A Meta-Analytic Review of Tactile-Cued Self-Monitoring Interventions Used by Students in Educational Settings

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Abstract

In this meta-analytic review, we critically evaluate procedures and outcomes from nine intervention studies in which students used tactile-cued self-monitoring in educational settings. Findings suggest that most tactile-cued self-monitoring interventions have moderate to strong effects, have emerged only recently, and have not yet achieved the evidence-based status of audio-cued and visual-cued self-monitoring. At present, tactile-cued self-monitoring is a promising practice with the potential to promote a variety of outcomes in educational settings. We also identify strengths and limitations of tactile-cued self-monitoring studies, provide recommendations for future research and practice, identify limitations of this analytic literature review, and list resources for researchers and practitioners.

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Technological advances and expanded use of electronic devices, such as personal digital assistants (PDAs) and smart phones, present opportunities and challenges for educators and learners (Earle, 2002; Obringer & Coffey, 2007; Williams & Pence, 2011). In this paper, we address how devices that emit tactile cues or vibrations present opportunities for educators to promote desirable outcomes for students. We present a meta-analytic literature review of interventions in which students with disabilities used an emerging form of self-monitoring, called tactile-cued self-monitoring (TCSM). First, however, we describe the theoretical basis for self-monitoring and other behavioral self-management (BSM) techniques, and we review BSM interventions, particularly those that use self-monitoring.

Cognitive-Behavioral Theory, Reactivity, and BSM Models and Techniques

Reactivity. BSM techniques, including self-monitoring, are based on the theory of cognitive-behavioral modification (CBM) (Meichenbaum, 1977). The CBM principle of reactivity describes how people can self-direct their own learning, as well as how people can control and manage their own behavior. The principle of reactivity posits that when people become cognitively aware of their behavior and the environment, they are better positioned to change their behavior. Cognitive processes such as awareness and self-talk, and behavioral factors, such as antecedents, observable actions, and consequences link together to produce reactive effects and behavioral changes (Kanfer & Karoly, 1972; Rachlin, 1974; Skinner, 1953).

Four-component model of BSM. In 1973, Glynn, Thomas, and Shee proposed a four-component model for what they called behavioral self-control, now called BSM. The first two components of their model, *self-assessment* plus *self-recording,* constitute *self-monitoring*. In self-assessment, individuals ask themselves - covertly via self-talk or via some type of audio, visual, or other cue – a question about their current performance, such as “Am I working quickly?” Immediately afterwards, individuals self-record their response to the self-assessed question, either covertly via self-talk or via overt actions, such as checking yes or no on a self-recording form. The third and fourth components of Glynn, Thomas, and Shee’s BSM model are *self-determination of reinforcement* (i.e., specifying for oneself the types, amounts, and schedules of reinforcement) and *self-administration of reinforcement* (i.e., delivering to oneself reinforcement contingent on performance). BSM has evolved to include additional components or techniques.

BSM techniques. During the past forty years, numerous BSM techniques have emerged. One of the earliest BSM techniques was *self-verbalization,* also called *self-talk* and *self-instruction* (Meichenbaum, 1977). Self-verbalization is a process by which students covertly talk themselves through the steps of a task while doing that task. For example, students who calculate the sum of the problem 14 + 28 might silently talk themselves through the steps, starting with, “Plus sign means add. Four plus eight equals 12. Two in the one’s column of my answer, carry the one above the ten’s place.” Educators have adapted self-verbalization or self-instruction to teach students how to perform various multi-step tasks, such as cover-copy-compare to study spelling words (Skinner, McLaughlin, & Logan, 1997).

In the 1980s, self-determination emerged as a guiding principle in the field of disabilities. Deci and Ryan (1985) defined self-determination as the process by which individuals with disabilities have “the capacity to choose and to have those choices be the determinants of one’s actions” (p. 38). Although self-determination is not a BSM component, researchers and practitioners have reported that BSM skills such as self-monitoring are necessary for *self-determination*. Researchers have developed additional BSM components, three of which are *self-evaluation, video self-modeling* (VSM), and *self-graphing*. In self-evaluation, learners judge the quality of their own performance (Grossi & Howard, 1998). One critical difference between self-monitoring and self-evaluation is when the learner uses the technique. Self-monitoring occurs while the learner performs a task, whereas self-evaluation occurs after the learner completes a task. In VSM, learners view videotaped or digitally recorded images of their selves performing, or appearing to perform, a particular task. VSM relies on self-as-model to promote learners’ existing behaviors, or to promote behaviors that are within the learner’s reach, or zone of proximal development (Dowrick, 1999; Hitchcock, Dowrick & Prater, 2003; Lonnecker, Brady, McPherson, & Hawkins, 1994). Finally, in self-graphing, after learners complete a task, they obtain immediate feedback then record their results on a graph (DiGangi, Maag, & Rutherford, 1991; McDougall & Brady, 1998).

Research and Evidence Base for BSM

The research and evidence base for BSM is plentiful, with most BSM interventions demonstrating moderate to strong impact across a wide range of learners, tasks, and settings (McDougall, Skouge, Farrell & Hoff, 2006). Moreover, BSM interventions have a long-standing record of efficacy for use with students who face academic difficulties and social challenges, as evidenced in reviews, analytic reviews, and meta-analytic reviews published in the 1970s (McLaughlin, 1976; O'Leary & Duby, 1979); the 1980s (Hughes, Ruhl, & Misra, 1989; Martin & Mithaug, 1986; Skiba & Casey, 1985); the 1990s (McDougall, 1998; Stage & Quiroz, 1997; Wolery & Schuster, 1997; Nelson, Smith, Young, & Dodd, 1991; the 2000s (Barry & Haraway, 2005; Hitchcock, Dowrick, & Prater, 2003; Lancioni & O'Reilly, 2001; McDougall, Skouge, Farrell, & Hoff, 2006; Mooney, Ryan, Uhing, Reid, & Epstein, 2005; and the 2010s (Joseph & Eveleigh, 2011; Yucesoy-Ozkan & Sonmez, 2011).

Self-Monitoring: The Most Prominent and Versatile BSM Technique

Self-monitoring has been the most frequently applied and most versatile of all BSM techniques and is considered an evidence-based technique with moderate to strong efficacy (McDougall, Skouge, Farrell & Hoff, 2006). Self-monitoring studies typically target outcomes for students with disabilities. However, investigators also have conducted self-monitoring studies with students who did not have disabilities. The vast majority of such studies have used single-case research designs with one to three students, rather than true- or quasi-experimental designs for large groups of students.

Self-monitoring alone and combined with other interventions. Numerous studies have used self-monitoring as a sole intervention component (Prater, Hogan, & Miller, 1992; Prater, Joy, Chilman, Temple, & Miller, 1991). Many more studies, however, have combined self-monitoring with other BSM or non-BSM components. Self-monitoring has been combined with self-determination of reinforcement, self-administration of reinforcement, and self-graphing (McDougall & Brady, 1998); praise, token reinforcement, and graphing (Edwards, Salent, Howard, Brougher, & McLaughlin, 1995); self-instruction and peer tutoring (Hogan & Prater, 1993); self-evaluation, self-recruitment of teacher attention, and self-recruitment of token reinforcement (Todd, Horner, & Sugai, 1999); goal setting, self-evaluation and self-reinforcement (Snyder & Bambara, 1997; Wehmeyer, Yeager, Bolding, Agran, & Hughes, 2003). Whether used alone or combined with other BSM or non-BSM components, self-monitoring tends to have moderate to strong efficacy.

Wide range of target behaviors. In self-monitoring studies, researchers have targeted a wide range of academic or non-academic outcomes for individual students. Oftentimes, these researchers have targeted variations of on-task behavior, off-task behavior, and time-on-task as the sole dependent variable (Crum, 2004; Glynn, Thomas, & Shee, 1973). Some scholars, however, have suggested that researchers target more tangible outcomes (e.g., academic productivity as in the number of answers written correctly) instead of, or concurrently with, collecting data on on-task behavior (McDougall, Skouge, Farrell & Hoff, 2006). Indeed, self-monitoring studies have targeted tangible academic outcomes such as math fluency, productivity, or accuracy (McDougall, Skouge, Farrell & Hoff, 2006; McDougall & Brady, 1998; Rock, 2005). In addition, many self-monitoring studies have targeted academically-related behaviors and socially-related behaviors, such as pre-K and kindergarten students' verbal complements during free play (Apple, Billingsley, & Schwartz, 2005); middle school students' appropriate touching, direction following, and contributions to classroom activities (Agran, Blanchard, Wehmeyer & Hughes, 2002); and organizational skills and initiating conversations (Agran, Blanchard, Wehmeyer & Hughes, 2001). Overall, across various target behaviors, settings, and participants, self-monitoring interventions have produced moderate to strong outcomes.

Rationales for Using Self-Monitoring and Other BSM Techniques

Rationales for teaching students to use self-monitoring and other BSM techniques include potential and actual benefits for students and teachers, as well as promoting inclusion of students with disabilities in general education settings (McDougall, Skouge, Farrell, & Hoff, 2006).

Benefits for students. Christie, Hiss, and Lozanoff (1984) noted that BSM "has offered the promise of a set of procedures to modify undesirable behavior without relying on external agents (such as parents, teachers, peers) to administer reinforcement and punishment contingencies" (p. 392). Rooney, Hallahan, and Lloyd (1984) indicated that BSM "encourages the child to become a more responsible agent in the education process [and] engenders initiative and independence" (p. 360). In addition, BSM reduces dependence on external agents, such as teachers and parents, for reinforcement, control, and guidance (Nelson, Smith, Young, & Dodd, 1991; Workman & Hector, 1976) and helps students "learn and behave in the absence of adult oversight" (Prater, Hogan & Miller, 1992, p. 44). BSM also helps students meet teachers' expectations to perform routinely in general education settings, including arriving punctually for class, having materials ready, completing tasks accurately, and completing homework (Clees, 1994-5). Hogan and Prater (1993) note that BSM promotes self-regulation, responsibility, and skills that students use throughout their lifetime. BSM also reduces excessive or coercive adult control (Dunlap, Dunlap, Koegel, & Koegel, 1991; Falk, Dunlap & Kern, 1996). In addition, BSM promotes active involvement and counteracts inactive learning styles, strategy deficiencies, inattentiveness, and passivity (Hallahan, Marshall, & Lloyd, 1981; Prater, Joy, Chilman, Temple, & Miller, 1991; Rooney, Hallahan, & Lloyd, 1984).

Benefits for teachers. BSM 'frees up' time for teachers to teach lessons, rather than having to manage problem behaviors (Rosenbaum & Drabman, 1979; Trammel, Schloss & Alper, 1994). BSM also requires less adult supervision compared to teacher-directed strategies (Dunlap, Dunlap, Koegel, & Koegel, 1991). Finally, BSM improves efficiency by saving teachers' time and money (Clees, 1994-5; Gardner, Clees, & Cole, 1983).

Promoting inclusion. For the following reasons, numerous authors have proposed that BSM techniques have the potential to promote inclusion of students with disabilities in general education settings (Edwards, Salent, Howard, Brougher, & McLaughlin, 1995; McDougall, Skouge, Farrell, & Hoff, 2006; McDougall, 1998; Rooney, Hallahan, & Lloyd, 1984). First, BSM techniques are adaptable and easy enough to implement (Dunlap, Dunlap, Koegel, & Koegel, 1991) such that general education teachers might implement BSM as opposed to more intrusive procedures (Hogan & Prater, 1993; Prater, Hogan, & Miller, 1992; Rooney, Hallahan, & Lloyd, 1984). Second, BSM techniques are portable across settings (Thoreson & Mahoney, 1974). Third, BSM techniques can promote maintenance and generalization of performance special education settings to general education classrooms (Falk, Dunlap & Kern, 1996; Osborne, Kiburz & Miller, 1986; Rhode, Morgan, & Young, 1983).

Conclusions Based on BSM and Self-Monitoring Research Literature

Based on findings from the BSM literature, we conclude that self-monitoring is an evidence-based BSM technique that promotes moderate to strong improvements for a range of academic and non-academic tasks. To date, audio-cued self-monitoring and visually cued self-monitoring are two, long-standing, evidence-based forms of self-monitoring. However, researchers and practitioners have expressed concerns that the audio and visual cues used in these types of self-monitoring interventions might distract people who are not using, that is, who do not need to use these explicit self-monitoring techniques (McDougall, 1998). Moreover, researchers and practitioners have posited that the overt nature of such cues might stigmatize or bother users, for example, the student who uses an audio-cued or visually cued version of self-monitoring while in the presence of classmates (Amato-Zech, Hoff, & Doepke, 2006). The covert, non-intrusive nature of TCSM might alleviate the aforementioned concerns about audio-cued and visually cued forms of self-monitoring, while retaining the efficacy of audio- and visually cued self-monitoring. Compared to numerous audio- and visually-cued self-monitoring interventions, TCSM interventions in educational settings have been "rarely used" (McDougall, Skouge, Farrell, & Hoff, 2006, p. 44). Consequently, we examined how researchers have responded to recommendations to study the impact of TCSM in educational settings.

Purposes of this Analytic Literature Review

Based on our review of the literature, particularly recommendations from prior syntheses of BSM intervention studies, the purposes of our meta-analytic review were to analyze, synthesize, and evaluate processes and outcomes of intervention studies that have investigated the use of TCSM in educational settings and to provide recommendations for researchers and practitioners. The research questions that guided our review were as follows.

1. To what extent and how have researchers investigated the use of TCSM by students in educational settings? More specifically, how have TCSM techniques been implemented (e.g., by what individuals, using what procedures, for what outcomes)?
2. How effective have TCSM techniques been in improving outcomes for individuals in educational settings?
3. To what extent have TCSM interventions been implemented with quality, as evidenced by indicators of procedural integrity and treatment fidelity?

Method

Search Process

We searched for TCSM intervention studies using *EBSCOhost* and *Google Scholar*. With *EBSCOhost,* we used the databases Academic Search Premier, ERIC, Professional Development Collection, and Psychology and Behavioral Sciences Collection. We also searched for published reviews of self-monitoring and TCSM. In addition, we inspected reference lists of TCSM articles that qualified for our review. Our initial web-based searches used the terms *tactile-cued* and *self-monitoring.* Subsequent searches combined one or both of the preceding terms with other terms, including *general education*, *special education, disabilities, emotional, behavioral, disorders, disturbance, impairment, autism, speech, hearing, visual, mental retardation, developmental disabilities, attention deficit*, and *hyperactivity*. We read and eliminated all search-generated abstracts for articles that clearly failed to qualify for this review. Then, we obtained, screened, and read full-text articles for all remaining abstracts.

Criteria for Selecting TCSM Studies

We used the following inclusion and exclusion criteria to identify studies that qualified for this analytic literature review.

1. Study participants included at least one individual.
2. Study settings included at least one educational setting. Educational settings included formal settings, such as schools and classrooms, as well as informal settings where education or training took place.
3. Dependent variables included quantitative measures of educational or related variables, such as academic engagement, performance of tasks or skills, and social behaviors. We excluded descriptive studies without quantitative measure, as well as studies that reported only qualitative measures, verbal reports, or anecdotal information. We also excluded studies that targeted only non-educational outcomes, such as physiological measures.
4. Interventions included some form of TCSM, either as the sole component of the intervention, or as one of multiple components of an intervention package.
5. Participants in the studies used a TCSM device that emitted vibrations. The device could be commercially produced, such as the MotivAider or the Watchminder, or not commercially produced.
6. The vibrations produced by the TCSM device had to serves as cues for participants to self-monitor their then-current behavior. We excluded studies in which a tactile cue served only as an initial prompt for the participant to initiate a behavior, rather than to periodically self-monitor a behavior that they performed at the time of the cues. See, for example, Blicha and Belifore (2013) in which and elementary student with ADHD used a single vibration from a Watchmider, as a prompt, to get his homework folder.
7. The design could use a true- or quasi-experimental group design, or a single-case research design. If study authors used a single-case research design, the study had to include a minimum of two phases or conditions.
8. Studies had to be published in professional journals from 1973 through 2013 inclusive. We selected 1973 because that was the year that Glynn, Thomas, and Shee (1973) published the first cued self-monitoring intervention study in an educational setting. We excluded TCSM studies published as theses or dissertations.

Framework for Organizing, Presenting, and Analyzing Information

In order to organize, present, and analyze information from TCSM studies that qualified for this analytic literature review, we adapted and revised slightly the framework used by McDougall, Skouge, Farrell, and Hoff (2006). This framework is evident in the direct link between the wording we used for (a) column headings in Tables 1 and 2, and (b) subsection headings that appear in *Findings for Descriptive Variables* and in *Findings for Intervention Efficacy, Procedural Integrity, and Outcome Variables.* We operationally defined each variable of interest, that is, each column heading in Tables 1 and 2, by constructing and using directions for how to enter information from the nine studies that qualified for this review into columns of Tables 1 and 2. These directions are available upon request to the first author. We used the following method of iterative consensus to enter and verify data entries in Tables 1 and 2.

Step 1. First and second author independently entered data.

Step 2. First and second authors compared entries and resolved discrepancies.

Step 3. Third author independently entered data.

Step 4. First and third authors compared entries and resolved discrepancies.

Next, we analyzed data entries within each column to identify patterns, commonalities, and differences across the nine qualifying studies for each of the variables of interests (column headings) that appear in Tables 1 and 2. In Table 2, consistent with standards for evaluating efficacy of interventions in studies that use single-case research designs, we used visual inspection of graphed data to evaluate experimental control of the intervention over the dependent variable. That is, we visually inspected graphed data for changes in means, changes in trends, changes in level, stability-variability, latency, and overlap (Kazdin, 1982). We also searched for author-reported effect sizes. Only two studies included any type of effect size, so we adopted the following procedures to calculate and report effect sizes in Tables 3 and 4.

Effect size indices within each study. In Table 3, we report three types of effect size indices, specifically, percentage of non-overlapping data (*PND*), percentage of data exceeding the median (*PEM*), and the Phi coefficient (ϕ). *PND* and *PEM* are simple indices that quantify change, for a dependent variable measure, based on non-overlapping data between adjacent phases in studies that use single-case research designs (Parker, Vannest, & Davis, 2011). *PND* and *PEM* values of 90% to 100%, 70% to < 90%, 50% to < 70%, and < 50%, respectively, indicate highly effective, moderately effective, mildly effective, and ineffective (Scruggs, Mastropieri, Cook, & Escobar 1986). For Phi, we calculated the square root of the quantity, chi-square, divided by *N*, where *N* equaled the total number of sessions in adjacent baseline-to-intervention phases. Thus, we first had to calculate chi-square values, which we did by using Moods median test on data from adjacent baseline and intervention phases placed into 2 x 2 contingency tables. Unless denoted by an asterisk in Table 3, we used Yates correction for continuity to adjust downward all chi-square values. That is, most studies had relatively few data points in one or more phases, which resulted in expected frequencies of less than 5 in at least one of the four cells of the 2 x 2 contingency tables. Per Cohen (1988), Phi values of 0.10, 0.30, and 0.50, respectively, suggest small, medium, and large effect sizes.

The number of effect sizes we reported for each study depended on type of research design, that is, number of adjacent phase comparisons, number of students, and number of dependent variables within a study. Our first and third authors independently calculated *PND* and *PEM* indices for each study. Then they used the method of consensus to resolve discrepancies. In some studies, graphed data appeared in published journal articles without sufficient precision to calculate *PND* and *PEM*. In those cases, we requested and obtained from authors of those studies the numerical values for each session, participant, and dependent variable.

Overall effect size index for each study. In Table 3, we also report an overall effect size for each study. A study's overall effect size equaled the weighted (by number of sessions) mean of each Phi for all adjacent baseline-to-intervention (A-B and A_1-B_1) phase comparisons in that study. See Table 4. Overall effect size excludes Phi for any adjacent intervention-to-baseline (B-A_1) phase comparisons.

Table 1
Descriptive Information for Tactile-Cued Self-Monitoring Studies

Authors, Year	Participants	Setting	Dependent Variable	Dependent Variable Measurement	Independent Variable with Type of Cue	Research Design
Amato-Zech, Hoff, & Doepke, 2006	2M, 1F Age 11 2 Spch&LI + SLD 1 Spch&LI + ED No Information	SPED Reasoning & Writing Class Elementary School No Information Midwest USA	On-Task & Off-Task Behavior	% of 15-sec partial intervals	TCSM of attention using MotivAider & self-recording form: "Yes (No), I was (not) paying attention"	ABAB
Anderson & Wheldall, 2003	2F, 1M Age 10, 12, 11 ADHD, dyspraxia & learning difficulties; PDD; mild intellec-tual & moderate lan-guage delay No Information	SPED "independent folder work" "University school for children with special learning needs" No Information No Information (Australia?)	On-Task Behaviour	% of 15 momentary time sampling obs. (10-sec. x 3 participants in sequence = 1 obs. per participant every 30 sec.)	TCSM using Watchminder (vibration & display "PAY ATTN") & self-recording booklet (check box for either on-task or off-task)	MB across participants with embedded reversal
Boswell, Knight, & Spriggs, 2013	1M Age 11 Moderate Int. Disab. Caucasian	SPED Math Middle School Rural Southern USA	- On-Task Behavior - Math Fluency	- % of 3-min momentary time sampling obs. - correct digits written per min	TCSM using MotivAider , visual cue card, self-recording form: "Am I working?" plus reinforcement for SM accuracy	ABAB
Farrell & McDougall, 2008	4M, 2F Ages 15(5), 14(1) SLD Math (4) ADHD/Tourette(1) SED, ADHD & bi-polar	Basic Math Class High School Suburban Western USA	Math Fluency - correct rate - incorrect rate - accuracy	- correct (written) digits/min - incorrect (written) digits/min - % of digits written correctly	TCSM using Motivator & VCSM of Pace w/ Goal Setting & Self-Graphing:	MB across participants with embedded range-bound changing criterion

	Caucasian				Circled problem working on @ each cue to determine if behind, on, or ahead of pace	
Legge, DeBar, & Alber-Morgan, 2010	3M Ages 11(2), 13(1) Autism(2), Cerebral Palsy(1) No Information	SPED Math No Information Rural No Information	- On-Task Behavior - Accuracy of Self-Recording	- % of 2-min momentary time sampling obs. - % of agreements between student & experimenter	TCSM using MotivAider & self-recording form: “eyes on work” “in my seat” “doing work”	MB across participants
McDougall, Morrison, & Awana, 2012 (Study 1 of 2)	1M Age 15 ADHD Portuguese	GE Algebra High School Suburban Oahu, HI, USA	Algebra Productivity	% of steps for which student wrote correct responses	TCSM of productivity using MotivAider & self-recording form: “Am I completing my bellwork?”	AB
McDougall, Morrison, & Awana, 2012 (Study 2 of 2)	1M Age 12 ED Hawaiian	SPED English Middle School Urban Oahu, HI, USA	Task Completion	# of minutes student took to write answers to all required items on word-of-day task	TCSM of productivity using MotivAider & self-recording form: “Am I working?”	AB
Moore, Anderson, Glassenbury, Lang, & Didden, 2013	3M Age between 12-13 Low average ability (2) and average ability performing below potential No information	GE Humanities (combined English Literacy and Social Studies) No information No information No information	On-Task Behavior	% of 15-sec momentary time sampling observations	TCSM using MotivAider & self-recording form: write tick for on-task, cross for off-task; plus self-graphing of ticks on cumulative graph	MB across participants with follow-up sessions three and four weeks after final session of last intervention
State & Kern, 2012	1M Age 14 Asperger’s Caucasian	- Conference Room at School - Living Room at Home No Information No Information No Information	- Inappropriate Social Interactions - Inappropriate Noises - Appropriate Social Interactions	% of 15-sec partial-intervals	TCSM using vibrating wristwatch & self-recording sheet: ‘‘Did I have appropriate inter-actions?’’ versus Video Feedback w/token reinforcement	MB across 2 settings (student-teacher dyad & student-peer dyad) with embedded ABCBC or ABC depending on design element. See Table 3 note.

Note: ADHD = attention deficit hyperactivity disorder; ED = emotional disturbance; F = female; GE = general education; hmwk. = homework; LD = learning disability; M = male; SED = severe emotional disturbance; SM = self-monitoring; SPED = special education; TCSM = tactile-cued self-monitoring; VSCM = visual-cued self-monitoring; w/ = with

Table 2

Intervention Efficacy, Procedural Integrity and Outcome Measures for Tactile-Cued Self-Monitoring Studies

Authors, Year	Intervention Efficacy	Procedural Integrity	Reliability of Dependent Variable	Maintenance Probes/Follow-Up	Generalization	Social Validity of DV Changes
Amato-Zech, Hoff, & Doepke, 2006	EC = moderate to strong ES = not reported PND = not reported PEM = not reported	IT: not measured^{--} AD: 100% for 46% of intervention sessions using 5-item checklist	On-Task: M=96% (92-100% range) IOA for 18% of total sessions Off-Task: M=81% (0-100% range) IOA No Kappa^{--}	not conducted^{--}	Moderate-mixed Probes, in math, 10-12% of sessions in each baseline & intervention phase	Subjective evalua-tion via educators' (positive) & participants' (positive) responses on Intervention Rating Profile
Anderson & Wheldall, 2003	EC = mixed ES = not reported PND = not reported PEM = not reported	IT: not measured^{--} AD: not measured^{--}	On-Task Behaviour: M = 93% IOA for 25% of data sessions "during baseline" M = 90% (79-96% range) for 25% of data sessions across all phases No Kappa^{--}	Weak-Moderate & Variable 2 probes after end of the final intervention phase Alice & Nicholas: 20 & 27 days Amanda: 27 & 34 days	not conducted^{+}	
Boswell, Knight, & Spriggs, 2013	EC = moderate to strong ES = not reported PND = not reported PEM = not reported	IT: 100% for student (11-item checklist) & EA (16-item checklist) AD: 100% for 38% of intervention	On-Task: M = 98% point-by-point agreement for 65% of sessions No Kappa^{--}	not conducted^{+}	not conducted^{+}	Subjective evaluation via EA's (positive) & participant's (moderate) ratings

		sessions using 8-item checklist	Math Fluency: 100% agreement for 100% of sessions			of adapted scale items
Farrell & McDougall, 2008	EC = moderate to strong ES = not reported PND = not reported PEM = not reported	IT: 100% for 100% of training sessions using 7-item observational checklist AD: 100% for 72% of baseline sessions, using 5-item checklist; 100% for 72% of intervention sessions using 8-item checklist	Correct Digits: 99.7% interscorer agreement for 100% of total sessions Incorrect Digits: 98.3% interscorer agreement for 100% of total sessions No Kappa--	Strong Probes 1 & 2 weeks after end of final intervention phase	not conducted--	Social comparison (strong) Subjective evaluation via students' oral responses to 16-item questionnaire (positive)
Legge, DeBar, & Alber-Morgan, 2010	EC = strong ES = not reported PND = not reported PEM = not reported	IT: not measured – AD: 100% for 21% of baseline sessions; 45% of intervention sessions.	On-Task Behavior: Means for IOA ranged from 73 – 92% for 20-25% of baseline sessions; 98-100% for 20-29% of intervention sessions No Kappa--	Strong 1 probe/week, 3 consecutive weeks, after last session of fading phase	not conducted+	Not conducted --
McDougall, Morrison, & Awana, 2012 (Study 1 of 2)	EC = cannot evaluate/AB design ES = not reported PND = 100% PEM = not reported	IT: not measured+ AD: not measured+	Algebra Productivity: 100% point-by-point agreement for 100% total sessions No Kappa--	not conducted+	not conducted;+	Subjective evaluation by participant (positive)
McDougall, Morrison, & Awana, 2012 (Study 2 of 2)	EC = cannot evaluate/AB design ES = not reported PND = 100% PEM = not reported	IT: not measured+ AD: not measured+	Task Completion (duration): 100% IOA for 100% of total sessions Kappa not relevant	not conducted+	not conducted;+	Subjective evaluation by participant (positive)
Moore, Anderson, Glassenbury, Lang, & Didden, 2013	EC = strong ES = not reported PND = not reported PEM = not reported	IT: not measured-- AD: not measured--	On-Task Behavior: M = 94% IOA for 25% of all sessions; ranges 92-98%, 92-	Strong Probes 3 & 4 weeks after end of intervention phase	not conducted+	Subjective evaluation by participants and their teachers

			100%, 94-100% for 3 participants No Kappa--			(positive)
State & Kern, 2012	EC = *not applicable ES = not reported PND = not reported PEM = not reported	IT: not measured-- AD: not measured--	- Inappropriate Social Interactions: M = 85% (59-100% range) - Inappropriate Noises: M = 91% (73-100% range) - Appropriate Social Interactions: M = 72% (59-100%) [for “30% of the sessions”] No Kappa--	not conducted+	not conducted;+	Subjective evaluation via student’s response (moderate) to School Intervention Rating Form

Note: AD = adherence to ongoing procedures by student-participants or teachers-adults during baseline, intervention, or maintenance phases; EA = educational assistant; ES = effect size (*phi, d,* or other); EC = experimental control based on visual inspection of graphed data; IOA = interobserver agreement; IT = initial training of students; M = Mean; PEM = percentage of data points exceeding median; PND = percentage of non-overlapping data; * = study did not include any direct comparison of TCSM efficacy from a baseline phase to a subsequent TCSM-only intervention phase. + = study’s authors acknowledged limitation;
-- = study’s authors did not acknowledge limitation.

Findings for Descriptive Variables

Table 1 and the following paragraphs summarize findings for descriptive variables from the nine TCSM intervention studies that qualified for this review.

Authors and Year of Publication

From 1973 through 2013, eight journal articles with a total of nine studies qualified for this analytical literature review. None of the articles were sole-authored. Three articles had two authors, four articles had three authors, and one article had five authors. Zero TCSM studies were published from 1973 though 2002. Anderson and Wheldall (2003) were first to publish a study when they investigated the impact of the Watchminder. Three years later, Amato-Zech, Hoff, and Doepke (2006) were first to publish a study using a MotivAider. The seven remaining studies were published in 2008 (n = 1), 2010 (n = 1), 2012 (n = 3), and 2013 (n = 2). Thus, five of the nine studies were published during the final two years of the 1973 – 2013 review period.

Participants

Number. The nine studies included a total of 22 participants (*range* = 1 to 6 participants). Four studies had one participant, four studies had three participants, and one study had six participants.

Gender and age. Seventeen of 22 participants (77%) were male and 5 participants (23%) were female. The 22 participants ranged in age from 10 years old to 15 years old. In order of frequency, participants' age in years included 11 (n = 7), 15 (n = 6), 12 (n = 5), 14 (n = 2), 13 (n = 1), and 12 (n = 1).

Disability status. Eight of the nine studies included one or more participants with at least one disability. The other study included students without disabilities whom the authors described as having low average and average ability. Three studies included one or more participants with multiple disabilities. Seven studies included one or more participants with a single disability. In order of magnitude (with number of participants indicated in parentheses), authors of qualifying studies reported that participants had the following disabilities: LD or SLD (6), Speech and Language Impairments or Moderate Language (4), ADHD (4), Emotional Disturbance or Serious Emotional Disturbance (3), Autism (2), Asperger's Syndrome (1), Tourette's Syndrome (1), Bi-polar (1), Moderate Intellectual Disability, mild intellectual disability (1), dyspraxia (1), Pervasive Developmental Disability, and Cerebral Palsy (1). Finally, authors of one study included the term *learning difficulties*.

Settings

Eight of the nine studies had a singular (school) setting. The one remaining study had two settings, including a conference room at school and a living room at the student's home. Authors of the *school only* studies identified the respective settings as special education classroom (n = 5), general education classroom (n =2), and basic classroom (n = 1). Classes by subject included math (n = 3 studies), as well as Algebra, English, Reasoning and Writing, Humanities (English and Social Studies combined), and independent folder work (n = 1 study each).

School level. Two studies were conducted at elementary schools, two at middle schools, and two at high schools. Authors of three studies did not indicate school level.

Community settings. Two studies occurred in suburban communities, two in rural communities, and two in an urban community. Authors of the three remaining studies did not indicate the community setting.

Region. Two studies were conducted in Hawai'i, one in Midwest USA, one in Southern USA, and one in Western USA. Authors of the four remaining studies did not identify the region.

Dependent Variables

Five of nine studies targeted multiple dependent variables and the other four studies targeted a single target behavior. Dependent variables targeted most frequently, with number of studies in parentheses, included variations of on-task, engaged, and disruptive behaviors (6), math fluency (2) homework tasks or homework completion (2), algebra productivity (1), self-recording accuracy (1), and social interactions (1). Teachers or researchers – not student-participants - selected the dependent variable in each of the nine studies.

Measurement of Dependent Variables

Researchers used various ways to measure dependent variables. Four studies used momentary time sampling and two studies utilized partial interval recording. Three studies reported percentages to measure accuracy. Two studies reported rate measures and one study reported duration. One study used percentage of agreement as a measure of a dependent variable.

Independent Variables

Seven studies used the MotivAider to produce tactile cues and two studies used a wristwatch to produce tactile cues. TCSM was the sole intervention component in five studies. Four studies combined TCSM with at least one other component, including goal setting, video-cued self-monitoring, and self-graphing (Farrell & McDougall, 2008); a visual cue card plus reinforcement for self-monitoring accuracy (Boswell, Knight, & Spriggs, 2013); self-graphing (Moore et al, 2013). State and Kern (2012) compared the impact of two multi-component interventions - TCSM plus token reinforcement versus video feedback plus token reinforcement.

Research Designs

Each of the nine TCSM studies used a single-case research design. Two studies used the ABAB, two studies used the AB, and two studies used a simple multiple baseline across participants. In the three remaining studies, the researchers embedded one or more single-case designs within a multiple baseline design. Of those three combined designs, one study embedded a reversal design, another embedded the range-bound changing criterion design, and another embedded an ABCBC and ABC design. Eight of the nine studies used designs that included one or more baseline phases adjacent to one or more TSCM phases. One study (State & Kern, 2012) used a design that did not allow us to compare a participant's performance across adjacent baseline and TCSM phases. That study was unique in that it compared the impact of two types of interventions (video feedback versus in-vivo TCSM), rather than investigating the impact of TCSM versus baseline conditions.

Findings for Intervention Efficacy, Procedural Integrity, and Outcome Variables

The following paragraphs summarize findings for intervention efficacy, procedural integrity, and outcome variables.

Intervention Efficacy

Our findings here are based on results listed in the Intervention Efficacy column of Table 2 and on effect sizes displayed in Tables 3 and 4. Findings for intervention efficacy are based on 8 of the 9 studies that qualified for this meta-analytic review. We did not evaluate efficacy for State and Kern (2012) because that study did not include any adjacent phases whereby a baseline phase immediately preceded a TCSM-only intervention phase.

Experimental control per visual inspection of graphed data. Based on visual inspection of graphed data, experimental control of the target behavior was strong in two studies, moderate-to-strong in three studies, and mixed in one study. Two other studies used the A-B design, which did not permit conclusions about experimental control of the intervention over the target behavior.

Effect size indices. Other than one *PND* index (100%) reported in each of two studies, authors did not report effect sizes of any type. Because authors reported only 2 of 34 possible *PND*s, 0 of 34 possible *PEM*s, and 0 of 34 possible Phis for the main effect of TCSM, we calculated these *PND*, *PEM*s, and Phi indices. See Tables 3 and 4.

PNDs ranged from 0% to 100% (*Md* = 95.5%). Of 34 *PND*s we calculated, (a) 18 PNDs (17 *PNDs* = 100% and 1 *PND* = 91%) indicated very effective interventions; (b) four *PNDs* indicated moderately effective interventions; (c) four *PNDs* indicated mildly effective interventions; and (d) eight *PNDs* indicated ineffective interventions. *PEMs* ranged from 0% to 100% (*Md* =100%). Of 34 *PEM*s we calculated, (a) 27 *PEMs* (26 *PEMs* = 100% and 1 *PEMs* = 93%) indicated very effective interventions; (b) four *PEMs* indicated moderately effective interventions; (c) two *PEMs* indicated mildly effective interventions; and (d) one *PEM* indicated an ineffective intervention. Phis ranged from 0.18 to 0.89 (*Md* = 0.65). Of 34 Phis we calculated, magnitude of effect sizes were large (*n* =23), medium (*n* = 5), small (*n* = 4) and near zero (*n* = 2).

Of the 34 Phis we calculated, 27 represented comparisons for *instituting TCSM*, that is, compared a student's performance from (a) an initial baseline phase versus the subsequent initial intervention phase, or (b) a return-to-baseline phase versus the subsequent phase in which researchers re-instituted the TCSM intervention. See Table 4. The remaining 7 of 34 Phis represented *removing TCSM*, that is, compared a student's performance from an initial intervention phase to the subsequent return-to-baseline phase when the TCSM was removed. For the aforementioned 27 *instituting TCSM* comparisons, Phi ranged from 0.18 to 0.89 (*Md* = 0.74), with magnitude of effect sizes being large (*n* = 22), medium (*n* = 2), and small (*n* = 3). For the aforementioned 7 *removing TCSM* comparisons, Phi ranged from 0.00 to 0.53 (*Md* = 0.32), with magnitude of effect sizes being large (*n* = 1), medium (*n* = 3), and small (*n* = 1), and zero (*n* = 2). Not surprisingly, Phis for these 7 *removing TCSM* comparisons were generally smaller than Phis for the 27 *instituting TCSM* comparisons. That is, each of the 7 Phis compared performance in studies that used an ABAB (reversal) design when the initial intervention phase was compared to the return-to-baseline phase. In studies that use an ABAB design, a student's performance might not revert to levels seen in the initial baseline, especially if the target behavior is not prone to being unlearned (Kazdin, 1982). Finally, for each of the eight studies that compared a student's performance during one or more baseline phases to one or more subsequent TCSM phases, we calculated an overall effect size. The overall weighted *Phis* for those eight studies (0.49, 0.51, 0.61, 0.64, 0.76, 0.78, 0.80, and 0.84, respectively) indicated seven studies had a large effect size and one study had a medium effect size.

Table 3

Effect Sizes - PND, PEM and Phi

Author, Year	% of Nonoverlapping Data Points (*PND*)	% of Data Points Exceeding Median (*PEM*)	Individual & Overall Phi Subsequent to Moods Median Test
Amato-Zech, Hoff, & Doepke, 2006	Jack: A-B = 100% (9/9) B-A_1 = 44% (4/9) A_1-B_1 = 100% (8/8) David: A-B = 100% (9/9) B-A_1 = 22% (2/9) A_1-B_1 = 100% (7/7) Allison A-B = 100% (10/10) B-A_1 = 60% (6/10) A_1-B_1 = 88% (7/8)	Jack: A-B = 100% (9/9) B-A_1 = 56% (5/9) A_1-B_1 = 100% (8/8) David: A-B = 100% (9/9) B-A_1 = 77% (7/9) A_1-B_1 = 100% (7/7) Allison A-B = 100% (10/10) B-A_1 = 70% (7/10) A_1-B_1 = 100% (8/8)	Jack: A-B = 0.89 B-A_1 = 0.00 A_1-B_1 = 0.87 David: A-B = 0.80 B-A_1 = 0.00 A_1-B_1 = 0.86 Allison A-B = 0.85* B-A_1 = 0.19 A_1-B_1 = 0.74 Overall = 0.84
Anderson & Wheldall, 2003	Alice:	Alice:	Alice:

	A-B = 100% (8/8) B-A_1 = 25% (2/8) A_1-B_1 = 50% (4/8) Amanda: A-B = 75% (6/8) B-A_1 = 63% (5/8) A_1-B_1 = 100% (5/5) Nicholas: A-B = 0% (0/8) B-A_1 = 13% (1/8) A_1-B_1 = 17% (1/6)	A-B = 100% (8/8) B-A_1 = 100% (8/8) A_1-B_1 = 100% (8/8) Amanda: A-B = 88% (7/8) B-A_1 = 75% (6/8) A_1-B_1 = 100% (5/5) Nicholas: A-B = 100% (8/8) B-A_1 = 100% (8/8) A_1-B_1 = 67% (4/6)	A-B = 0.63 B-A_1 = 0.53 A_1-B_1 = 0.60 Amanda: A-B = 0.73 B-A_1 = 0.41 A_1-B_1 = 0.80 Nicholas: A-B = 0.23 B-A_1 = 0.32 A_1-B_1 = 0.18 Overall = 0.51
Boswell, Knight, & Spriggs, 2013	Sam: A-B = 100% (5/5) B-A_1 = 100% (5/5) A_1-B_1 = 100% (3/3)	Sam: A-B = 100% (5/5) B-A_1 = 100% (5/5) A_1-B_1 = 100% (3/3)	Sam: A-B = 0.82 B-A_1 = 0.42 A_1-B_1 = 0.67 Overall = 0.76
Farrell & McDougall, 2008	Jeff: A- B_{1-4} = 100% (17/17) Ronnie: A- B_{1-3} = 47% (8/17) Anisa: A- B_{1-4} = 69% (9/13) Shaun:	Jeff: A- B_{1-4} = 100% (17/17) Ronnie: A- B_{1-3} = 100% (17/17) Anisa: A- B_{1-4} = 100% (13/13)	Jeff: A- B_{1-4} = 0.50 Ronnie: A- B_{1-3} = 0.37 Anisa: A- B_{1-4} = 0.75* Shaun:

	A- B_{1-3} = 86% (12/14) Peter: A- B_{1-3} = 91% (10/11)	Shaun: A- B_{1-3} = 93% (13/14) Peter: A- B_{1-3} =100% (11/11)	A- B_{1-3} = 0.77* Peter: A- B_{1-3} = 0.83* Overall = 0.64
Legge, DeBar, & Alber-Morgan, 2010	Joshua: A-B = 100% (15/15) Matt: A-B = 89% (8/9) Adam: A-B = 0% (0/3)	Joshua: A-B = 100% (15/15) Matt: A-B = 100% (9/9) Adam: A-B = 0% (0/3)	Joshua: A-B = 0.46 Matt: A-B = 0.71 Adam: A-B = 0.28 Overall = 0.49
McDougall, Morrison, & Awana, 2012 (1st of 2)	Gabriel: A-B = 100% (5/5)	Gabriel: A-B = 100% (5/5)	Gabriel: A-B = 0.78 Overall = 0.78
McDougall, Morrison, & Awana, 2012 (2nd of 2)	Kawika: A-B = 100% (5/5)	Kawika: A-B = 100% (5/5)	Kawika: A-B = 0.80 Overall = 0.80
Moore, Anderson, Glassenbury, Lang, & Didden, 2013	Abe: A-B = 100% (8/8) Ben: A-B = 100% (8/8) Chaz: A-B = 100% (5/5)	Abe: A-B = 100% (8/8) Ben: A-B = 100% (8/8) Chaz: A-B = 100% (5/5)	Abe: A-B = 0.53 Ben: A-B = 0.74 Chaz: A-B = 0.54

			Overall = 0.61
State & Kern, 2012	Not applicable	Not applicable	Not applicable

Note: Phi = square root of the quantity, chi-square divided by *N*, with Phi having been calculated with Moods median test. Unless denoted by an asterisk, we used Yates correction for continuity to adjust downward all chi-square values because most studies had relatively few data points in one or more phases, which resulted in expected frequencies of less than 5 in at least one of the four cells of the 2 x 2 contingency tables. A study's overall effect size equals the weighted (by number of sessions) mean of each effect size for all adjacent baseline-to-intervention (A-B and A_1-B_1) phase comparisons in a study. Overall effect size excludes effect sizes for any adjacent intervention-to-baseline (B-A_1) phase comparisons. We did not report any effect size indices for State and Kern (2012) because the research design had zero adjacent phase comparisons for baseline versus TCSM-only intervention. State and Kern was the only study that compared TCSM to another type of intervention. We opted not to report any effect size indices for State and Kern to maintain equivalence when interpreting values displayed here in Table 3.

Table 4
Distributions for 3 Effect Size Indices by Magnitude: Initiating TCSM Versus Removing TCSM

Magnitude Of Effect Size	Initiation TCSM: A-B, A_1-B_1 (n =27)			Removing TCSM: B-A_1 (n =7)			Total Comparisons (N = 34 each Index)		
	PND	PEM	Phi	PND	PEM	Phi	PND	PEM	Phi
Large	17	24	22	1	3	1	18	27	23
Medium	4	1	2	0	3	3	4	4	5
Small	2	1	3	2	1	1	4	2	4
Near Zero	4	1	0	4	0	2	8	1	2
Total	27	27	27	7	7	7	34	34	34

Procedural Integrity

We identified whether authors reported numerical indices for two aspects of procedural integrity, that is, adherence to initial training procedures, and treatment fidelity or adherence to ongoing intervention procedures (Mertens, 1998). Seven of nine studies did not include a numerical index to quantify adherence to initial training procedures. Both of two remaining studies included a numerical index of 100% for adherence to initial training procedures. Both of those studies utilized observational checklists. Four of nine studies included one or more numerical indices for treatment fidelity, that is, for adherence to ongoing intervention procedures. In each case, the index equaled 100% based on observations using a checklist. Frequency of use of such checklists ranged from 21% to 72% of the sessions within a particular phase of a study. Of the four studies in which authors reported indices for adherence to ongoing intervention procedures, two studies included an index for the baseline phase and an index for the intervention phase, and two studies reported an index for only the intervention phases. Authors of five of the nine studies that qualified for this review did not report an index to quantify adherence to ongoing intervention procedures.

Interobserver Agreement or Reliability Indices for Dependent Variables

Each of the nine studies included indices of interobserver (IO) agreement or inter-scorer agreement (hereafter reliability) for dependent variable measures. Means reported for reliability of each and every dependent variable measured within a particular study, exceeded 97% in four of the nine studies. Means reported for reliability of dependent variables measured within the five remaining studies were, respectively, 81% and 96%; 73% to 92% and 98% to 100%; 85%, 91%, and 72%; 93% and 79% to 96%; and 94%. Of the eight studies that could have used Kappa to adjust for chance agreement, zero studies reported Kappa.

The nine studies varied in how frequently researchers collected reliability data. In four of nine studies, authors reported having collected reliability data for 100% of all sessions, total sessions, or all baseline and intervention sessions. Another study's author reported having collected reliability data for 65% of sessions (for on-task behavior) and 100% of sessions (for math fluency). Authors of the four remaining studies reported having collected reliability data for approximately 20 % to 30% of sessions.

Maintenance Probes or Follow-Up

Five on the nine studies included no maintenance data. Investigators in the four remaining studies formally assessed maintenance of changes in participants' target behaviors. Maintenance was strong in three of those four studies and weak-to-moderate in the other study.

Generalization

Of the nine studies, only Amato-Zech, Hoff, and Doepke (2006) reported generalization data. Results for generalization in the aforementioned study were moderate and mixed.

Social Validity of Changes in Target Behaviors

Investigators in eight of nine studies reported results for social validity of improvements in participants' target behaviors by using one or both of two common methods – the subjective evaluation method or the social comparison method. Six of those eight studies employed only the subjective evaluation method, whereas the other two studies utilized both of the methods. Of the eight studies that reported results for subjective evaluation, those results were positive with very few exceptions. Participant-students were the source of the data in each of those eight studies. Four of those eight studies also used teachers or educational assistants as data sources for subjective evaluation. In the two studies that included the social comparison method, results strongly support social validity in one study and were mixed in the other study.

Discussion

In this section, we discuss findings in response to three research questions that guided our review and we critically evaluate the strengths and weaknesses of the nine TCSM studies. We also provide recommendations for researchers based on the aforementioned strengths and weaknesses and we note limitations of our review. Finally, we list BSM and TCSM resources for researchers and practitioners.

Extent and Nature of TCSM Intervention Studies (Research Question 1)

Given that Glynn, Thomas, and Shee (1973) published their seminal audio-cued self-monitoring study four decades ago, and that audio-cued and visually cued self-monitoring have achieved status as evidence-based practices, TCSM intervention studies are relative newcomers to the BSM literature. Indeed, the "oldest" TCSM intervention studies include (a) Anderson and Wheldall (2003), who were first to publish a qualifying TCSM study when they investigated the impact of the Watchminder, and (b) Amato-Zech, Hoff, and Doepke (2006), who were first to investigate the impact of TCSM using the MotivAider. Moreover, of the nine TCSM studies we reviewed, five of those studies were published very recently (2012 – 2013). Thus, TCSM seems to be gathering interest quite recently among researchers. Some researchers appear to have heeded recommendations, from authors of previous BSM reviews, to investigate use of TCSM in educational settings (McDougall, 1998; McDougall, Skouge, Farrell, & Hoff, 2006).

Researchers have started to investigate students' use of TCSM, but across a relatively limited range of ages and settings. For example, the 22 participants across the nine qualifying studies ranged in age from 10 to 15 years old. Thus, we recommend that researchers expand age range to include children in early elementary grades, as well as high schools. In addition, math and algebra (n =4 studies) constituted the only academic subjects that served as the setting in more than one study. Thus, we recommend that researchers expand the range of academic subjects in which participants apply TCSM. Finally, given the small number of TCSM studies (N = 9) conducted to date, it is not surprising that researchers have targeted dependent variables of a relatively restricted range – and that a number of these dependent variables have been investigated in only one study to date. Thus, we recommend that researchers expand the range and depth of dependent variables (target behaviors), including replication or extension studies. We also recommend that researchers attempt to increase the "self" in self-monitoring interventions, for example, by having students identify the task or behavior that they self-monitor. In each of the nine studies that we reviewed, researchers or teachers determined the target behaviors. In future studies participants could decide themselves, or with guidance from adults, which academic and non-academic behaviors shall be the target of TSCM interventions.

To date, researchers – as in prior audio-cued and visual-cued versions of self-monitoring – have investigated the impact of TCSM alone and in combination with other intervention components. Five of the nine studies in this review used TCSM as the sole intervention and four studies combined TCSM with at least one other intervention component. We recommend that researchers continue to design and investigate TCSM alone and in combination with other components, such as self-graphing. For multi-component TCSM interventions, we recommend that researchers consider using dismantling strategies (Kazdin, 1982). In such studies, researchers initiate the first intervention phase of the study using TCSM plus other intervention components. Then, they remove individual intervention components during successive phases of the intervention to determine if participants maintain or improve upon the gains they demonstrated during the first phase of the intervention. We also recommend that researchers examine the extensive literature on multi-component audio-cued and visually-cued self-monitoring, and consider combining TCSM with other intervention components that have been shown to be effective. In particular, the BSM literature suggests that self-graphing is an effective, easy to use, and malleable technique, which merits being combined with self-monitoring (McDougall, Skouge, Farrell & Hoff, 2006).

To date, no published studies have compared the efficacy of TCSM to other forms of self-monitoring, including audio-cued and visual-cued self-monitoring. Thus, we recommend that researchers consider implementing such comparative studies. We suspect, however, that differences in students' performance will be negligible. The literature to date suggests moderate to strong outcomes for most self-monitoring interventions, regardless of the type of cue. Advantages of TCSM versus other forms of self-monitoring will probably be related to benefits that can accrue given the more covert and private nature of tactile cues (Amato-Zech, Hoff, & Doepke, 2006). Finally, we recommend that researchers investigate TCSM of pace. To date, only one study has investigated students' self-monitoring of the pace at which they were performing (i.e., writing answers to math problems). Much more common in published self-monitoring studies is having students self-monitor their on-task behavior ("Am I paying attention?") or their work productivity ("Am I working?"). Self-monitoring of pace requires that students monitor their ongoing performance against a precise standard, to ascertain if they are behind pace, on pace, or ahead of pace. Self-monitoring of pace might help students who, when assigned independent practice tasks, (a) produce answers erratically rather than consistently throughout the assigned period, (b) produce too many error responses based on answering too quickly, and (c) produce errorless responses, but too few responses.

Efficacy of TCSM Studies (Research Question 2)

Most of the nine TCSM interventions that we reviewed demonstrated moderate to strong efficacy. Visual inspection of graphed data indicated that five studies demonstrated strong or moderate-to-strong experimental control. Mixed control was evident in another study and the three remaining studies used designs that did not permit us to evaluate experimental control via visual inspection of graphed data. TCSM efficacy was moderate to very strong for 22 of 34 (65%) *PND*s, 31 of 34 (91%) *PEM*s, and 28 of 34 (82%) Phis we calculated. For the following reasons, however, researchers should conduct additional studies before we can reach definitive conclusions about the overall efficacy of TCSM in educational settings. First, too few TSCM studies with rigorous single-case research designs have been published to date. Of the nine studies that we analyzed, each of which used a single-case design, only seven studies used research designs amenable to evaluating experimental control via visual inspection of graphed data. Moreover, we excluded another study (State & Kern, 2012) because it did not include adjacent phases in which baseline immediately preceded a TCSM-only phase. Second, TCSM studies, like the vast majority of studies that use single-case research designs, very infrequently include any effect size index. Third, researchers might consider using true-experimental group research designs, when appropriate, to investigate the efficacy of TCSM. In conclusion, results from TCSM interventions are promising. Efficacy of TCSM, however, has not yet achieved the evidence-based status attained by more established versions of self-monitoring, that is, audio-cued and visually-cued self-monitoring.

Quality of Implementation of TCSM Studies (Research Question 3)

Among our most interesting findings are those in response to the third major research question that guided this review: To what extent have TCSM interventions been implemented with quality, as evidenced by indicators of procedural integrity and treatment fidelity? We conclude that the quality of TCSM interventions to date has varied considerably. Moreover, our findings reflect some of the patterns reported in previous BSM reviews, in particular, McDougall, Skouge, Farrell, and Hoff (2006), and McDougall (1998). In the following section, we evaluate how researchers did and did not attend to elements summarized in Table 2.

As displayed in column 2 of Table 2, we evaluated two aspects of procedural integrity. The first aspect was initial training (IT) of TCSM, which typically occurred between the last session of the baseline phase and the first session of the intervention phase. The second aspect was adherence (AD) to ongoing procedures by student-participants or teachers-adults during baseline, intervention, or maintenance phases. Authors of only two of the nine qualifying studies reported data to evaluate the integrity of initial training procedures. In the seven remaining studies, authors of only two studies noted, as a limitation of their study, their failure to collect data on integrity of initial training procedures. Findings were more favorable for adherence to ongoing procedures, at least for intervention phases of the studies. Four of eight studies reported data to evaluate adherence to ongoing procedures. In the five remaining studies, authors of two studies noted, as a limitation of their study, not collecting data on adherence to ongoing procedures. Interestingly, even in the four studies where authors collected data on the integrity of ongoing procedures, they tended to collect such data during intervention and maintenance phases, but only two studies reported such data for baseline phases. Thus, most researchers did not collect data that would enable them to evaluate the extent to which baseline protocols were or were not followed. Overall, we recommend that researchers collect data to evaluate the integrity of initial TCSM training, as well as the ongoing procedures for each phase of a study, including baseline and intervention phases. Without such data about procedural integrity, we believe that researchers cannot conclude credibly that interventions are responsible for outcomes.

In contrast to infrequent data collection for the two aforementioned aspects of procedural integrity, authors of the nine TCSM studies routinely collected and reported data on the reliability of measurement for dependent variables. Nonetheless, room for improvement remains. The majority of the studies used observational recording systems and reported traditional indices for interobserver agreement. Those traditional indices suggested that reliability was strong in nearly all of the studies. However, of the eight studies that could have used Kappa to adjust for chance agreements, none did so. Thus, we recommend that researchers who use traditional indices to report interobserver agreement also report Kappa.

Findings for maintenance and generalization provide further guidance for future research. Four of the nine qualifying studies reported outcomes for maintenance of target behaviors and only one of nine studies reported outcomes for generalization. Of the five studies that did not report outcomes for maintenance, authors of four studies acknowledged lack of maintenance data as a limitation. Of the eight studies that did not report outcomes for generalization, authors of seven studies acknowledged that limitation. In conclusion, we recommend that researchers consistently collect and report data on maintenance and generalization. Given that cued self-monitoring interventions lend easily to fading procedures (i.e., reducing the frequency of cues, or increasing the time that elapses between cues), we are somewhat surprised by the lack of maintenance phases, fading procedures, or maintenance probes in the studies that we reviewed. The research literature, however, suggests that one reason why researchers fail to address maintenance is that they begin their studies too late in the school year (McDougall, Skouge, Farrell, & Hoff, 2006). Indeed, as authors noted explicitly in one of the studies that we reviewed, the school year ended before they could collect maintenance data.

Finally, findings about social validity suggest that, with one exception, authors of the nine TCSM studies collected data that enabled them to evaluate the social validity of improvements in participants' target behaviors. This suggests that authors are well on their way to establishing, as a routine or minimal expectation, the practice of evaluating social validity. However, findings also indicate that researchers underutilized the social comparison method. Only two of the nine TCSM studies in our review reported social comparison data. This finding is consistent with findings from other research syntheses, which reported that the social comparison method appears to be underutilized (McDougall, Skouge, Farrell, & Hoff, 2006; Pierce, Reid, & Epstein, 2004). Moreover, consistent with research syntheses of single-case intervention studies, we found that authors almost universally reported positive results when they used the subjective evaluation method to evaluate social validity. It is possible that subjective evaluation procedures tend to elicit positive responses. The wording of items, nature of relationships between who asks and who answers subjective evaluation questions, and social desirability of positive responses could bias results in a favorable direction. Consequently, we recommend that authors increase use of the social comparison method when evaluating social validity. Obtaining such data could provide a more comprehensive picture of the social validity of changes in participants' target behaviors.

One additional finding emerged when we inspected the graphed data from the qualifying studies. Most authors adhered to graphing conventions. However, we noted some error patterns. Some authors connected data points from non-consecutive sessions within a phase. Some graphs appeared with session numbers misaligned to tic marks on the x-axis. At least one graph mislabeled the y-axis by indicating percentage of observation intervals rather than percentage of momentary time sampling observations. Finally, a number of graphs appeared with the zero value for the y-axis appearing on, rather than slightly above, the x-axis.

In conclusion, compared to earlier BSM studies, TCSM researchers have improved upon the procedural integrity and quality indicators listed as column headings in Table 2. However, further improvements are needed. In our current review, for the 33 limitations that we identified and reported in Table 2, authors of those studies explicitly noted 15 (45%) of those limitations and failed to note 18 (55%) of those limitations. This represents a marked improvement in authors' self-acknowledged study limitations based on a finding from an earlier BSM analytic literature review conducted by McDougall, Skouge, Farrell, and Hoff (2006): "We found that for each author-reported weakness … authors failed to report five other weaknesses … Thus, we recommend that researchers be vigilant and identify explicitly, in a limitations section, the methodological and procedural weaknesses of their studies" (p. 46).

Limitations of Our Meta-Analytic Review of TCSM Intervention Studies

Three limitations of our meta-analytic review are as follows. First, we did not evaluate reliability of data entries into the cells of Tables 1 and 2. Instead, we used a method of iterative consensus as we describe in the Methods section. Second, we did not report findings about how much time participants in each study expended while performing the target behavior. Doing so would have allowed us to evaluate the extent to which authors of the nine studies followed guidelines for effective use of cued self-monitoring. The BSM literature suggests that when students learn to self-monitor, they should do so for relatively brief periods of time such as a few minutes rather than for hours or the entire school day (McDougall, 2002). Third, we did not report findings to evaluate the economic cost and the effort expended by teachers, students, and researchers. The extent to which practitioners adopt interventions might depend on such factors.

BSM Resources for Practitioners

Many resources are available for practitioners, including articles on how-to-teach BSM (Alberto & Sharpton, 1987; Daly & Ranalli, 2003; Dunlap, Dunlap, Koegel, & Koegel, 1991; Frith & Armstrong, 1986; Gunter, Miller, Venn, Thomas, & House, 2002; Hughes, Ruhl, & Peterson, 1988; Johnson & Johnson, 1999; Lee, Palmer, & Wehmeyer, 2009; Liberty & Paeth, 1990; McConnell, 1999; Schloss, 1987; Young, West, Li, & Peterson 1997). Additional resources include instructional videos (McDougall, 2003); books and booklets (Agran, 1997; King-Sears, & Carpenter, 1997; King-Sears, Wehmeyer, & Copeland, 2003); and guides and manuals (Dowrick, 1991; Young, West, Smith, & Morgan, 1995). For TCSM, Flaute, Peterson, Van Norman, Riffle, and Eakins (2005) have described 20 ways to use the MotivAider to improve performance of students and teachers.

Conclusion

We conclude here by re-iterating major findings and recommendations from our meta-analytic review. TCSM appears to be a promising practice that typically produces moderate-to-strong outcomes. TCSM, however, has not yet achieved the evidenced-based status of more established forms of self-monitoring, that is, audio-cued and visual-cued self-monitoring. We suspect that TCSM will achieve evidenced-based status when researchers attend to the following. First, utilize more frequently than in the past, research designs that enable evaluation of experimental control. Second, implement high quality studies by attending to procedural integrity elements, as recommended in this review and a prior review (McDougall, Skouge, Farrell, and Hoff (2006). Third, authors could report appropriate effect size indices, as well as links to raw data. Doing so would bolster – not replace –visual inspection of graphed data as a means to evaluate intervention efficacy in studies that use single-case designs. Providing links to raw data could make it easier and more routine for researchers to independently analyze and verify the efficacy of interventions in published studies (McDougall, Narkon, & Wells, 2011). Finally, research and practice suggest that resources are a necessary but not sufficient condition for applying BSM techniques in educational settings. If TCSM is to achieve evidence-based research status and widespread use in schools, then we believe that educators will require adequate training and support (see Wehmeyer, Agran, & Hughes, 2000, and Agran & Alper, 2000). Thus, we recommend that teacher preparation programs, as well as professional development and advanced programs for general education and special education teachers, provide training in how to use BSM techniques, including TCSM.

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(Superscripts indicate the TCSM intervention studies that qualified for this review.)

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