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Using self-monitoring and differential reinforcement of low rates of behavior to decrease repetitive behaviors: A case study

Kate Looney | Jaime A. DeQuinzio ⓘ | Bridget A. Taylor

Alpine Learning Group, Paramus, NJ, USA

Correspondence
Jaime A. DeQuinzio, Alpine Learning Group,
777 Paramus Road, Paramus, NJ 07652, USA.
Email: jdequinzio@alpinelearninggroup.org

We used a reversal design to evaluate the effects of a self-monitoring system and differential reinforcement of low rates of behavior on decreasing repetitive body movements in a child with autism. A trial-based functional analysis revealed that repetitive body movements were maintained by automatic reinforcement. Treatment consisted of teaching the participant to use a self-monitoring system to monitor the occurrence of repetitive body movements. A stimulus control analysis revealed the self-monitoring system acquired stimulus control over the repetitive body movements, in that they were more likely to occur in the absence of the system than in its presence. The self-monitoring system was implemented with a differential reinforcement of low rates of behavior, and their combined effects were evaluated within a reversal design. Repetitive body movements decreased with the implementation of the treatment. The use of self-monitoring systems to target problem behavior is discussed.

1 | INTRODUCTION

Restrictive repetitive behaviors (RRBs) are one of the defining features of autism spectrum disorder and include restricted, repetitive patterns of behavior, interests, or activities that might include stereotyped motor movements (e.g., hand flapping), repetitive use of objects (e.g., lining up toys), and repetitive speech (e.g., echolalia; *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*, American Psychiatric Association, 2013). RRBs may interfere with learning, social interactions, and communication and may be stigmatizing to individuals with autism (Troyb et al., 2016). Behavioral intervention research has addressed the reduction of RRBs using stimulus control procedures (Della Rosa, Fellman, DeBiase, DeQuinzio, & Taylor, 2015; O'Connor, Prieto, Hoffmann, DeQuinzio, & Taylor, 2011), response interruption and redirection (Ahearn, Clark, MacDonald, & Chung, 2007; Ahrens, Lerman, Kodak, Worsdell, & Keegan, 2011; Cassella, Sidener, Sidener, & Progar, 2011), differential reinforcement procedures (Taylor, Hoch, & Weissman, 2005), and combinations of these procedures (see DiGennaro Reed, Hirst, & Hyman, 2012, for review).

Past research has found self-monitoring to be an effective strategy for reducing RRBs (Crutchfield, Mason, Chambers, Wills, & Mason, 2015; Koegel & Koegel, 1990; Nuernberger, Vargo, & Ringdahl, 2013). During

self-monitoring training, participants learn to respond to occurrences and nonoccurrences of their own behavior (typically by tallying them) and to deliver or not deliver reinforcement on the basis of predetermined criteria (Nuernberger et al., 2013).

Crutchfield et al. (2015) used an ABAB reversal design with an embedded multiple baseline design to evaluate the functional relationship between a technology-based self-monitoring system and decreases in stereotypic behavior for two students with autism. The authors' goal was to determine the effects of implementing self-monitoring alone and did not use differential reinforcement or any other intervention. They first trained participants to use the electronic self-monitoring device. Every 30 s the device flashed the question "Quiet hands and mouth?" and participants were taught to answer "yes" or "no" by touching either of those words displayed on the screen. Participants were required to respond to the device independently on 80% of the intervals but were not required to answer the question correctly (i.e., they were not required to accurately discriminate occurrences and nonoccurrences of stereotypy). The authors started the treatment analysis once participants learned to respond to the prompts of the electronic device. Introduction of the self-monitoring system resulted in a decrease in stereotypy for both participants from initial baseline levels, and withdrawal of the system resulted in an increasing trend in stereotypy for both participants. The authors concluded that the electronic self-monitoring device was an efficient way to decrease stereotypy without additional treatment components such as differential reinforcement and discrimination training. They also argued that participants' accurate use of the self-monitoring systems was not necessary for the system to be effective at decreasing problem behavior.

Other studies have combined the use of self-monitoring systems with differential reinforcement procedures, such as differential reinforcement of other behavior (DRO) and differential reinforcement of low rates of behavior (DRL). For instance, Nuernberger et al. (2013) found DRO and self-monitoring were effective in reducing repetitive hair pulling in a 19-year-old female with autism. In another example, Shabani, Wilder, and Flood (2001) evaluated the use of discrimination training, DRO, and self-monitoring to reduce severe body rocking in a 12-year-old boy with autism. In this study, the participant first learned to discriminate between occurrences and nonoccurrence of body rocking modeled by a therapist, and later, he learned to discriminate occurrences of his own body rocking from nonoccurrences. The self-monitoring system was implemented across the day along with a DRO system for reinforcing the nonoccurrence of body rocking. Results indicated that the treatment package consisting of self-monitoring and DRO were effective in eliminating body rocking.

Because of the success of combining self-monitoring and differential reinforcement interventions, we decided to design a similar intervention to address the repetitive body movements of a student with autism in our program. We wanted to outline a progressive intervention for the participant to learn to identify and score the occurrence of his own behavior. The purpose of the current study was to conduct a partial replication and extension of Shabani et al. (2001) by assessing the effects of a DRL and self-monitoring system on the reduction of repetitive body movements of a young male with autism. Similar to Shabani et al. (2001), we used a differential reinforcement system combined with a self-monitoring system during the treatment analysis. We extended this research by implementing a systematic process for teaching self-monitoring and evaluated the use of this system with a DRL during the treatment analysis.

2 | METHOD

2.1 | Setting and participant

The study was conducted at a school specialized in the behavioral treatment of children with autism. The primary methodology employed at the school was applied behavior analysis. Sam was 8 years old at the time of the study and was diagnosed with autism spectrum disorder by an independent agency. Sam was enrolled in the program for 5 years at the time of the study. He had well-developed vocal verbal behavior. For example, he could mand for items and information, engage in exchanges of conversation, and recall and relate information about experiences.

Academically, Sam was on grade-level curricula for most academic subjects. Sam's skill acquisition goals at the time of the study focused on increasing compliance with changes in routine, engaging appropriately with peers, playing group games, conversational skills, and participating in group instruction.

We chose Sam to participate in the study because his repetitive body movements often interfered with peer interactions and instructional programming. In addition, he was scheduled to graduate the school at the end of the program year, and we were interested in identifying an intervention that would provide him with the skills necessary to monitor his own behavior once he left our program.

2.2 | Materials

We used a self-monitoring data sheet that consisted of several small boxes printed on a 12.7 × 17.8 cm size piece of paper. We created several videos to teach self-monitoring. The videos consisted of adults, Sam engaging in common activities (e.g., running, clapping, and catching), and Sam engaging in the target repetitive behaviors. We used a timer, chocolate candy, Sam's individualized token motivational system, and a data sheet to tally the target behavior.

2.3 | Experimental design

We used a reversal design with three withdrawals to determine the effects of the self-monitoring system and a DRL on the frequency of repetitive behaviors.

2.4 | Dependent measures

Repetitive behaviors were defined as any repeated occurrence of jumping up and down, flapping of the hands, scratching of the head and neck, and rubbing of the eyes. During the treatment analysis of the self-monitoring and DRL intervention, the teacher scored the frequency of repetitive behaviors. We chose to use a frequency measure of repetitive behaviors because we wanted one that was easy for the participant to use during self-monitoring. Therefore, the main measure we used during the treatment analysis had to match that of the participant so that we could ensure reliability of scoring.

For self-monitoring training, we measured the percentage of correct responses for each of the steps. Correct responding was defined differently across the training steps. During Steps 1 and 2 of self-monitoring training, the teacher scored a plus (+) if Sam answered correctly and minus (−) if he answered incorrectly. For Steps 3 and 4, the teacher scored a plus (+) on her data sheet if Sam's tallies matched the tallies that she scored for each trial, and she scored a minus (−) if Sam's tallies did not match the tallies that she scored for each trial.

2.5 | Interobserver agreement

Interobserver agreement (IOA) was calculated during 40% of the self-monitoring training sessions at 100%. An agreement was counted if both the teacher and a second observer independently scored a response as correct or incorrect in the same trial. IOA was calculated on a trial-by-trial basis by dividing the number of agreements by the number of agreements plus disagreements and converting the result to a percentage. IOA was also collected for 20% of treatment analysis sessions and was 100%. An agreement was counted if both the teacher and a second observer independently scored the same occurrence of repetitive behaviors. IOA was calculated as the total number of agreements divided by the total number of occurrences and multiplied by 100.

Treatment integrity (TI) data were collected on the accurate implementation of self-monitoring training and baseline and intervention conditions of the treatment analysis. An independent observer used a checklist containing all of the procedures described below for each step of the self-monitoring training (e.g., starts timer for 1 min and uses manual guidance to teach learner to score a tally on the data sheet) and the treatment analysis (e.g., reviews DRL criteria at start of the session and provides candy when DRL criteria are met). TI was collected for 12% of

self-monitoring training sessions and was 100%. TI was collected for 20% of the treatment analysis sessions and a mean of 93% (range 88–100%).

2.6 | Procedures

2.6.1 | Trial-based functional analysis

A trial-based functional analysis was conducted using procedures adapted from Bloom, Iwata, Fritz, Roscoe, and Carreau (2011). The control and test trials were embedded throughout the day. Ten trials were conducted for each condition: play, attention, demand, tangible, and alone. Each test trial was preceded by a control trial, and trials were 2 min in length. If the behavior occurred in the test condition, the session was terminated (Bloom et al., 2011). The functional analysis revealed that Sam's repetitive behaviors occurred in the alone condition, the tangible condition, and the attention condition, but it did not occur in the demand condition (see Figure 1). Because the repetitive behaviors occurred in many conditions, we hypothesized that the behavior was maintained by automatic reinforcement. We chose a self-monitoring system that could be used when there was minimal adult supervision (e.g., as he transitioned from room to room independently). Additionally, because we observed the behavior in attention and tangible conditions, we wanted to incorporate a differential reinforcement intervention.

2.6.2 | Self-monitoring training

There were four steps to self-monitoring training. During each step, correct responses of accurate use of the self-monitoring system were scored on a trial-by-trial basis and summarized as the percentage of correct responses. Teaching began on each step when the participant did not respond correctly on 100% of the trials.

For Step 1, Sam viewed a video of familiar people engaging in common actions (e.g., reading) and was asked yes/no questions about the actions (e.g., "Is the person reading?") to ensure that he could discriminate when a behavior was occurring or not occurring. During Step 2, Sam viewed a video of himself engaging in actions and was asked yes/no questions about the actions (e.g., "Are you reading?") to ensure that Sam could discriminate when his own behavior was occurring and not occurring. For both steps, Sam viewed 20 video clips, and for each, the teacher
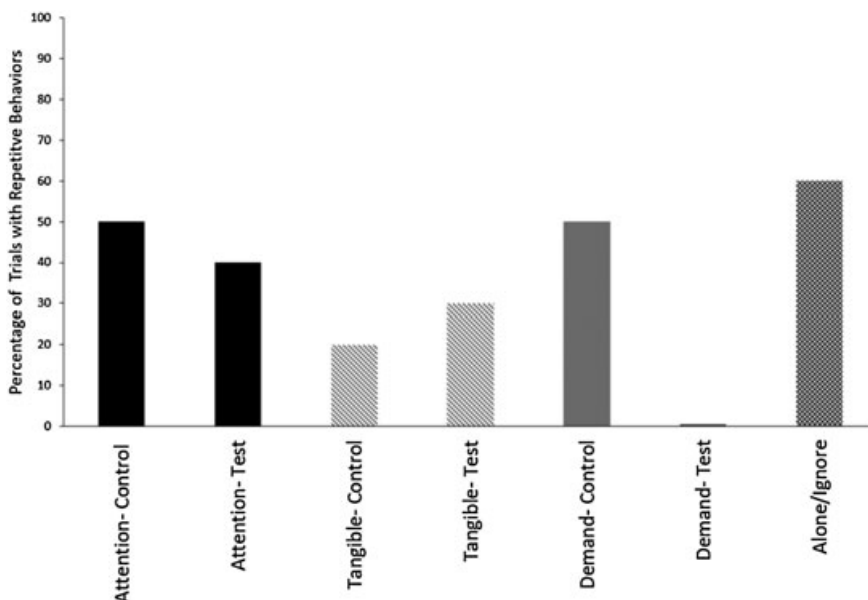

FIGURE 1 Percentage of trials with repetitive behaviors across conditions of the trial-based functional analysis

scored a plus (+) if he answered correctly and a minus (−) if he answered incorrectly. Sam scored 100% on the pretest for both of these steps so we did not have to implement a teaching intervention.

During Step 3, we tested if Sam could identify the occurrence of repetitive behaviors while viewing himself in a video. The video included Sam engaging in various activities, but some of the time, he also engaged in repetitive behaviors (e.g., Sam was writing and would stop and flap his arms). During Step 4, we taught Sam to score his own repetitive behaviors as they occurred in vivo during 10-min sessions in which he was engaged in regularly scheduled tasks. At the beginning of the session, the teacher provided the self-monitoring data sheet and the instruction, "Score a tally every time you move your body in ways you shouldn't." The teacher then modeled some of the actions such as repeatedly rubbing eyes to provide an example of the target behaviors. The teacher started a timer for 1 min. Each 1-min interval represented one trial, and 10 total trials were conducted. When a repetitive behavior occurred and Sam independently scored a tally on the data sheet within 3 s, the teacher placed a token on Sam's individualized motivation system and provided praise (e.g., "Good you made a tally on the sheet when you scratched your head"). When a repetitive behavior occurred and Sam did not score a tally on the data sheet within 3 s, the teacher paused the video and replayed the segment (during Step 3), asked Sam a yes/no question (i.e., "Did you move your body in a way you shouldn't?"), and manually prompted Sam to score a tally on the data sheet. The teacher simultaneously scored occurrences on a separate data sheet out of view of Sam to ensure reliability of scoring. For each trial, the teacher scored a plus (+) on her data sheet if Sam's tallies matched the tallies that she scored. The teacher scored a minus (−) if Sam's tallies did not match the tallies that she scored or if she had to use prompts. Verbal instructions and manual guidance were faded using a most-to-least prompt-fading procedure, and criterion was set at 100% of responses correct for two sessions.

The actual occurrence of body movements during Step 4 was low to near-zero levels; therefore, the opportunities to score body movements was also low. Because of this observation, we hypothesized that the presence of the self-monitoring system during training had served as a discriminative stimulus for Sam to refrain from body movements. To test this hypothesis, we conducted a brief stimulus control analysis.

2.6.3 | Stimulus control analysis

A stimulus control analysis was conducted to determine if the presence of the self-monitoring system was a discriminative stimulus for not engaging in repetitive behaviors. Five-minute sessions were alternated with the system present in one condition and the system absent in another condition. During this time, Sam engaged in regularly scheduled activities. We scored the frequency of repetitive behaviors within both conditions. We did not use any prompts for Sam to use the system during this analysis, and no instructions were provided related to the self-monitoring system.

2.7 | Treatment analysis

2.7.1 | Baseline

Baseline and intervention sessions were all 30 min. During baseline, Sam engaged in regularly scheduled tasks. If repetitive behaviors occurred, the teacher redirected Sam back to the task (e.g., "Do your math please"), or if there was no specific task (e.g., Sam was watching a movie), the teacher provided a verbal instruction to place his hands down (i.e., "Hands down please."). The self-monitoring system and DRL were not used.

2.7.2 | Self-monitoring and DRL

During intervention, the self-monitoring system and DRL were used. At the beginning of each session, the teacher reviewed the DRL criteria (written on the top of the paper) with Sam (e.g., "If you have less than 10 body movements, you can have chocolate") and prompted Sam to start the timer for the specified DRL interval. The teacher simultaneously scored repetitive behaviors as they occurred. If Sam did not score a target response when it occurred, the teacher used manual guidance and verbal instructions as error correction. For example, she said, "You just moved your body in a way you shouldn't. Mark a tally here." At the end of the session, the teacher used manual guidance and

verbal coaching to prompt Sam to total all occurrences of repetitive behaviors at the bottom of the self-monitoring system. If the frequency was at or below the DRL criterion, the teacher provided chocolate candy. For each session that Sam met the DRL criterion, the criterion was decreased by two responses.

The DRL intervals were increased from 1 min at the start of the study to 5 min by the end of the study. During the first phase of intervention, we used 30, 1-min intervals. We started with 1-min intervals because they matched the interval length used during self-monitoring training. The DRL criterion during this phase was initially 10 and was reduced to 2. During the second phase of the intervention, the DRL intervals were initially 30, 1-min intervals and were increased to 15, 2-min intervals, 10, 3-min intervals, and 6, 5-min intervals. The DRL criterion was one throughout this entire phase of intervention. During the final phase of the intervention, the DRL interval remained at 6, 5 min intervals, and the DRL criterion was 1.

3 | RESULTS

Figure 2 shows the results of self-monitoring training. Sam scored 100% for Steps 1 and 2 of the self-monitoring training. During the pretest for Step 3, Sam responded correctly on 70% of the opportunities. When verbal instructions, manual guidance, and reinforcement were implemented, responding increased to 100%. When asked to score repetitive behaviors in vivo (Step 4), Sam responded correctly on 60% of the opportunities during the pretest. When verbal instructions, manual guidance, and reinforcement were implemented, responding increased to 100%.

Figure 3 shows the results of the stimulus control analysis. The results showed that the overall frequency of repetitive behaviors was higher in the absence of the self-monitoring system than in the presence of the self-monitoring system.

Figure 4 shows the frequency of repetitive behaviors during baseline and intervention. During baseline, the frequency of repetitive behaviors was at a moderate to high level ranging from 14 to 34 occurrences per day. When self-monitoring and a DRL were introduced, responding eventually decreased to zero levels. The DRL criterion was systematically reduced from 10 to 2 occurrences per session within this phase. When we returned to baseline,
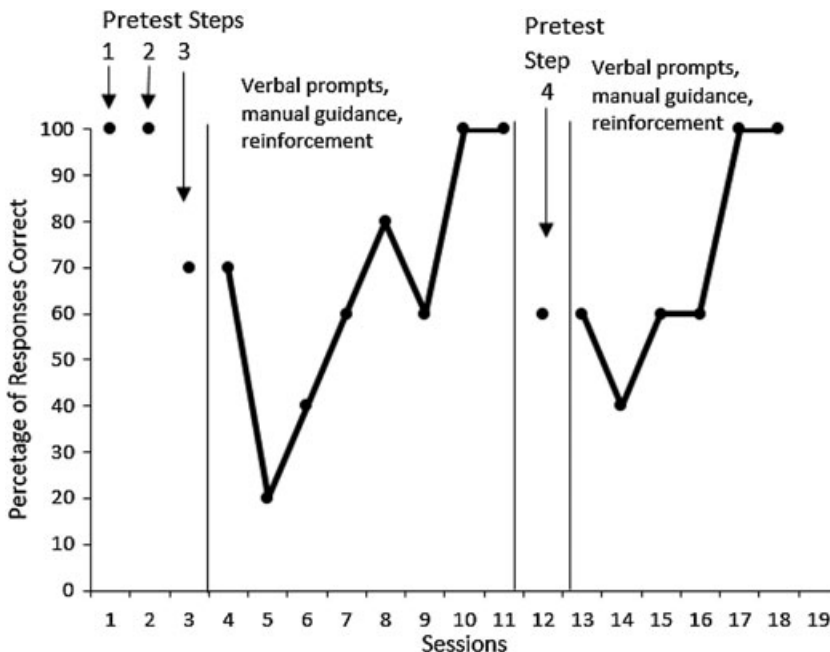

FIGURE 2 Percentage of responses correct during the different phases of self-monitoring training across sessions
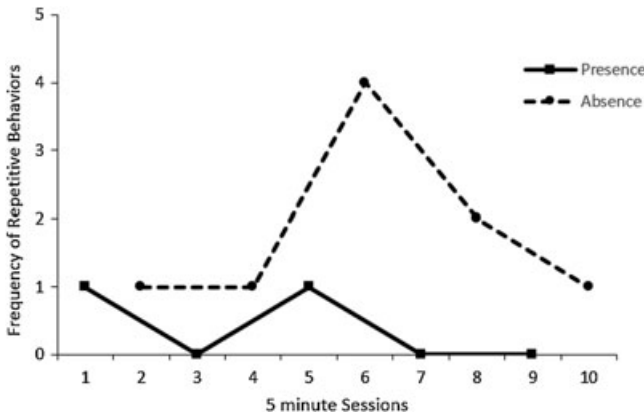
FIGURE 3 Frequency of repetitive behaviors in the presence and absence of the self-monitoring system during the stimulus control analysis
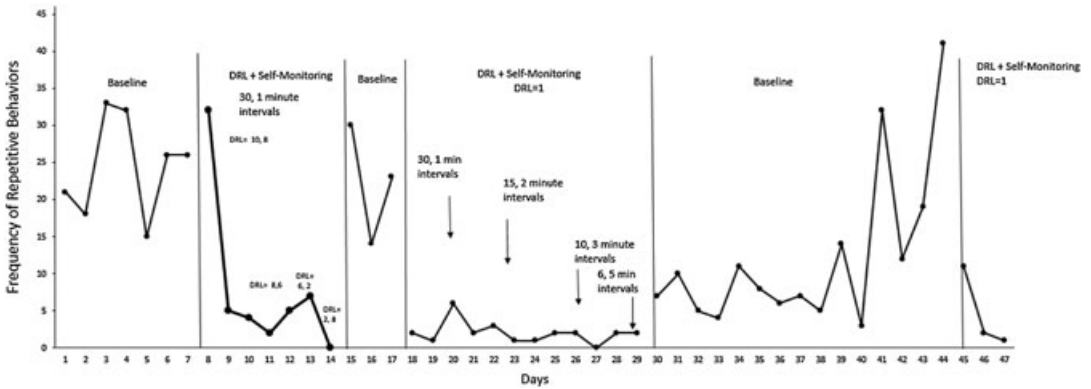

FIGURE 4 Frequency of repetitive behaviors during baseline and the differential reinforcement of low rates of behavior (DRL) and self-monitoring intervention conditions of the reversal design

responding increased to 30 occurrences. When intervention was reintroduced and the DRL criterion was reduced to one occurrence, responding returned to near-zero levels. We returned to the baseline procedure, and responding eventually reached 41 occurrences. In the next intervention phase with a DRL criterion at one occurrence, responding returned to near-zero levels.

4 | DISCUSSION

With the implementation of the DRL and the self-monitoring system, we demonstrated systematic decreases in the frequency of repetitive behaviors that matched the criterion for reinforcement set in each phase of the DRL. The effectiveness of the DRL and self-monitoring system was demonstrated within a reversal design when reliable changes occurred in the frequency of repetitive behaviors when the intervention was applied and removed. This partially replicates the findings of Shabani et al. (2001), whose results demonstrated that DRO and self-monitoring were effective in reducing stereotypic behavior. As in our study, they first began with teaching a discrimination between appropriate and inappropriate behavior before implementing self-monitoring and a DRO (Shabani et al., 2001). We expanded on this study by including a systematic process for teaching Sam to use the self-monitoring system and by using a DRL that allowed for a slower reduction in behavior and systematic increases in the interval during which Sam was required to refrain from RRB.

Through the stimulus control analysis, we demonstrated that the self-monitoring system alone controlled the occurrence and nonoccurrence of repetitive behaviors prior to implementing it during the treatment analysis. These findings are in line with those of Fritz, Iwata, Rolider, Camp, and Neidert (2012) who argued that instructional control by the self-monitoring system served as a discriminative stimulus to refrain from stereotypy. Our results might also support the argument by Crutchfield et al. (2015) that accurate discrimination of stereotypy might not be necessary for a self-monitoring system to be effective. However, the stimulus control analysis did indicate another type of discrimination: when and when not to engage in the target behavior. This type of discrimination, usually taught via discrimination training and discussed as stimulus control procedures for reducing problem behavior, has been demonstrated to be an effective component of interventions targeting stereotypy or other problem behavior (Della Rosa et al., 2015; O'Connor et al., 2011).

Certainly, the results of the stimulus control analysis provided evidence that the self-monitoring system alone was effective at reducing repetitive body movements and that perhaps the DRL was not a necessary component to the treatment package. Regardless of this, we decided to include the DRL in the treatment analysis so that we could systematically reinforce lower levels of responding as the time interval was slowly increased.

In this study, the self-monitoring system was presented on a piece of paper. Although it eventually was faded down to a smaller size, it might not be practical for participants to carry it everywhere. Future research might consider using similar systems programmed into tablets or the use of smartphones for portability, privacy, and independence (Crutchfield et al., 2015). As a case in point, Bouck et al. (2014) compared self-monitoring with paper/pencil and with an iPad and found that students were more independent when using the iPad. Additionally, they found that from a social validity perspective, self-monitoring on the iPad was preferred over paper/pencil (Bouck et al., 2014).

With the current evaluation, the separate effects of the DRL system and the self-monitoring system cannot be determined. Future research could compare the effects of these systems separately using a component analysis similar to that of Crutchfield et al. (2015). Finally, future research should evaluate the use of self-monitoring systems and DRLs on other types of problem behavior. For Sam, self-monitoring with a DRL component greatly reduced repetitive behaviors and allowed him to independently use his own behavior plan.

ORCID

Jaime A. DeQuinzio 🔟 http://orcid.org/0000-0001-8855-2202

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