the duration between the delivery of a prompt and the naturally occurring stimulus that should control the behavior (Oppenheimer, Saunders, & Spradlin, 1993). In other words, by increasing the duration between tactile prompts yet keeping the same daily goals with self-monitoring, participants needed to recognize the naturally occurring stimulus (i.e., student on-task behavior) to prompt delivery of BSP.

Delayed prompt fading was introduced following three consecutive days at mastery criterion (i.e., meeting daily goal). Three consecutive days was chosen as that amount of time allowed participants to demonstrate mastery in delivering BSP (Gelfand & Hartman, 1975; Sidman, 1960), while keeping the number of sessions short enough as not to develop prompt dependence (Cameron, Ainsleigh, & Bird, 1992). Prompt dependence is when a person only responds to prompts and not the cues that are expected to evoke the target behavior. Although MacDuff et al. (2001) acknowledge the individuality of prompt fading and suggest ongoing assessment to determine whether fading is too rapid. After the initial rate of 12 prompts per session, six prompts were removed each subsequent fading phase in order to fade as quickly as possible, yet not too quickly as to impede acquisition of BSP. Throughout intervention, and tactile prompt fading, teacher participants continued to self-monitor progress in order to meet daily goals.

Booster session. If teachers did not meet mastery criterion (i.e., three consecutive days at or above 12 BSP statements), a booster session was introduced. Each booster session involved re-conducting the initial training. In addition, the booster session was tailored to individual deficits, for example, if the teacher was not delivering accurate BSP, the booster session entailed the entire initial training while also reemphasizing the definition, examples, and practice delivering accurate BSP. If the teacher was only responding to tactile prompts during the fading phases, for example, the booster session involved the initial training while also reemphasizing the importance of self-monitoring and going back to a higher rate of BSP tactile prompts, then fading more gradually.

Maintenance. Prompt fading continued until zero tactile prompts were delivered per session. Following complete prompt fading, teachers entered maintenance phase and self-monitoring was also removed. Teachers continued to wear the Apple Watch during maintenance, however, it was not operating, as in baseline condition. Maintenance data for all three dyads began at the same time, following winter break (i.e., at least two weeks post intervention cessation). Five data points were collected for each dyad over a six-week period. A complete study timeline is presented in Appendix C.

Procedural Reliability

The first author trained all teacher participants to use eTAPS. For training procedural reliability, a training fidelity checklist, with 16 items, was completed during each training (see Figure 3). Additionally, trainings were audio recorded and a second rater listened to each training session (*n* = 3) and coded whether each item on the checklist was completed. Procedural reliability of trainings across participants was 100%. In addition, a procedural reliability checklist was used by data collectors to monitor the steps needed for themselves as well as teacher participants to successfully complete the intervention condition and ensure consistency throughout phases (figure 4). Procedural reliability was collected across every intervention condition for all sessions. Throughout the study, fidelity of implementation was 100% across all observations.

RESULTS

We sought to analyze the effects of eTAPS on teachers' use of BSP towards students demonstrating off-task behavior, any change in target student behavior, and the social validity of the intervention. Specifically, we asked three research questions: 1) What are the effects of eTAPS on teacher's use of BSP? 2) What are the effects of teachers' use of eTAPS on students' on-task behaviors? and 3) Do teachers find eTAPS to be an acceptable and practical intervention in the classroom while teaching? Results are presented in accordance with each research question using systematic visual analysis (Lane & Gast, 2014), Tau-U effect sizes (Parker et al., 2011), and descriptive statistics.

Teacher Results

Visual analysis demonstrates a functional relation between the use of eTAPS and the frequency of BSP statements by each teacher participant (see figure 5). Aggregated Tau-U results across teacher participants (see Table 2) suggest a very high effect [ES = 1.0, $p < .001$; confidence interval (90%) = .673 < > 1.0].

During baseline, Ms. Shannon demonstrated an average BSP frequency of 1.8 statements per 20-minute session. Variability was stable at 100% (i.e., 100% of data points within stability envelope) with a relative level trend of +0.5. An immediate level jump occurred, exceeding the daily goal, following the initiation of eTAPS. Throughout intervention, Ms. Shannon provided an average of 16 BSP statements per session; stability reduced to 67% with a relative level trend of -2.5. Ms. Shannon continually met daily goals, therefore, after the initial three sessions of intervention with 12 tactile prompts, the next three sessions utilized six tactile prompts, and the final three sessions of intervention had zero tactile prompts. Tau-U effect size for Ms. Shannon from baseline to through intervention was very high [ES = 1.0, $p < .002$; confidence interval (90%) = .452 < >1.0]. Maintenance resulted in an average of 14 BSP statements per session, 60% stability, and a +1.0 relative level trend.

Ms. Amy similarly had low and stable (100%) baseline levels of BSP with an average of 0.5 statements. Intervention resulted in an immediate BSP level jump with an average of 12.4 statements throughout the intervention phase. Ms. Amy initially met daily goals for three consecutive sessions following intervention introduction, however, after tactile prompts were faded to six per session, she fell below the daily goal of 12 BSP statements during session 13. Subsequently, Ms. Amy received a booster training session and the tactile prompting schedule returned to initial frequency (i.e., 12 prompts) and the participant was required to meet mastery criterion before fading. Ms. Amy received another booster session following session 20. Ms. Amy did not reach the daily goal during session 20 because she began to use general praise instead of BSP. The booster training session, therefore, focused on the definition and practice of BSP, and the tactile prompting schedule was not reset to a higher frequency. Throughout intervention, Ms. Amy's BSP stability was 64% with no relative level trend. Tau-U effect size for Ms. Amy from baseline through intervention was very high [ES = 1.0, $p < .001$; confidence interval (90%) = .570 < > 1.0]. During maintenance, the average BSP frequency was 9.4 with less stability at 40% and a relative trend of -1.5.

Ms. Katie also had low and stable (100%) BSP frequency during baseline with an average of 2.0 statements per session. The eTAPS intervention led to an immediate level jump with an average BSP frequency of 17.4 statements per session. Stability during intervention reduced to 67% with a -2.0 relative trend. Ms. Katie continually met daily goals, therefore, tactile prompting was faded every three sessions from 12 prompts, to six prompts, to zero prompts. During maintenance, Ms. Katie's average BSP frequency increased to 19.6 statements, stability was 60%, and there was a relative trend of -3.33 BSP statements. Tau-U effect size for Ms. Katie was very high [ES = 1.0, $p < .001$; confidence interval (90%) = .563 < > 1.0].

Student Results

Regarding student behavior, visual analysis demonstrates a functional relation between the use of eTAPS to increase the frequency of BSP rates towards a targeted student and the percentage of on-task behavior by that targeted student (see figure 6). Aggregated Tau-U results across student participants (see Table 2), furthermore, suggest a very strong effect [ES = .93, $p < .001$; confidence interval (90%) = .605 < > 1.0].

During baseline, Jamar was on-task 44% of the time with variable stability at 40% across baseline sessions. In addition, there was an +8% trend during baseline. An immediate level jump occurred following intervention initiation as well as increased stability (100%) and an average of 86% on-task. There was a relative level trend of +10% during intervention. Tau-U effect size for Jamar from baseline through intervention was very high [ES = 1.0, $p < .002$; confidence interval (90%) = .452 < > 1.0]. Maintenance demonstrated continued stability at 100% and elevated levels of average on-task behavior at 91%. A slight trend of -2.5% during maintenance occurred.

Dylan had low percentages of on-task behavior during baseline with an average of 55%. Stability was also low at 63% and a relative trend of -6% occurred. An immediate level jump with an average of 90%, no trend, and stability at 100% resulted during intervention. Tau-U effect size for Dylan from baseline through intervention was high [ES = .89, $p < .001$; confidence interval (90%) = .462 < > 1.0]. Intervention results continued during maintenance with an average of 98% on-task, 100% stability, and a slight relative trend at +2%.

Nate's average on-task behavior during baseline was 53%. Stability was also low at 55% and an undesirable decreasing trend of -33% occurred. The intervention resulted in an immediate level jump with an average of 86% on-task, increased stability at 89%, and a trend of -2.0%. Tau-U effect size for Nate from baseline through intervention was high [ES = .92, $p < .001$; confidence interval (90%) = .482 < > 1.0]. Intervention results were similar during maintenance for Nate with 85% average on-task behavior, less stability at 40%, and a relative trend at +5%.

Social Validity Results

After intervention (before maintenance), all teacher participants were asked to complete a 9-item Likert-scale survey to assess the acceptability and practicality of intervention. All teacher participants rated eTAPS as an acceptable and practical classroom-based intervention (see Table

3). Teachers agreed or strongly agreed that eTAPS was effective in changing their behavior (i.e., increased BSP rates), and that the intervention improved student behavior. All teacher participants strongly agreed that the intervention was good for their students and that they liked the procedures used.

DISCUSSION

The primary purpose of this study was to evaluate the effectiveness of eTAPS to increase teachers' frequency of BSP towards students demonstrating off-task behavior. Replication of effects across teacher participants suggest a strong functional relation between the eTAPS intervention and frequency of BSP. Two out of three teacher participants consistently met BSP daily goals during tactile prompt fading with self-monitoring and sustained high frequencies of BSP during maintenance. The third participant's variable results are discussed in further detail below. Findings also suggest a strong functional relation between the use of eTAPS to increase BSP and students' on-task behavior. Positive results support previous research on the efficacy of BSP to affect student outcomes (Rose & Church, 1998). High social validity ratings by teacher participants indicate that eTAPS has the qualities of an appropriate, effective, and efficient intervention.

Increasing and Maintaining BSP

We designed the eTAPS intervention as a behavior modification tool that allows users multiple opportunities to practice a behavior and overcome cognitive overload with tactile prompting, receive positive reinforcement as an artificial maintaining contingency through self-monitoring, and sustain an intervention until contact with natural maintaining contingencies (see figure 1). Positive results from this study support previous research indicating the efficacy of tactile prompting to increase BSP (e.g., Haydon & Musti-Rao, 2011; Rivera et al., 2015). Given the complexities of classroom environments and competing stimuli for teachers' attention (i.e., cognitive overload), it makes sense that a strong functional relation exists between tactile cue and behavior delivery. Research, however, has not sufficiently explored the maintenance of tactile cue interventions and limited research suggests tactile prompting alone may not be sufficient to affect sustained behavior change (Markelz et al., in press). In addition, the concern of prompt dependence led Petscher and Bailey (2006) to suggest future tactile prompting interventions gradually fade tactile prompting to avoid prompt dependence. By combining tactile prompting and self-monitoring we hypothesized that self-monitoring would provide positive reinforcement to the teacher (i.e., meeting daily goals), while fading the tactile prompt until contacting natural maintaining contingencies (i.e., improved student behavior). The successful fading of intervention and sustained elevated levels of BSP for both Ms. Shannon and Ms. Katie, and to a lesser degree Ms. Amy, during maintenance for a considerable amount of time following intervention removal (eight weeks in total), supports our hypothesis and is promising for future research with eTAPS as a behavior modification tool.

Ms. Amy was the more novice teacher (3 years of experience) and during initial intervention observations, it was apparent that she was uncomfortable delivering BSP. Her BSP statements were often repetitive (e.g., "Nice job paying attention, Dylan"), and delivered hesitantly rather than sincerely. It was not until session 17 (eight days of intervention) that Ms. Amy told a data collector that she was starting to feel more comfortable delivering praise, and that is was becoming easier for her. The duration it took Ms. Amy to feel comfortable delivering BSP, compared to the other two participants, highlights the individuality of BSP fluency and the importance of an intervention to provide sufficient practice opportunities.

Another possible contribution to Ms. Amy's variable results was a social dynamic between her and the target student, Dylan. On the second day of intervention (session 10), Dylan notice he was receiving more praise and asked, "Why do you keep doing that?" Ms. Amy responded, "Doing what?" Dylan replied, "Keep saying my name and that I'm doing a 'nice job.' Why don't you say their names too?" This interaction underscores two key factors when considering the social implications of verbal praise on older students. The first is that Dylan recognized he was being singled out from his peers. Dylan's reaction coincides with previous research suggesting teachers need to consider the awareness older students have of verbal praise (Brophy, 1981; Wehby, Symons, & Shores, 1995). As the oldest student in the study (10 years old), Dylan was not upset when praised, in fact he often said, "thank you" to Ms. Amy after receiving praise, however, this age range may be when more discreet BSP (e.g., quiet verbal praise, hand-written notes) is preferred by students.

The second key factor on the social implications of praise is to deliver it sincerely and variably. Students are aware if praise is repetitive and insincere which reduces its effectiveness (Willingham, 2006). Although our study examined teacher/student dyads, it is important for teachers to deliver BSP across all students in the classroom. Targeting the most disruptive student with BSP may be an effective intervention for that student, however, all students require positive reinforcement to maintain or increase desirable behaviors. Praising a variety of students will also increase the variability of praise and may be received as sincerer by students.

Increasing and Maintaining On-Task Behavior

All three student participants increased and maintained on-task behaviors. When considering our results, it is important to remember that BSP is not always synonymous with positive reinforcement. In fact, the function of BSP is determined by its actual effect on student behavior which can be determined by a variety of verbal/nonverbal teacher behaviors and contexts in which the interaction occurs (Brophy 1981). Teachers, therefore, must consider the function of a student's off-task behavior prior to implementing a proactive strategy, such as BSP, to increase on-task behavior. We conducted a FAST to determine that Jamar and Dylan were exhibiting attention seeking behaviors, leading us to believe BSP would serve as a positive reinforcement. Ms. Katie indicated that Nate's off-task behavior resulted from "zoning out." His quiet nature in the classroom meant that Ms. Katie would not recognize when he was off-task, therefore, during baseline, Nate often sat for several minutes without academic engagement. By using eTAPS, Ms. Katie more regularly checked in with Nate, and provided BSP or corrective procedures to increase his on-task behavior (e.g., "Nate, great job completing your first two problems, keep going, you're working hard").

Although we did not measure students' academic achievement, research supports that increasing on-task behavior promotes academic achievement (Korpershoek et al., 2016). The repetitive prompting schedule by eTAPS for teacher participants promoted opportunities for positive reinforcement towards their students in need of more intensive intervention. Our findings suggest eTAPS may not only be beneficial for students displaying attention seeking off-task behaviors, but regarding Ms. Amy and Nate, also to regularly engage students that may slip between the cracks of teacher attention. Teachers are constantly presented with competing stimuli (i.e., cognitively overloaded), yet, subtle off-task behaviors require teacher attention as well.

Social Validity

Social validity is defined as the acceptance of intervention by those who implement it or benefit from its implementation (Killu, 2008). Interventions that are viewed as demanding, ineffective, or contrary to philosophical beliefs are more likely to be implemented without integrity or abandoned entirely (Gunter & Denny, 1996). It is also important to consider technological anxieties by participants when implementing interventions that utilize technology (Brzycki, & Dudt, 2005). High social validity ratings by teacher participants suggests eTAPS was an acceptable intervention. The two apps that combined as the basis for eTAPS were preprogrammed on the Apple Watches and the watches did not require tethering to an iPhone. Teacher participants, therefore, only needed to put on the watch, start the apps, and begin their lessons. The relative ease in initiating the eTAPS intervention likely contributed to high social validity ratings. Advancements in technology are allowing tactile prompting interventions to transition from simplistic devices, such as the MotivAider, to more complex devices (i.e., smartwatches). As wearable technologies increase in popularity (Donnelly, 2018), and more complex devices are creating opportunities for researchers and teacher educators to explore multifaceted behavior modification tools, researchers must remain keenly aware of user experience and barriers to adoption that may inhibit procedural fidelity.

LIMITATIONS AND FUTURE RESEARCH

There are at least three limitations to this study that must be considered and may inform future research. First, a data collector was present in the classroom (two data collectors for IOA sessions) during each session. We cannot eliminate the possibility, therefore, that the data collector served as a discriminative stimulus for teacher participants to deliver BSP throughout intervention and during maintenance. Future research should implement a data collection procedure where the teacher is unaware when data collecting is taking place, for example, training a paraprofessional, who is always present in the room, to systematically observe and collect data.

A second limitation was that the eTAPS intervention consisted of multiple components (i.e., training, tactile prompting, and self-monitoring). Since all three components were implemented at the same time, it is difficult to determine which component contributed to treatment effects and in what quantity. To better understand treatment interventions, an add-in component analysis (Baer, Wolf, & Risley, 1968; Cooper, Heron, & Heward, 2007) would allow analyses of individual components before presenting the treatment package. By systematically presenting individual components, then in combination, researchers could identify which component is contributing to treatment effect. Ward-Horner and Sturmey (2010) concluded that add-in reversal designs provide the most comprehensive analysis of a treatment package because they reduce potential confounding from the behavioral effects of component combinations.

Finally, a third limitation was that generalization of BSP was not measured. Given known benefits of BSP, it is desirable that teachers use BSP towards all students across all settings. Not only do researchers in teacher preparation want treatment effects to maintain but also generalize. Therefore, even though eTAPS was designed to allow users to contact natural maintaining contingencies, a known strategy for promoting generalization (Stokes and Baer, 1977), future research should explicitly measure generalization data.

IMPLICATIONS

There are several implications from this study, which to our knowledge, is the first to combine tactile prompting and self-monitoring into one device as a teacher preparation tool. The major finding was the effectiveness of eTAPS to increase and maintain teachers' BSP. Teachers continue to identify student behaviors as a major challenge (Westling, 2010), therefore, it is imperative that researchers explore interventions that overcome known barriers to proactive classroom management, such as cognitive overload, insufficient training, and lack of natural maintaining contingencies. This study empirically explored the novelty of eTAPS and found tactile prompting as an operative method to overcome cognitive overload and provide multiple opportunities to practice delivering BSP. In addition, fading tactile prompts while continuing to self-monitor was an effective and efficient way to systematically remove the intervention without developing prompt dependence and allowing participants to contact natural maintaining contingencies.

When training preservice teachers, or providing in-service professional development, it is important to consider the individuality of teachers' learning curves for specific skills. As demonstrated by Ms. Amy, she required a longer duration of intervention to maintain mastery (i.e., three consecutive days above daily goal). Too often, time constrained preparation programs, or resource intensive interventions limit the practicality of extending practice opportunities. Yet, similarly with our PreK-12 students, where teachers should not move on to the next academic task until mastery of foundational skills are demonstrated, so too is it with preparing preservice teachers. Proactive classroom management is foundational to effective teaching; especially for teachers of students with emotional and behavioral disabilities. Teacher educators must account for variable durations and intensities of training for individual teachers to reach mastery. Data collection and analysis, therefore, is essential in the decision-making process about preservice teacher progress and readiness.

Positive student outcomes from this study are further evidence of the efficacy of BSP to promote desirable behaviors (e.g., Gage & MacSuga-Gage, 2017). Student disengagement and simple disruptions can consume as much as 80% of a teacher's instructional time (Simonsen et al., 2010), therefore, training and practicing proactive classroom management strategies, such as BSP, must remain a priority for teacher educators and professional development. Additionally, our teacher/student dyad results suggest that eTAPS is effective in increasing the intensity of behavioral support. If a student is not responding to class-wide or environmental behavior supports (e.g., seating arrangements, token economies), eTAPS can remind a teacher to provide more intensive levels of support, for example increases in BSP.

Teachers' proactive classroom management skills fall on a continuum from no implementation to effortless implementation. Interventions to increase proactive classroom management behaviors are worthwhile endeavors, and the end goal should be to ensure those behaviors are maintained and generalized. Moving teachers towards expertise requires the automation of classroom management skills to accommodate greater complexity in the classroom (Feldon, 2007). Many interventions, however, are personnel resource intensive. The field of teacher preparation will benefit from research that explores innovative technologies, which may reduce the need for an interventionist, and allow teachers to self-improve identified areas of deficiency. Preparing and supporting teachers in proactive classroom management will ultimately result in positive student outcomes; the gold standard for measuring teacher effectiveness.

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TABLES AND FIGURES

Table 1

Participant Demographic Information

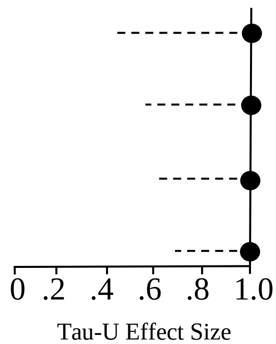
	Dyad 1	*Dyad 2*	*Dyad 3*
Teacher Characteristics	**Ms. Shannon**	**Ms. Amy**	**Ms. Katie**
Gender	Female	Female	Female
Age	36	28	26
Highest Level of Education	M.Ed. Special Education	M.Ed. Special Education	MS in ABA
Experience	LS (3 years) ES (10 years)	General Ed. (1 year) ES (2 years)	BSC (2 years) ES (.5 years) AS (3 years)
Student Characteristics	**Jamar**	**Dylan**	**Nate**
Gender	Male	Male	Male
Age	8	10	8
Grade	2nd	4th	3rd
Diagnosis	Emotional Disability	Intellectual Disability	Autism

Note. LS = Learning Support; ES = Emotional Support; M.Ed. = Master of Education; MS = Master of Science; ABA = Applied Behavior Analysis; BSC = Behaviors Specialist Consultant

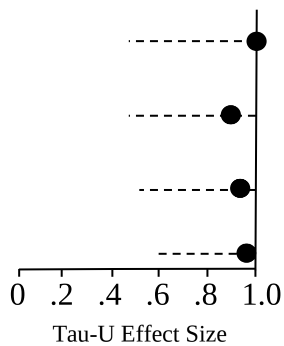
Table 2

Tau-U results with Forest Plot

Teacher	Tau-U Effect Size	Confidence Interval (90%)	Forest Plot
Shannon	1.0	.452 < >1.0	
Amy	1.0	.570 < > 1.0	
Katie	1.0	.563 < > 1.0	
Aggregated	1.0	.673 < > 1.0	



Student	Tau-U Effect Size	Confidence Interval (90%)	Forest Plot
Jamar	1.0	.452 < > 1.0	
Dylan	.89	.462 < > 1.0	
Nate	.92	.482 < > 1.0	
Aggregated	.93	.605 < > 1.0	



Note. Tau-U effect sizes 0.65 or lower = small effect; between 0.66 and 0.92 = medium to high effect; and 0.93 to 1.0 = very high effect

Table 3

Participant Responses to the Modified Intervention Rating Profile (IRP-15)

Question	Ms. Shannon	Ms. Amy	Ms. Katie	Mean
This intervention was effective in changing my behavior.	6	5	6	5.6
I would suggest the use of this intervention to other teachers.	6	5	5	5.3
I would be willing to continue to use this intervention in the classroom setting.	6	6	5	5.6
This intervention would ***not*** result in negative side effects for children.	6	4	5	5
This intervention would be appropriate for a variety of teachers.	6	6	5	5.6
This intervention improved student behavior.	5	6	6	5.6
The time and effort required to participate in this intervention is reasonable.	6	5	6	5.6
I liked the procedures used in this intervention.	6	6	6	6
Overall, this intervention was good for my students.	6	6	6	6

Note. 1 = Strongly disagree; 2 = Disagree; 3 = Somewhat disagree; 4 = Somewhat agree; 5 = Agree; 6 = Strongly agree

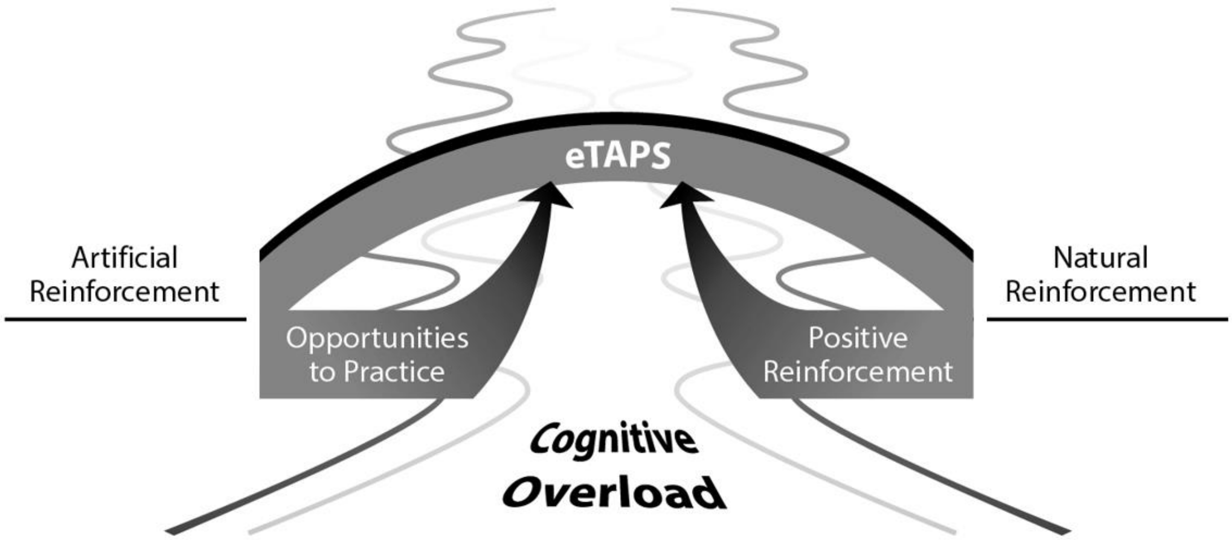


Figure 1. Visual representation of eTAPS

Within Condition Analysis of Graphed Data	Between Condition Analysis of Graphed Data
Step 1. A-B-C Notation	Step 1. Determine Number of Variables that Changed Between Conditions
Step 2. Number of Sessions by Condition	Step 2. Change in Trend Direction Between Adjacent Conditions
Step 3. Stability of Level and Range of Data by Condition	Step 3. Change in Trend Stability
Step 4a. Level Change Within Each Condition	Step 4a-d. Level Change Between Conditions
Step 4b. Absolute Level Change	Step 5a-b. Overlap of Data Between Conditions
Step 5. Estimate Trend	
Step 6. Trend Stability	
Step 7. Data Paths Within Trend	

Figure 2. Steps of visual analysis (Lane & Gast, 2014)

Training of Behavior-Specific Praise

- ☐ Inform participant on the purpose of training
- ☐ Provide definition of behavior-specific praise: ***Behavior Specific Praise*** *is a positive statement intended to reinforce the desired behavior of an individual that acknowledges the individual by name (or in a manner in which he/she knows who is being praised) and specifically identifies the individual's behavior.*
- ☐ Provide at least five examples of behavior-specific praise
- ☐ Participant delivers at least five examples of behavior-specific praise
- ☐ Provide positive and/or corrective feedback as necessary
- ☐ Training was no more than 15 minutes (trainer records time of training)

Training of eTAPS

- ☐ Introduce participant to Apple Watch
- ☐ Provide tutorial on navigating Apple Watch
  - Locating and initiating Repeat Timer app
  - Locating and initiating Clicker app
- ☐ Participant demonstrates capability set interval schedule and initiate intervention
- ☐ Participant practices delivering behavior specific praise on an expedited interval schedule (e.g., 10 seconds)
- ☐ Participant demonstrates capability of stopping intervention and checking daily progress
- ☐ Provide positive and/or corrective feedback as necessary
- ☐ Participant again demonstrates capability set interval schedule and initiate intervention for second time
- ☐ Participant practices individually delivering behavior-specific praise on an expedited schedule for second time
- ☐ Provide positive and/or corrective feedback and repeat procedures as necessary until proficiency (i.e., complete independence)
- ☐ Training was no more than 30 minutes (trainer records time of training)

Figure 3. Teacher participant training checklist

Procedural Reliability of Intervention Condition

- ☐ Teacher clips on microphone and starts audio recording app
- ☐ Teacher puts on Apple Watch, sets and initiates periodic timer
- ☐ Teacher initiates clicker app
- ☐ Data collector(s) initiates momentary time sampling audio app
- ☐ Lesson begins
- ☐ Lesson ends
- ☐ Teacher turns off periodic timer and teacher checks clicker app to see whether daily goal of BSP statements was achieved
- ☐ Data collector(s) record frequency count and PTCOS data
- ☐ Teacher sends audio file to cloud storage

Figure 4. Procedural reliability of intervention conditions

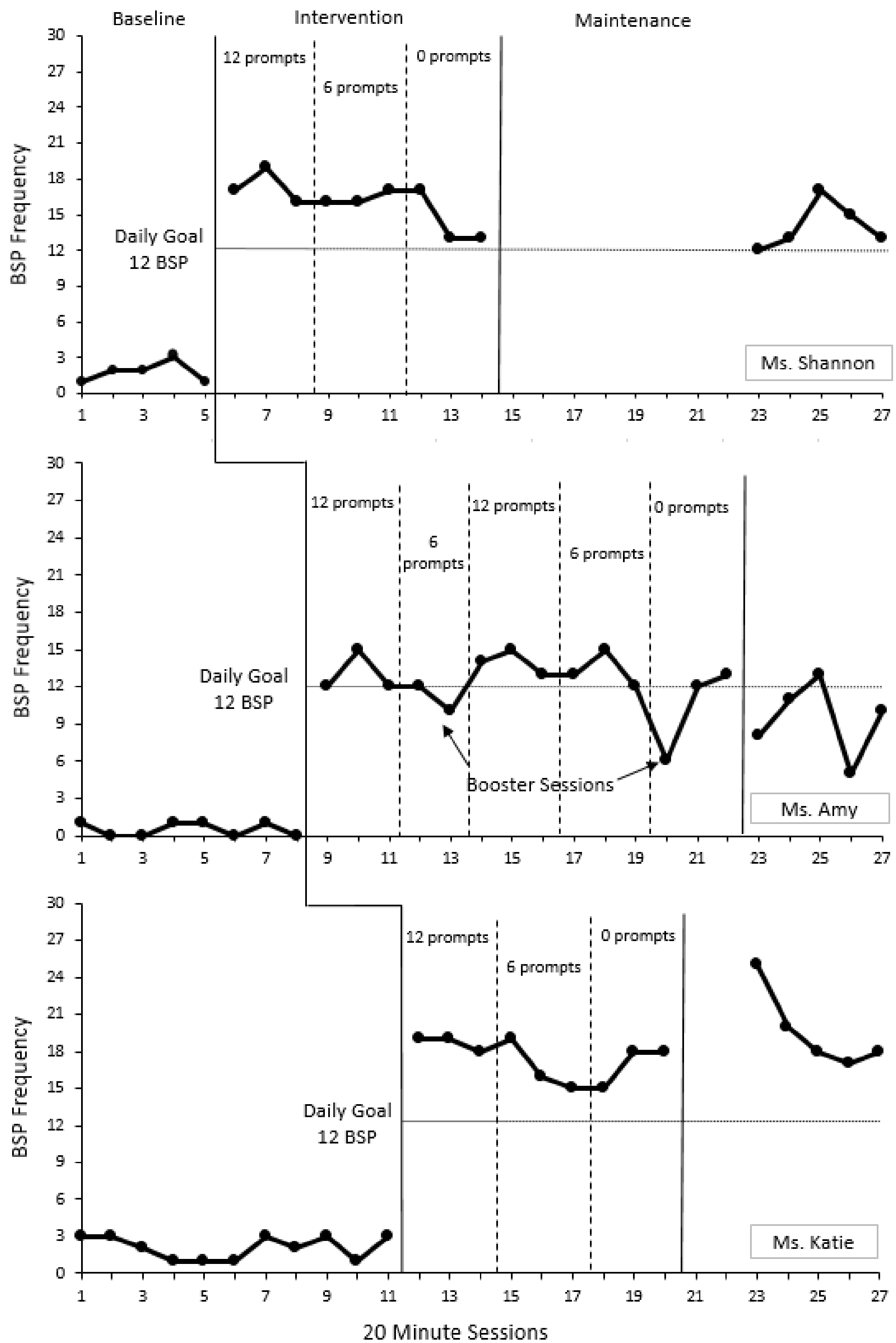


Figure 5. Frequency of behavior specific praise (BSP) statements given by teachers

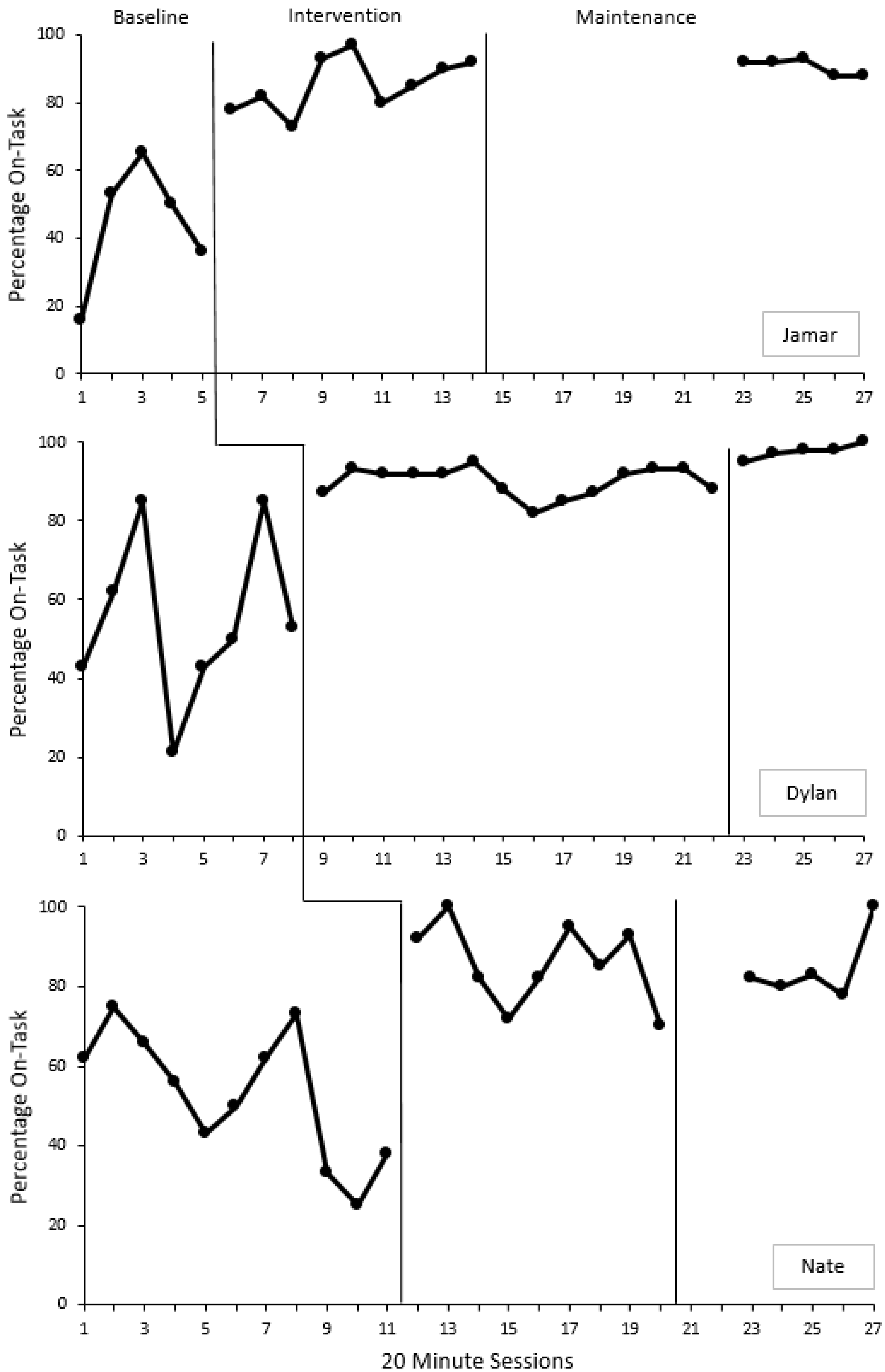


Figure 6. Percentage of on-task behavior displayed by students

APPENDIX A

Literature Review

Tactile Prompting in Teacher Education: A Literature Review

Andrew Markelz

The Pennsylvania State University

Abstract

Teacher education researchers are exploring innovative technologies to more effectively and efficiently prepare educators. Tactile prompting is when a worn device produces a vibratory signal on a time schedule prompting the user to perform a specific behavior. A literature review was conducted to explore the role of tactile prompting in teacher education. Eight studies meeting inclusion criteria were synthesized and analyzed based on how tactile prompting is used in teacher education, effects of tactile prompting, and quality of research. Findings suggest large Tau-U effect sizes and social acceptability of tactile prompting on classroom management teaching behaviors. Simplistic prompting devices reduce cost, training, and anxiety barriers to adoption, however, innovations in wearable technology may provide opportunities for a more robust behavior modification tool. Research suggests tactile prompting reduces cognitive load and provides multiple opportunities to practice, which has value in time-constrained preparation programs. Limited high-quality research calls for further exploration of this innovative technique in teacher education.

Keywords: tactile prompting, vibratory cue, teacher education, teacher training,

Tactile Prompting in Teacher Education: A Literature Review

How do teacher educators more effectively and efficiently prepare teachers to address the unique social, emotional, and academic needs of their students? This question has and will continue to invoke great debate in teacher education. Although technology in education is not a 21st century phenomenon (Ruark, 1961), exponential advancements and availability have grounded technology's role within the conversation of teacher education and propelled researchers to explore innovative possibilities.

Beyond the impact of preservice teachers' access to personal laptops, teacher education has explored a multitude of technological innovations. Content Acquisition Podcasts (CAPs; Kennedy & Thomas, 2012) combine audio recordings uploaded to the internet (i.e., podcasts) with visual supports to enact evidence-based instructional design principles. Video case studies involve learners engaging with multimedia outside of class to prepare and reflect on instructional practice (Dieker et al., 2014). Online delivery of content allows learners more control over time, place, and pace of instruction (Cavanaugh, Gilan, Kromrey, Hess, & Blomeyer, 2004). Supervision and feedback have been enhanced through eCoaching (Rock et al., 2014) and Bug-In-Ear technology (Scheeler & Lee, 2002). Finally, virtual or simulation experiences use games, avatars, and immersive simulated environments (e.g., TeachLivE) for learners to feel like, and act like they are interacting in real-world situations (Dieker et al., 2014).

In parallel with teacher education, K-12 educators have capitalized on emergent technologies for their students' benefits. One promising technology with an increasing evidence-base of efficacy for students with disabilities is tactile prompting (McDougall, Ornelles, Mersberg, & Amona, 2012). *Tactile prompting* is when a worn device produces a vibratory signal on a time schedule prompting the user to perform a specific behavior. Research shows tactile prompting positively affects K-12 students' on-task/off-task behavior (Amato-Zech, Hoff, & Doepke, 2006; Anson, Todd, & Cassaretto, 2008), social initiations (Shabani, Katz, Wilder, & Beauchamp, 2002; Taylor & Levin, 1998), and academic productivity (Farrell & McDougall, 2008; Rafferty, 2012). For example, in one study, four students with autism wore tactile prompting devices to promote self-monitoring and increase on-task behaviors (Finn, Ramasamy, Duke, & Scott, 2015). The device was programmed to provide a vibratory cue on a 2-minute interval schedule. Every time a vibratory cue was delivered the student asked himself, "What am I doing right now?" and then checked "yes" or "no" on a checklist to self-monitor his on-task behavior. Results from this study suggest substantial level jumps across participants in percentage of on-task behaviors and reduction in variability (e.g., 23.5% and decreasing during baseline to 86.15% and stable during intervention). The authors conclude that tactile prompting effectively reminded the participants to self-monitor their on-task behaviors.

The efficacy of tactile prompting is grounded in research about external aids to compensate for limitations of working memory, which restricts the processing of stimuli (Baddeley & Hitch, 1974). Working memory resources are limited to consciously thinking about a maximum of five to nine ideas or chunks of information at once (Miller, 1956). Classroom environments produce a plethora of competing stimuli. When an additional task is presented (e.g., self-monitoring) that requires remembering, the participant is likely to forget to perform the additional task due to cognitive overload (Sweller, Van Merrienboerer, & Paas, 1998). In other words, the competing cognitive demands of academic, social/emotional, and sensory stimuli are all that one can process; therefore, remembering to self-monitor is forgotten. Tactile prompting, however, requires few cognitive resources with its continual reminders via vibratory cues.

Tactile prompting is an ideal external memory aid because it bypasses the need to remember to perform the behavior.

The effectiveness of tactile prompting for students is likely to transfer to teachers, who also encounter constant streams of cognitive demands in complex and dynamic classrooms. Pedagogical skills, classroom management, and curricular content often consume most of a teacher’s cognitive resources (Swanson, O’Connor, & Cooney, 1990). As a result, teachers are often reactionary to classroom management issues rather than proactive with antecedent-based strategies (Maag, 2001), which require cognitive resources to remember to perform. For example, a student who is disrupting the class will get the teacher’s attention and likely lead to a reprimand. However, the student who is reading quietly at his desk will often go unnoticed by the teacher, particularly if the teacher is busy reacting to undesirable behaviors in the classroom. Unfortunately, in this scenario, the opportunity to praise and reinforce the student for reading on-task is missed. A tactile prompting device could help alleviate this problem by reducing the teacher’s cognitive load. For example, the tactile prompting device could cue the teacher every 3-minutes to praise students for being on-task. The repetitive reminder will ensure the teacher is delivering praise at least every three minutes. Based on the benefits of praise on student behavior (Kern & Clemens, 2007; Simonsen, Fairbanks, Briesch, Myers, & Sugai, 2008), an increase in praise rates would likely lead to an increase in on-task behaviors.

An additional benefit for teachers is that the repetitive schedule of tactile prompting provides multiple opportunities to perform targeted behaviors for extended practice. Time-constrained preparation programs may limit student-teaching experiences, and without student interactions, preservice teachers may not have the opportunity to sufficiently practice classroom management behaviors. In fact, preservice teachers and faculty members report insufficient opportunities to practice evidence-based teaching behaviors in preparation programs (Begeny & Martens, 2006; Hemmeter, Santos, & Ostrosky, 2008). Hemmeter et al. found that early childhood faculty reported lack of opportunities to implement practices in field placement and not enough room in their curriculum as reasons for preservice teachers' unpreparedness to manage challenging behaviors. Whether preservice teachers are student-teaching, or novice teachers are in the classroom, the repetitive schedule of tactile prompting will continually provide opportunities to practice teaching behaviors which may not have arisen during student-teaching, or are forgotten due to cognitive overload.

As technology continues to advance in teacher education, and given the importance of teacher quality on student achievement (Hattie, 2009), the purpose of this review was to explore the role of tactile prompting in teacher education as a strategy to increase desirable teaching behaviors. Research on this innovative technique with K-12 students suggests tactile prompting may help teachers overcome cognitive overload and provide multiple opportunities to practice effective teaching behaviors. Specifically, the following research questions were addressed to direct the search and analysis:

1. What are the characteristics of tactile prompting research in teacher education?
2. What are the effects of tactile prompting research in teacher education?
3. To what degree of quality is tactile prompting research in teacher education?

Method

Study Eligibility

Empirical articles selected for inclusion used tactile prompting to increase teaching behaviors. Specifically, included studies met the following criteria: (a) an independent variable was tactile prompting—either solely or in combination with other independent variables, (b) the dependent variable was a teaching behavior, (c) the participant(s) was/were educators, (d) the setting was in an educational environment, (e) and studies were published in either peer-reviewed journals or publicly available dissertations.

Information Sources

The review of literature consisted of searching the following databases: ProQuest Education, PsychINFO, Educational Resources Information Clearing House (ERIC), and Google Scholar. The following terms were entered in keyword fields using Boolean operators (e.g., AND/OR): “tactile prompting,” “vibratory prompting,” “teacher education,” “teacher training,” and “teacher preparation.” No search date was set. The last search was conducted in February 2017.

Search and Review Procedures

The initial search of databases resulted in 123 articles. Titles, abstracts, and methods of those articles were reviewed to identify empirical studies that matched inclusion criteria. Eight studies met inclusion criteria. Ancestral searches were conducted yielding no additional studies. Furthermore, a forward search using *The Social Science Citation Index* was used to look for articles citing included studies. Likewise, no additional studies were identified. A total of eight studies were included in this review (see Figure 1). Information from included studies was extracted from the methods and results sections and organized in a table based on: (a) participant characteristics, (b) setting, (c) design, (d) independent variable (i.e., device used for tactile prompting), (e) dependent variable(s), (f) social validity (i.e., was social validity of the intervention measured), (g) train to mastery (i.e., mastery criterion identified in study), and (h) maintenance data. Separate tables were created for Tau-U effect sizes and design standards which needed additional calculations.

Effect size tool. Single-case design studies can provide a strong basis for casual inference (Horner et al., 2005). Effect size calculations allow for easy analysis of intervention effectiveness and between-case comparisons. Tau-U was chosen a priori to calculate effect sizes and demonstrate improvement of data between phases (Parker, Vannest, Davis, & Sauber, 2011). Data points were extracted from each study using an online image capturing tool (Rohatgi, 2015). Then, numerical information was entered into an online Tau-U calculator (Vannest, Parker, Gonen, & Adiguzel, 2016). A research assistant independently calculated Tau-U scores following the same procedures for three randomly selected studies (43%) and received 100% reliability within +/- 0.05. Tau-U scores can be interpreted with the following criteria: 0.65 or lower = small effect; between 0.66 and 0.92 = medium to high effect; and 0.93 to 1.0 = very high effect (Parker & Vannest, 2009; Rakap, 2015).

Design standards. Single-case studies rely on phase repetition and effect replication to establish internal validity. Design standards allow researchers to evaluate the methodological procedures of individual studies. Design standards were evaluated based on the What Works Clearinghouse single-case designs technical documentation (Kratochwill et al., 2010). Studies were reviewed using the 'Criteria for Designs that Meet Evidence Standards' to determine those that *Meet Evidence Standards*, those that *Meet Evidence Standards with Reservations*, and those that *Do Not Meet Evidence Standards* (Kratochwill et al., 2010). Studies that meet evidence standards satisfy all four requirements: a) systematically manipulate independent variable, b) achieve at least 20% inter-assessor agreement, c) attempt at least three demonstrations of intervention effect, and d) collect minimum data points per phase (number of data points depends on study design). For this review, only participants and phases where tactile prompting was implemented within each study were considered for design standard evaluation. A research assistant independently evaluated design standards of all studies with 100% agreement.

Results

Eight studies identified for review were summarized according to the following variables: (a) participant description, (b) independent variables, (c) dependent variables, (d) effect size, (e) social validity, (f) train to mastery, (g) maintenance, and (h) design standards. Results are presented in relation to each research question. A summary of individual study results is provided in Table 1. Individual studies are referenced when specific differentiation is warranted or additional information provided.

Characteristics of Tactile Prompting Research in Teacher Education

Participant and setting description. Twenty-four participants received tactile prompting to increase teaching behaviors including general education teachers (n = 9), special education teachers (n = 2), a special education preservice teacher (n = 1), early childhood instructors (n = 3), instructional assistants (n = 5), and college students (n = 4). Participant age ranged from 18 years old to 64 years old (M = 39 years). Teaching experience of participants ranged from 0 to 10+ years (M =3.4 years). Settings of studies were conducted in elementary schools (n = 4), middle schools (n = 2), a Head Start program (n = 1), and a summer program (n = 1).

Independent variables. The tactile prompting device used in 4 studies was the MotivAider® (Behavioral Dynamics, 2010). Three of those studies used the pager-size device that clips on a participant's waist or pocket (Haydon & Musti-Rao, 2011; LaBrot, Pasqua, Dufrene, Brewer, & Goff, 2016; Thompson, Marchant, Anderson, Prater, & Gibb, 2012), while one study used the MotivAider app operated on a smartphone (Charlton, 2016). The MotivAider device and app provide vibratory prompting on a fixed/interval schedule for a single behavior. Another study used an app on smartphones for prompting as well (Rivera, Mason, Jabeen, Johnson, 2015). One study used the Gentle Reminder™ which clips to a participant's waist or pocket to provide fixed/interval vibratory prompting for a single behavior (McDonald, Reeve, & Sparacio, 2014). Another study used a remote pager that was controlled by the interventionist who delivered a vibratory prompt when he/she saw an opportunity for the participant to perform the targeted behavior (Petscher & Bailey, 2006). Lastly, one study used an Apple Watch™ worn by the participant who received text messages from the interventionist on a fixed/interval schedule (Markelz, Taylor, Scheeler, Riccomini, & McNaughton, in press). Differing from the other devices used, the Apple Watch provided a vibratory prompt in addition to a visual display on the watch screen. The vibratory cue prompted the participant to reference the watch display to determine which teaching behavior to perform because behaviors were interleaved.

Four studies used tactile prompting as the sole independent variable (Haydon & Musti-Rao, 2011; Markelz et al., in press; McDonald et al., 2014; Rivera et al., 2015). The remaining four studies used tactile prompting in combination with a variety of other independent variables including training, verbal prompts through radio communication, self-monitoring, performance feedback, student feedback, coaching, and positive reinforcement.

Dependent variables. All studies measured participant delivery of behavior specific praise (BSP) as a dependent variable. Five studies measured additional dependent variables including general praise, reprimands, active questioning, classroom scanning, token delivery, managing disruptions, and prompting appropriate behaviors. Along with participant dependent variables, three studies also measured student disruptive behaviors (Haydon & Musti-Rao, 2011), on/off-task behaviors (Rivera et al., 2015), and student stereotypic behaviors (McDonald et al., 2014).

Effects of Tactile Prompting Research in Teacher Education

Effect size. Tau-U effect sizes and confidence intervals (CIs) are presented in Table 2. Five studies indicate very high effect. Two studies show medium to high effect, and one study demonstrates a small effect. All studies are significant at the $p < .05$ level. Of the studies with tactile prompting as the single independent variable, three indicate very high effect (Haydon & Musti-Rao, 2011; Markelz et al., in press; Rivera et al., 2015) with 95% CIs [0.434, 1.0], [0.638, 1.0] and [0.71, 1.0] respectively, and the other with a medium to high effect (McDonald et al., 2014), 95% CI [0.612, 1.0].

Effect sizes of student data were also calculated to demonstrate effects of tactile prompting on student behaviors (see Table 2). Three studies that measured student data reported decreases in student disruptions; Tau-U = -1.00 with 95% CI [-1.00, -0.43] and student stereotypic behavior; Tau-U = -0.657 with 95% CI [-0.93, -0.39], and an increase in percentage of student on-task behavior; Tau-U = 0.610 with 95% CI [0.38, 0.82].

Social validity. Social validity data are important to determine the acceptability of the intervention by the participant and impact of dependent variables. Five included studies measured social validity data, however, only three addressed tactile prompting specifically (Haydon & Musti-Rao, 2011; Markelz et al., in press; Rivera et al., 2015). Participants in these studies reported that tactile prompting was unobtrusive and did not interfere with instruction. Specifically, when discussing the benefits of tactile prompting to increase BSP, the participant wrote, “it [tactile prompting] served as a small reminder to monitor my students’ responses more closely in order to tell them exactly what they did correctly so they can begin to make that behavior a habit" (Markelz et al., in press).

Maintenance. A goal of any intervention is to increase effective teaching behaviors to maintain effects over time following intervention withdrawal. Measuring maintenance data is necessary to determine lasting effects. Two studies collected maintenance data (Markelz et al., in press; Petscher & Bailey, 2006). It was challenging to attribute maintenance data results to tactile prompting in the study by Petscher and Bailey (2006) due to confounding independent variables. Markelz et al. used a multiple baseline across behaviors design and only collected maintenance data on the first behavior (BSP). Following 10 days of intervention to increase BSP, rates dropped back down to baseline levels upon removal of prompting.

Quality of Tactile Prompting Research in Teacher Education

Train to mastery. Repeated practice at high levels of performance criteria leads to skill acquisition (Blessing & Anderson, 1996). Establishing a mastery/goal criterion during intervention, therefore, allows researchers to determine whether sufficient intensity is taking place. Three studies set mastery/goal criteria for differing objectives. Thompson et al. (2016) encouraged participants to achieve BSP rates 50% greater than baseline means. Petscher and Bailey (2006) established a goal of delivering bonus points one time during a 10-minute session. The study by Markelz et al. (in press) established a mastery criterion of responding to tactile prompting with 80% accuracy (i.e., eight out of ten prompts per session) for three consecutive days.

Design standards. Based on the intervention of tactile prompting, design standards of individual studies are presented in Table 3. Three studies met evidence standards by a) systematic manipulation of the independent variable, b) at least 20% of inter-assessor agreement across all phases, c) three attempts of effect, and d) minimum number of data points per phase (Markelz et al., in press; McDonald et al., 2014; Rivera et al., 2015). Each study used tactile prompting as the sole independent variable. Two studies met standards with reservations, whereas three studies did not meet standards.

Discussion

The purpose of this review was to explore the role of tactile prompting in teacher education and evaluate the current literature. In doing so, the following research questions were addressed: 1) What are the characteristics of tactile prompting research in teacher education? 2) What are the effects of tactile prompting research in teacher education? and 3) To what degree of quality is tactile prompting research in teacher education? Study results suggest positive effects and social acceptability of tactile prompting on multiple dependent variables with a variety of tactile prompting devices. All but one study used simplistic prompting devices targeting a single teaching behavior. Findings from this review also identified a limited amount of quality research specifically analyzing effects of tactile prompting. A more thorough analysis is provided based on individual research questions.

Characteristics of Tactile Prompting Research in Teacher Education

Tactile prompting has been used with students having disabilities for nearly 20 years (Taylor & Levin, 1998), yet its use in teacher education is relatively new. The devices for tactile prompting varied and all but one performed a simplistic function (i.e., single behavior prompting). Apple Watch enabled for more complex behavior prompting with tactile prompting and visual display to alert multiple targeted behaviors. Targeting multiple teaching behaviors and providing more effective practice, such as interleaving (Brown, Roediger, & McDaniel, 2014), increases the possibility of tactile prompting to become a more comprehensive behavior modification tool, however, greater complexity in technology presents more barriers to implementation and adoption.

Technology in teacher education has several barriers including cost, lack of technical support, and technology anxiety (Brzycki & Dudt, 2005). The cost of Apple Watch ($249) is substantially more than the MotivAider ($50). The learning curve for the teacher is also greater with Apple Watch. Pairing the smartwatch and smartphone, personalizing settings, and learning operational functions may require extended training and technical support. While the MotivAider does have an application (app) for download on smartphones, the MotivAider device—which most studies utilized—is simplistic with an "on/off" switch and two additional buttons for timer setting. The simplicity of single prompting devices, such as the MotivAider, is attractive. Smartwatch technologies, however, are increasingly gaining market share (Reisinger, 2017), and it would be wise for researchers to continue exploring this budding technology.

Supported by social validity data, the ability of differing participants to execute tactile prompting across settings for a variety of dependent variables suggests an ease in implementation. Furthermore, a majority of studies used tactile prompting as a supplemental independent variable signifying the technique requires little training and is effective for increasing targeted teaching behaviors. Only one study, however, implemented tactile prompting in a preservice setting. Although differences between preservice teachers and certified teachers with regards to technology adoption may not be substantial, a preparation program's role in preparing preservice teachers add a layer of complexity to the technology adoption process. If tactile prompting is to assume a role in teacher education, then instructors/supervisors would need to be favorable and knowledgeable of the technology as well.

The barrier of technology anxiety in teacher education is undergoing seismic shifts. Prior to the inundation of technology in our lives today, both preservice teachers and teacher educators needed to overcome technology anxieties and receive support and training for successful implementation. Today, the generation of preservice teachers are increasingly familiar and comfortable navigating innovative technologies, while the current generations of teacher educators may remain tentative. Although it should not be assumed that "tech savvy" millennials will naturally adopt innovative technologies, training and support for technology adoption should focus on the hesitancies of teacher educators.

Effects of Tactile Prompting Research in Teacher Education

Medium to high effects within seven out of eight studies suggest a strong functional relation between tactile prompting and dependent variables. Notably, all studies measured BSP as a dependent variable indicating efforts among researchers to increase this evidence-based practice (Kern & Clemens, 2007) that is underutilized as a classroom management strategy (Jenkins, Floress, & Reinke, 2015). One explanation as to why BSP is targeted as a dependent variable is that tactile prompting overcomes contingencies that suppress teachers' use of BSP—namely, lack of training and cognitive overload (Markelz et al., in press).

Preservice special education and general education teachers report receiving little preparation in teaching behavioral evidence-based practices (Begeny & Martens, 2006). Complimentarily, faculty members report lack of opportunities in field placement and little room in the curriculum as reasons for preservice teachers' lack of preparation to manage students' challenging behaviors (Hemmeter et al., 2008). The simplicity and unobtrusiveness of tactile prompting allows preservice/inservice teachers to easily implement behavioral interventions that are sustainable over extended periods of time. The sustainability of tactile prompting is that it does not require a second party to operate and deliver prompts. Interval scheduling permits a teacher to individualize the intervention depending on how much practice is needed with a particular teaching behavior. Therefore, tactile prompting is a strategy that could allow a teacher to practice specific teaching behaviors for weeks, months, or longer. Although specific evidence-based classroom management teaching behaviors are not being practiced sufficiently in university coursework (Hemmeter et al., 2008), tactile prompting can be implemented in student teaching for repeated practice of deficient teaching behaviors.

At the time of this review, all measured dependent variables were teaching behaviors that can be performed quickly (e.g., token delivery, praise, classroom scanning) and all but one study operated on an interval schedule. The efficacy of tactile prompting with interval schedules requires ongoing, contingent teaching behaviors. In other words, the tactile prompt is not dependent on a specific antecedent before prompt delivery. The user of tactile prompting, therefore, must be able to respond to the prompt at any time during a lesson—or decide to ignore the prompt if it comes at an inopportune time. Whether the targeted teaching behavior is delivered by the teacher or not, the tactile prompt has brought that behavior into the working memory of the teacher which may be beneficial in itself. For example, Ms. Renee is a 3rd grade teacher who recently established a token economy, however, she continually forgets to deliver tokens for appropriate behaviors. She starts using a tactile prompting device to remind her to deliver tokens on a 5-minute schedule. During her lesson, she is alerted to a needed call from a parent. She takes the call, and while speaking with the parent, is prompted to deliver a token. She decides not to interrupt the phone conversation and, therefore, misses an opportunity to deliver a token. But, the opportunity to think about delivering a token is a chance for her to link the targeted behavior to more contexts and ideas. Ms. Renee will develop multiple links to various contexts around the prompting and delivery of tokens via repeated processing in working memory and resultant storage in long-term memory (Tulving & Thomson, 1973; Godden & Baddeley, 1975). Thus, the tactile prompting may yield more associations to token delivery in long-term memory, promoting more frequent, and eventually more automatic, delivery of tokens in the classroom.

In combination with tactile prompting, additional components of intervention, such as self-monitoring and/or performance feedback, may lead to quicker behavior acquisition and automaticity. In a review of literature on interventions to increase teachers' use of BSP, Markelz, Scheeler, Taylor, and Riccomini (in press), suggested self-monitoring and performance feedback positively reinforced teachers' behaviors leading to successful increases in BSP. Being aware of one's success is a potential reinforcer (Vargas, 2013), therefore, setting and realizing goals with tactile prompting and self-monitoring and/or performance feedback may have greater influence on behavior acquisition and automaticity by adding positive reinforcement to the intervention.

Quality of Tactile Prompting Research in Teacher Education

The quantity and quality of tactile prompting research in teacher education is limited. With only four studies measuring the effects of tactile prompting without confounding independent variables, and only three of those studies meeting criteria for evidence standards, there is a need for more rigorous research. If tactile prompting can remedy the lack of practice opportunities in preservice programs, while also assisting teachers who are cognitively overloaded, then continued research is warranted on this technique for preparing teachers.

Critical to future research on tactile prompting is mastery criteria to establish sufficient intensity of intervention. Each study included in this review sought to increase specific classroom management teaching behaviors due to positive effects of those behaviors on student outcomes. An expert teacher uses many of these effective teaching behaviors automatically, or without conscious thought (Feldon, 2007) because through repetition and history of reinforcement the behaviors are solidified in an expert teacher's repertoire. High levels of practice are integral to sufficient skill acquisition and the solidification process (Blessing & Anderson, 1996). Without mastery criteria it is difficult to determine if high levels of practice are occurring. Establishing mastery criterion 50% above baseline mean (Thompson et al., 2016) is a sufficient way to account for individual variability when increasing behavior rates but does not measure performance accuracy. Establishing an accuracy criterion, for example 80% (Markelz et al., in press), indicates whether the level of performance is too easy or too difficult. Practicing a skill at mastery criterion for a short duration of time, however, may not be sufficient to truly acquire a skill as an automatic behavior. The only way to measure longevity of skill acquisition is with maintenance data.

To date, insufficient research has been conducted on the lasting effects of tactile prompting in teacher education. Only one study included in this review measured maintenance data on one behavior within a multiple baseline across behavior design. Immediate level jumps in data across studies indicates a strong functional relation between tactile prompting and dependent variables. Although the ease and sustainability of using tactile prompting is beneficial, eventually fading prompting or practicing new behaviors is the ideal use if tactile prompting is to be considered an operative method for training teacher behavior. More research is needed to establish optimal durations of tactile prompting durations in order to acquire and maintain targeted teaching behaviors after intervention withdrawal.

Implications

This review highlights several implications for tactile prompting in teacher education. Study results support tactile prompting as successful in reminding the user to perform a predetermined behavior. Although explanations as to why the user is not performing the targeted behavior in the first place requires more nuanced analyses (e.g., insufficient training/practice, cognitive overload), tactile prompting overcomes those barriers. Therefore, tactile prompting should be considered a tool in teacher preparation to encourage practice opportunities of deficient teaching skills. To date, tactile prompting has demonstrated efficacy with classroom management behaviors. Insufficient preparation in managing challenging behaviors (Oliver & Reschly, 2010) and correlations between effective classroom management and student achievement (Jones & Jones, 2012) suggest value in targeting classroom management behaviors with tactile prompting. Future research, however, should additionally explore instructional or academic related behaviors (e.g., checking for understanding, choral response, think time, etc.) to broaden the scope of tactile prompting's utility.

Barriers to technology use such as cost, training, and adoption anxiety must be considered by preparation programs when conducting cost/benefit analyses. The MotivAider and Gentle Reminder are simplistic devices that were used by a majority of studies. Compared to emerging wearable technology (e.g., Apple Watch), simplistic devices will remain attractive to preparation programs until more specialized programs and apps are ready-made and tailored for teachers and teacher educators. Although free interval timers do exist in app stores, increased adoption anxiety and training may continue to dissuade teacher educators from exploring these options. If tactile prompting is considered a viable technique, preparation programs would benefit from professional development to increase awareness of tactile prompting and available devices.

Limitations

There are at least three limitations to the methodology used in this review. First, effect sizes and design standards were only calculated for participants and phases of studies using tactile prompting. Effect sizes and design standards presented on four out of eight studies do not reflect the totality of those studies (Charlton, 2016; Labrot et al., 2016; Petscher & Baily, 2006; Thompson et al., 2012). Secondly, effect size scores were averaged within studies with multiple participants to obtain total study effect sizes. Averaging scores eliminates the possibility to analyze inner-study variability and suppresses the specificity of individual study data. It is recommended that individual studies are referenced to obtain greater detail on specific intervention levels, variabilities, and trends. Third, confounding independent variables in four studies, and deficient design standards across studies, diminishes the ability to confidently attribute effects to tactile prompting. Emergent evidence on the benefits of tactile prompting in teacher education should be recognized yet taken with caution until a greater body of research is established.

Conclusion

Given the novelty of tactile prompting in teacher education, this review starts the conversation on its role in teacher education. Increased pressure from the public and legislators on professional readiness should propel researchers to explore innovative technologies to more effectively and efficiently prepare educators (Steinhauer, 2017). Preliminary research on tactile prompting in teacher education is promising. Coupled with advancements in wearable technology, more rigorous research is recommended to explore this innovative method of increasing effective teaching behaviors.

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TABLES AND FIGURES

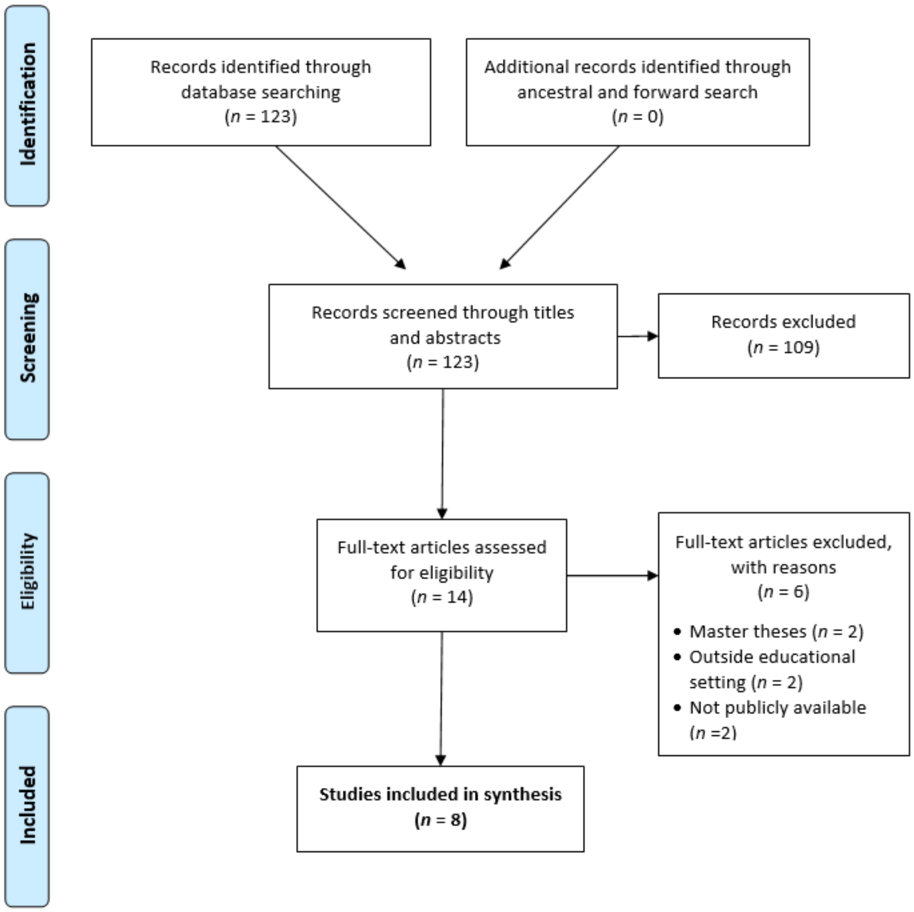

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of search procedure

Table 1

Summary of Articles

Studies	Participants	Setting	Design	Independent Variable	Dependent Variable	Social Validity	Mastery	Maintenance
Charlton (2016)	4 College students	Summer program	MB Participants	MotivAider +	BSP Gen. Praise	Yes	No	No
Haydon & Musti-Rao (2011)	2 Gen. Ed.	Middle	MB Participants	MotivAider	Reprimands BSP Gen. Praise Student: Disruptions	Yes	No	No
LaBrot et al. (2016)	3 Early childhood	Head Start	MB Participants	MotivAider +	BSP	No	No	No
Markelz et al. (in press)	1 SPED Preservice	Elementary	MB Behaviors	Apple Watch	BSP Active Questioning Classroom scanning	Yes	Yes	Yes
McDonald et al. (2014)	4 Gen. Ed.	Elementary	MB Participants	Gentle Reminder	BSP Token delivery Student: Stereotypic behavior	No	No	No
Petscher & Baily (2006)	3 Instructional assistants	Middle	MB Behaviors	Remote pager +	Managing disruptions Point delivery/BSP Prompting	No	Yes	Yes
Rivera et al. (2015)	2 SPED 2 Instructional assistants	Elementary	ABAB	Smartphone	BSP Student: On-task	Yes	No	No
Thompson et al. (2012)	3 Gen. Ed.	Elementary	MB Participants	MotivAider +	BSP	Yes	Yes	No

Note. SPED = Special Education; Gen Ed. = General Education; MB = Multiple Baseline; “+” = Additional independent variables (e.g., performance feedback); BSP = Behavior Specific Praise

Table 2

Effect Size per Study

Studies	Tau-U	Confidence Interval 95%
Charlton (2016)	0.542*	0.08 < > 1.00
Haydon & Musti-Rao (2011)	1.000*[a]	0.43 < > 1.00
Student stereotypic behavior	-1.000*	-1.00 < > -0.43
Markelz et al. (in press)	1.000*[a]	0.64 < > 1.00
LaBrot et al., (2016)	1.000*	0.16 < > 1.00
McDonald et al. (2014)	0.879*[a]	0.61 < > 1.00
Student disruptions	-0.657*	-0.93 < > -0.39
Petscher & Baily (2006)	0.985*	0.73 < > 1.00
Rivera et al. (2015)	0.942*[a]	0.71 < > 1.00
Student percentage on-task	0.610*	0.38 < > 0.82
Thompson et al. (2012)	0.692*	0.26 < > 1.00

Note. Tau-U only calculated between phases using tactile prompting. |0.65| or lower = small effect; between |0.66| and |0.92| = medium to high effect; and |0.93| to |1.0| = very high effect.

[a] Tactile prompting as sole independent variable

* Statistically significant at the $p < .05$ level

Table 3
Design Standards

Studies	IV systematically manipulated	At least 20% inter-assessor agreement	Three attempts to demonstrate effect	Minimum data points per phase	Criteria[a]
Charlton (2016)	Yes	Yes	Yes	No	Meets with reservations
Haydon & Musti-Rao (2011)	Yes	Yes	No	No	Does not meet
LaBrot et al. (2016)	Yes	Yes	No	No	Does not meet
Markelz et al. (in press)	Yes	Yes	Yes	Yes	Meets standards
McDonald et al., (2014)	Yes	Yes	Yes	Yes	Meets standards
Petscher & Baily (2006)	Yes	Yes	Yes	No	Meets with reservations
Rivera et al. (2015)	Yes	Yes	Yes	Yes	Meets standards
Thompson et al. (2012)	Yes	Yes	No	Yes	Does not meet

Note. IV = Independent variable; Studies were reviewed using the 'Criteria for Designs that Meet Evidence Standards' based on the What Works Clearinghouse single-case designs technical documentation (Kratochwill et al., 2010), to determine those that *Meet Evidence Standards*, those that *Meet Evidence Standards with Reservations*, and those that *Do Not Meet Evidence Standards*

[a] Only participants and phases with tactile prompting were evaluated for design standards

APPENDIX B

Data Collection Measures

I. Momentary Time Sampling and Frequency Count

Teacher: ____________ Observer: ____________ Date: ________

Student: ____________ Time: ______ to ______

Circle one: Baseline Intervention Maintenance

20-second MTS - On-task behavior

	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C												
D												
E												
F												

Total scored +: ______ divided by Total intervals: ______ x100 = ________%

Frequency Count - Teacher Behaviors

Target Student			Class	
BSP	Non-BSP	CF	BSP	Non-BSP
Total:	Total:	Total:	Total:	Total:

II. Social Validity Survey

Question
This intervention was effective in changing my behavior.
I would suggest the use of this intervention to other teachers.
I would be willing to continue to use this intervention in the classroom setting.
This intervention would ***not*** result in negative side effects for children.
This intervention would be appropriate for a variety of teachers.
This intervention improved student behavior.
The time and effort required to participate in this intervention is reasonable.
I liked the procedures used in this intervention.
I am comfortable with trying new technology.
Overall, this intervention was good for my students.

Note. 1 = Strongly disagree; 2 = Disagree; 3 = Somewhat disagree; 4 = Somewhat agree; 5 = Agree; 6 = Strongly agree

III. Functional Screening Assessment Tool (FAST)

Name:_______________________ Age: ___________ Date: ___________

Behavior Problem: ____

Informant: _______________________ Interviewer: _______________________

To the Interviewer: The Functional Analysis Screening Tool (FAST) is designed to identify a number of factors that may influence the occurrence of problem behaviors. It should be used only as an initial screening toll and as part of a comprehensive functional assessment or analysis of problem behavior. The FAST should be administered to several individuals who interact with the person frequently. Results should then be used as the basis for conducting direct observations in several different contexts to verify likely behavioral functions, clarify ambiguous functions, and identify other relevant factors that may not have been included in this instrument.

To the Informant: After completing the section on "Informant-Person Relationship," read each of the numbered items carefully. If a statement accurately describes the person's behavior problem, circle "Yes." If not, circle "No." If the behavior problem consists of either self-injurious behavior or "repetitive stereotyped behaviors," begin with Part I. However, if the problem consists of aggression or some other form of socially disruptive behavior , such as property destruction or tantrums, complete only Part II.

Informant-Person Relationship

Indicate your relationship to the person: _____Parent _____Teacher/Instructor _____Residential Staff _____Other

How long have you known the person? _____Years _____Months

Do you interact with the person on a daily basis? _____Yes _____No

If "Yes," how many hours per day?__________ If "No," how many hours per week? _________

In what situations do you typically observe the person? (Mark all that apply)

_____Self-care routines _____Academic skills training _____Meals _____When (s)he has nothing to do

_____Leisure activities _____Work/vocational training _____Evenings _____Other:__________________

Part I. Social Influences on Behavior

1.	The behavior usually occurs in your presence or in the presence of others	Yes	No
2.	The behavior usually occurs soon after you or others interact with him/her in some way, such as delivering an instruction or reprimand, walking away from (ignoring) the him/her, taking away a "preferred" item, requiring him/her to change activities, talking to someone else in his/her presence, etc.	Yes	No
3.	The behavior often is accompanied by other "emotional" responses, such as yelling or crying	Yes	No

Complete Part II if you answered "Yes" to item 1, 2, or 3. Skip Part II if you answered "No" to all three items in Part I.

Part II. Social Reinforcement

4.	The behavior often occurs when he/she has not received much attention	Yes	No
5.	When the behavior occurs, you or others usually respond by interacting with the him/her in some way (e.g., comforting statements, verbal correction or reprimand, response blocking, redirection)	Yes	No
6.	(S)he often engages in other annoying behaviors that produce attention	Yes	No
7.	(S)he frequently approaches you or others and/or initiates social interaction	Yes	No
8.	The behavior rarely occurs when you give him/her lots of attention	Yes	No
9.	The behavior often occurs when you take a particular item away from him/her or when you terminate a preferred leisure activity (If "Yes," identify:____________________)	Yes	No
10.	The behavior often occurs when you inform the person that (s)he cannot have a certain item or cannot engage in a particular activity. (If "Yes," identify:____________________)	Yes	No
11.	When the behavior occurs, you often respond by giving him/her a specific item, such as a favorite toy, food, or some other item. (If "Yes," identify:____________________)	Yes	No
12.	(S)he often engages in other annoying behaviors that produce access to preferred items or activities.	Yes	No
13.	The behavior rarely occurs during training activities or when you place other types of demands on him/her. (If "Yes," identify the activities: ____self-care ____academic ____work ____other)	Yes	No

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14.	The behavior often occurs during training activities or when asked to complete tasks.	Yes	No
15.	(S)he often is noncompliant during training activities or when asked to complete tasks.	Yes	No
16.	The behavior often occurs when the immediate environment is very noisy or crowed.	Yes	No
17.	When the behavior occurs, you often respond by giving him/her brief "break from an ongoing task.	Yes	No
18.	The behavior rarely occurs when you place few demands on him/her or when you leave him/her alone.	Yes	No

Part III. Nonsocial (Automatic)Reinforcement

19.	The behavior occurs frequently when (s)he is alone or unoccupied	Yes	No
20.	The behavior occurs at relatively high rates regardless of what is going on in his/her immediate surrounding environment	Yes	No
21.	(S)he seems to have few known reinforcers or rarely engages in appropriate object manipulation or "play" behavior.	Yes	No
22.	(S)he is generally unresponsive to social stimulation.	Yes	No
23.	(S)he often engages in repetitive, stereotyped behaviors such as body rocking, hand or finger waving, object twirling, mouthing, etc.	Yes	No
24.	When (s)he engages in the behavior, you and others usually respond by doing nothing (i.e., you never or rarely attend to the behavior.)	Yes	No
25.	The behavior seems to occur in cycles. During a "high" cycle, the behavior occurs frequently and is extremely difficult to interrupt. During a "low" cycle the behavior rarely occurs.	Yes	No
26.	The behavior seems to occur more often when the person is ill.	Yes	No
27.	(S)he has a history of recurrent illness (e.g., ear or sinus infections, allergies, dermatitis).	Yes	No

Scoring Summary

Circle the items answered "Yes." If you completed only Part II, also circle items 1, 2, and 3

								Likely Maintaining Variable
1	2	3	4	5	6	7	8	Social Reinforcement (attention)
1	2	3	9	10	11	12	13	Social Reinforcement (access to specific activities/items)
1	2	3	14	15	16	17	18	Social Reinforcement (escape)
19	20	21	22	23	24			Automatic Reinforcement (sensory stimulation)
19	20	24	25	26	27			Automatic Reinforcement (pain attenuation)

Comments/Notes:____

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APPENDIX C

Study Timeline

September 2017	**Date**
Present study to Erie School District committee	10/02
Identify all eligible teacher participants, send out invitation to participate	By 10/30
Obtain consent from teacher participants; deliver Apple Watch	11/10
Identify and obtain consent from student participants' parents	11/10-11/17
Conduct FASTs for student participants	By 11/17
November 2017	
Begin baseline data collection	11/20-ongoing
Intervention Week 1	11/27-12/01
Intervention Week 2	12/4-12/08
Intervention Week 3	12/11-12/15
January 2018	
Maintenance Week 1	Week of 01/08
Maintenance Week 2	Week of 01/15
Maintenance Week 3	Week of 01/22
Maintenance Week 4	Week of 01/29
Maintenance Week 5	Week of 02/01

Curriculum Vita (Abbreviated)

Andrew Markelz
amarkelz@gmail.com

EDUCATION

Ph.D.	Pennsylvania State University, University Park, PA	Aug. 2018
M.Ed.	Arcadia University, Philadelphia, PA	Jan. 2010
B.A.	Virginia Polytechnic Institute and State University, Blacksburg, VA	May 2003

TEACHING EXPERIENCE

College Teaching Experience

Instructor, SPLED 400 — Penn State
Inclusive Special Education Foundations: Law, Characteristics, Collaboration, Assessment, and Management — Fall 2016

Teacher Training Experience

Special Education Practicum Supervision — Penn State
The Pennsylvania State University - University Park, PA — 2014 - 2015
Experience with Exceptional Children (SPLED 495E)

Teacher Trainer United States Peace Corps — Republic of Kiribati
Host Country Teacher Trainer — 2004 - 2006

Public School Special Education Teaching Experience

Special Education Teacher — 2008 - 2014
Philadelphia Department of Education, PA

PUBLICATIONS

Markelz, A. M., Riden, B. S., & Rizzo, K. L. (2017). Training students with behavioral problems to recruit teacher praise. *Beyond Behavior, 27*, 37-44. https://doi.org/10.1177/1074295617723333

Markelz, A. M., Taylor, J. C., Scheeler, M. C., Riccomini, P. J., & McNaughton, D. B. (in press). Prompting with wearable technology to increase teaching behaviors of a special education preservice teacher. *Journal of the American Academy of Special Education Professionals.*

Markelz, A. M., Scheeler, M. C., Taylor, J. C., & Riccomini, P. J. (in press). A review of interventions to increase behavior specific praise. *Journal of Evidence Based Practice for Schools.*

Markelz, A. M., Riden, B. S., & Scheeler, M. C. (2017). Generalization training in special education teacher preparation: Does it exit? *Teacher Education and Special Education, 40*, 179-193. doi:10.1177/0888406417703752

Markelz, A. M., & Taylor, J. C. (2016). Effects of teacher praise on attending behaviors and academic achievement of students with emotional and behavioral disabilities. *Journal of Special Education Apprenticeship 5*(1). Retrieved from http://josea.info/index.php?page=vol5no1