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Basing Assessment and Treatment of Problem Behavior on Behavioral Momentum Theory: Analyses of Behavioral Persistence

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Abstract

The connection, or bridge, between applied and basic behavior analysis has been long-established (Hake, 1982; Mace & Critchfield, 2010). In this article, we describe how clinical decisions can be based more directly on behavioral processes and how basing clinical procedures on behavioral processes can lead to improved clinical outcomes. As a case in point, we describe how applied behavior analyses of maintenance, and specifically the long-term maintenance of treatment effects related to problem behavior, can be adjusted and potentially enhanced by basing treatment on Behavioral Momentum Theory. We provide a brief review of the literature including descriptions of two translational studies that proposed changes in how differential reinforcement of alternative behavior treatments are conducted based on Behavioral Momentum Theory. We then describe current clinical examples of how these translations are continuing to impact the definitions, designs, analyses, and treatment procedures used in our clinical practice.

Keywords

behavioral momentum theory; differential reinforcement of alternative behavior; long-term maintenance

1. Introduction

The development of functional analysis procedures (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) altered standard practice in the treatment of severe problem behaviors

by providing practitioners with a means to identify the class of reinforcement maintaining problem behavior. Understanding the response-reinforcer relations maintaining problem behavior permitted practitioners to treat problem behavior with functionally relevant reinforcement procedures. The treatment of problem behavior occurred primarily by eliminating the reinforcer maintaining problem behavior via extinction, while concurrently providing the same class of reinforcement for appropriate behaviors such as alternative communication (e.g., functional communication training [FCT], Carr & Durand, 1985). This practice led to a substantial increase in reinforcement-based treatments (Pelios, Morren, Tesch, & Axelrod, 1999), with the overall results being positive. As a recent example, Lindgren et al. (2016) showed that FCT often resulted in almost immediate reductions of problem behavior of at least 80% for young children with an autism spectrum disorder, even when all treatment procedures were conducted by parents who received only weekly telehealth consultation from an applied behavior analyst who never worked directly with the child.

Given these results, treatments based on differential reinforcement, such as FCT, have become the most common treatment for even the most severe forms of problem behavior (Tiger, Hanley, & Bruzek, 2008; Vollmer & Iwata, 1992). Differential reinforcement of alternative behavior (DRA) treatments are often effective because appropriate behavior is strengthened via reinforcement, while problem behavior is weakened via extinction across repeated exposures to the treatment. Epidemiological studies (e.g., Asmus et al., 2004; Iwata et al., 1994) have consistently shown average reductions in problem behavior of over 80% with sample sizes consisting of over 100 participants. However, these studies reported the immediate results of treatment whereas the long-term results of treatment, or evaluations of maintenance, are seldom reported (Wacker et al., in press). Overall, then, the current literature has documented that DRA treatments are often effective in treating problem behavior, and has led to additional questions, such as the maintenance of effects of DRA treatments for problem behavior (Nevin & Wacker, 2013).

1.1. Maintenance in Applied Behavior Analysis

There are two ways that long-term treatment effects are typically measured by applied behavior analysts. The first and most common approach is to probe the effects of treatment over relatively long time periods. For example, investigators such as Durand and Carr (1991) and Derby et al. (1997) showed that FCT continued to suppress problem behavior and maintain appropriate social communication over several months, as long as all treatment components continued to be implemented. Maintenance, as defined in these studies, was based on the definition provided by Stokes and Baer (1977), who described maintenance as the continued occurrence of steady-state responding under the prevailing conditions of treatment. Based on this definition, if behavior continues to be responsive to treatment, then treatment is considered to have produced maintenance. To make treatment more practical, schedule thinning or reinforcement fading (e.g., Fisher, Thompson, Hagopian, Bowman, & Krug, 2000; Hanley, Iwata, & Thompson, 2001) is then conducted. If fading can be achieved without disrupting the effects of treatment, then maintenance has been further achieved but the treatment itself has remained in place.

A second method for evaluating long-term maintenance is to probe both appropriate and problem behaviors when treatment is challenged, with the most common challenge being extinction. For example, Wacker et al. (2011) placed problem behavior, task completion, and alternative communication on brief periods of extinction intermittently over the long-term course of treatment to evaluate the relative persistence of all responses. Maintenance was achieved once appropriate behavior persisted and problem behavior failed to show persistence during these brief periods of extinction. This definition of maintenance, that the effects of treatment persist when challenged, was proposed by Nevin and Wacker (2013), and is based on Behavioral Momentum Theory (BMT; Nevin, 1974; Nevin, 1992; Nevin & Grace, 2000; Nevin, Tota, Troquato, & Shull, 1990). Maintenance is defined as occurring only when the effects of treatment persist following changes in the antecedent and consequent stimuli associated with the treatment of problem behavior. Problems with maintenance are also often measured via analyses of resurgence (Lattal & Wacker, 2015) of problem behavior following varying amounts of exposures to the treatment conditions or varying amounts of time post-treatment.

Unfortunately, both types of analyses of maintenance have shown that although DRA treatments are often effective in the short-term, the resurgence of problem behavior is common (Lattal & St. Peter Pipkin, 2009; Lieving, Hagopian, Long, & O'Connor, 2004; St. Peter Pipkin, Vollmer, & Sloman, 2010; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009), even following long-term treatment (Wacker et al., 2011; Wacker, Harding, et al., 2013). As described by Nevin and Wacker (2013), the lack of persistence of treatment effects in the applied literature provides a case in point for why studies of maintenance need to be more analytical, based on underlying basic processes, and less descriptive. To date in the applied literature (e.g., Wacker, Lee, et al., 2013), the definition of maintenance describes the outcome achieved; steady-state responding under the prevailing conditions of treatment. The most common design is a B (treatment) C (maintenance) case study design that documents the occurrence or lack of occurrence of steady-state responding post-treatment. Thus, the definition is not linked to specific behavioral processes other than the continued occurrence of reinforcement, and the evaluation is descriptive rather than analytical. When problems with maintenance are then encountered, as represented by the repeated documentation of the persistence of problem behavior, applied behavior analysts are unable to efficiently or systematically adjust the treatment to promote greater maintenance. By connecting our applied evaluations of maintenance to underlying behavioral processes and conceptual models of behavior, we can begin to better understand the conditions that are associated with maintenance, and then change our treatments to better promote maintenance. This connection to behavioral processes will almost certainly change how we define behavioral phenomena such as maintenance, the questions we ask about maintenance, the designs and analyses we use to evaluate maintenance, and, subsequently, the procedures used to promote maintenance.

There is, fortunately, a very long and rich tradition in behavior analysis of linking basic and applied behavior analysis (Hake, 1982; Mace, 1991; Mace, 1994; Mace & Critchfield, 2010; Nevin, 1996). Hake referred to the studies that link basic and applied behavior analysis as bridge studies because they connect all research in behavior analysis along a single continuum. Wacker (2000), then, conceptualized this applied/basic continuum as existing

along a u-shaped curve, with the highest frequencies of articles existing on either end of the continuum (basic or applied) and bridge studies occurring rarely but linking all articles together. Mace and Critchfield extensively discussed translational research, and defined it broadly as a, "...general inquiry that breaks new ground by uniting a concern for fundamental principles with a concern for everyday problems" (p. 296). Like Hake and Wacker, Mace and Critchfield conceptualized translational research as existing along a continuum, with some examples of translational research having more in common with basic research and other examples of translational research having more in common with applied research. Examples of the former might include laboratory evaluations of behavior that have implications for the everyday world (see, Ringdahl, Vollmer, Borrero, & Connell, 2001 for an example). Examples of the latter might include investigations in applied contexts that focus on intervention while, "invoking basic behavior principles as a way to improve practical outcomes" (p. 296; see, Wacker et al., 2011 for an example).

One implication of this connecting bridge is that when applications begin to experience problems, such as the persistence of problem behavior following even long-term DRA treatment, applied behavior analysts can seek to further understand these problems by linking the results of their treatments to basic processes, and to processes that had not been considered previously as underlying the effects of a particular treatment. BMT is one area of research related to fundamental principles that has implications for everyday problems. Through a series of studies (Nevin, 1974; Nevin, Mandell, & Atak, 1983; Nevin et al., 1990), relations between various reinforcement parameters (e.g., rate, magnitude, and delay) and contextual variables have been demonstrated to impact response strength. More specifically, these variables impact how resistant a response is to disruption. Similarly, other translational work related to BMT has demonstrated that often used treatments, such as DRA, may have unintended response-strengthening effects for problem behavior (Mace et al., 2010). Understanding what variables impact the strength of a response has clear implications related to how treatments are developed and implemented. Thus, in this paper and as a case in point, we describe how BMT is providing clinical guidance to us regarding why DRA treatments often have problems with persistence of problem behavior, and how we can alter the way we conduct DRA treatment to improve long-term maintenance. We then describe two more recent clinical case studies to show how both our interventions, and the questions we ask regarding treatment, have changed given the link formed between our analyses and BMT.

2. Applied Evaluations of Behavioral Persistence Based on BMT

There has been an increasing number of studies conducted in applied behavior analysis on the effects of reinforcement history on behavioral resurgence (Lattal & St. Peter Pipkin, 2009; Lattal & Wacker, 2015; St. Peter Pipkin & Vollmer, 2009). In Table 1, we provide a listing of articles in the applied behavior analysis literature that have evaluated behavioral persistence or compliance based on BMT. Please also see DeLeon, Podlesnik, and Miller (2015), Nevin and Shahan (2011), Podlesnik and DeLeon (2015), Pritchard, Hoerger, and Mace (2014), Pritchard, Hoerger, Mace, Penney, and Harris, (2014), and Shahan and Sweeney (2011) for a more comprehensive discussion of the application of BMT to clinical situations or applied behavior analysis.

Most of the studies in Table 1 provided translational replications of the conditions under which behavioral persistence occurred during disruptions. The results showed consistent findings across species (e.g., Mace et al., 2010), tasks (e.g., Dube & McIlvane, 2001), and behaviors (e.g., Dube, Ahearn, Lionello-DeNolf, & McIlvane, 2009). Follow-up studies have begun to further isolate specific variables related to increased behavioral persistence, such as types of disruptors (e.g., Lionello-DeNolf, Dube, & McIlvane, 2010) and distinct reinforcers (e.g., Grimes & Shull, 2001) and have begun to consider other variables such as preferences for stimuli (e.g., Berg et al., 2015). Although some of the assumptions of BMT have not been supported by research (Podlesnik & Shahan, 2008), the overall success of these initial applications has supported continued translation by applied behavior analysts, with one notable area being DRA treatments for severe problem behavior (Nevin & Wacker, 2013; Pritchard, Hoerger, Mace, Penney, et al., 2014).

2.1. Applied Translations Specific to DRA Treatments for Severe Problem Behavior

Mace et al. (2010) conducted an analysis of “unwanted” or “unintended” behavioral persistence that constituted an extension of previous applied research on behavioral persistence related to the treatment of severe behavior problems (Ahearn, Clark, Gardenier, Chung, & Dube, 2003; Mace & Belfiore, 1990). Specifically, Mace et al. (2010) evaluated if the most commonly used behavioral treatment of problem behavior, DRA, could be related to the subsequent persistence of problem behavior. In Experiment 1, three children with developmental disabilities were exposed to DRA or extinction conditions in different orders to determine if differential levels of persistence of problem behavior occurred post-treatment. This evaluation was conducted by arranging for an extinction condition to follow either a DRA condition, in which problem behavior had been reduced, or a baseline condition, in which problem behavior was reinforced. As expected, given the large volume of applied research on DRA procedures (Vollmer & Iwata, 1992), DRA resulted in immediate decreases in problem behavior. Unfortunately, problem behavior occurred almost immediately with the discontinuation of the DRA treatment. Further, the occurrence of problem behavior was more pronounced following DRA than following baseline, showing that problem behavior was inadvertently strengthened during the DRA treatment even while it was being reduced in frequency of occurrence. These findings replicated the more basic results of Experiment 2, which was conducted with rats, and were then subsequently replicated with pigeons (Podlesnik, Bai, & Elliffe, 2012). Taken together, as discussed by Shahan and Sweeney (2011), ongoing reinforcement of alternative behavior produces cumulative behavioral persistence of both target and alternative behavior, and thus accounts for at least some maintenance failures of behavioral treatment. Although other variables, such as the fidelity with which treatment is conducted (St. Peter Pipkin et al., 2010; Volkert et al., 2009), have been shown to be correlated with resurgence, the manner with which DRA treatment is conducted may contribute directly to maintenance failures. Specifically, and as predicted by BMT, the reinforcement of alternative behavior in the same context in which problem behavior previously produced the same class of reinforcement strengthens problem behavior as well as appropriate behavior. Maintenance failures such as the persistence of problem behavior can thus occur because of this inadvertent strengthening of problem behavior during DRA treatment.

Although these results can be accounted for via BMT, treatment of problem behavior has rarely been based explicitly on BMT (or other basic behavioral processes). Because clinical procedures, or adjustments in clinical procedures, are not based by applied behavior analysts directly on behavioral processes, treatments such as DRA continue to be conducted in a very similar manner across studies with similar benefits (e.g., immediate reductions in problem behavior that are often demonstrated via reversal designs) and similar problems (e.g., lack of maintenance of treatment effects again demonstrated via reversal designs). It is notable that both the positive short-term effects of DRA treatments and the long-term problems with maintenance are most often documented by showing the immediate persistence of problem behavior within reversal designs when the treatment is discontinued or challenged in some other way. These demonstrations show that the treatment package continues to exert control over the rate of target behavior, but at the same time show that there can be substantial problems associated with obtaining durable treatment effects when the treatment is challenged by changes in antecedent and consequent variables (Nevin & Wacker, 2013). These challenges to treatment are inevitable in applied settings (Wacker et al., 2005), and thus warrant consideration when evaluating the clinical effects of treatment.

2.2. Applied Solutions Specific to DRA Treatments for Severe Problem Behavior

Mace et al. (2010) proposed one solution to the unwanted persistence of problem behavior associated with DRA treatment; provide reinforcement of the alternative behavior in a context that is distinct from the target context. Many programs in applied behavior analysis consider it best practice to initiate treatment in the target context whenever possible as that is where the problem behavior is occurring. However, if treatment is based on BMT, then it may be of greater benefit to initiate the treatment in a separate context, such as a clinic or laboratory setting. By providing the discriminative stimuli and reinforcers for alternative behavior during treatment within a separate context, the unwanted strengthening effects on problem behavior may be reduced because problem behavior is not correlated with a history of reinforcement in that separate context, and thus, is not expected to correlate with the alternative behavior in that separate context.

Using this approach, reductions in unwanted response persistence were shown for both rats (Experiment 2) and children with disabilities (Experiment 3) by Mace et al. (2010), and results were generalized to the treatment context after treatment effects were obtained in the separate context. This treatment was based on both the basic literature and applied literature that previously demonstrated this type of generalization (Berg, Wacker, Harding, Ganzer, & Barretto, 2007; Wacker et al., 2005). Overall, Mace et al. was the first translational study to show how a commonly applied treatment could be altered in a practical manner to reduce the persistence of problem behavior (see also Mace & Nevin, in press), which have subsequently been supported in the basic literature (e.g., Podlesnik & Bai, 2015; Podlesnik et al., 2012; Podlesnik, Bai, & Skinner, 2016).

Wacker et al. (2011) proposed a second potential solution to the unwanted persistence of problem behavior associated with DRA treatment: extend the length of treatment until the effects of treatment persist during challenges to the treatment. The participants in this study were 8 children with developmental disabilities who displayed problem behavior at home.

All received a type of DRA treatment (FCT, Carr & Durand, 1985) in their homes (target setting) by their parents on the same tasks that were associated with ongoing displays of problem behavior. Thus, treatment was conducted in the exact same context in which problem behavior had been historically reinforced. Over the long-term (e.g., 35 weeks) course of treatment, the persistence of alternative behavior and the persistence of problem behavior were probed as measures of maintenance during extinction challenges. Both the target and alternative behavior were placed on extinction during 5-min extinction challenge sessions. The findings initially replicated Mace et al. (2010) in showing: (a) very quick reductions in problem behavior with the initiation of FCT, and (b) very quick occurrences of the persistence of problem behavior during the extinction challenges (return to baseline extinction condition) within reversal designs. However, over the long-term course of treatment, alternative behavior persisted and problem behavior failed to show persistence during the extinction challenges, demonstrating that maintenance had occurred. Importantly, from a clinical standpoint, once maintenance had occurred during extinction challenges, it also occurred during other types of challenges such as when a new task was provided. Thus, although treatment needed to continue for a longer period of time than is typical in the applied literature, the maintenance and generalization achieved showed that it may actually be more efficient to conduct the treatments until durable treatment effects are achieved during challenges to the treatment.

As discussed by Nevin and Wacker (2013), the results of Wacker et al. (2011) are consistent with BMT in that DRA treatments should show a gradual strengthening of alternative behavior over repeated trials due to reinforcement and a gradual weakening of problem behavior due to extinction. This outcome is exactly what occurred for all but one of the participants. Thus, even if treatment is conducted in the target context (setting, parent, and task), good maintenance effects can be achieved with DRA treatments, but these treatments may need to be conducted for a much longer time period to achieve durable effects than are often reported in the applied literature.

2.3. Summary of Applied Translations Specific to DRA Treatments for Severe Problem Behavior

The Mace et al. (2010) and Wacker et al. (2011) studies provided examples of how translational studies involving socially meaningful behavior can be based on behavioral processes and achieve improved clinical outcomes than are commonly reported in the applied literature. Clinical studies that are based on behavioral processes can change the way evaluations are designed (e.g., quantitative methods augmenting single case designs), how outcomes such as maintenance are defined (e.g., persistence of treatment effects when treatment is challenged), and how the procedures are conducted (e.g., treatment is initiated in a separate context from the target context). Rather than describing that an effect such as maintenance either occurred or did not occur, analyses are conducted to show the conditions under which that effect was most likely to occur or not occur. Mace et al. proposed that DRA be conducted in a separate context, and Wacker et al. proposed that DRA be conducted over greater numbers of treatment trials. Both provided quantitative measures of persistence to determine the success of treatment. These studies and others like them across the basic/applied continuum (e.g., Bland, Bai, Fullerton, & Podlesnik, 2016; Nevin et al., 2016)

provide demonstrations of how our definitions, designs, analyses, and procedures can be altered in clinically pragmatic ways when clinical decisions are based on behavioral processes.

3. Case Descriptions of Current Clinical Applications

We now describe current clinical applications we are conducting to further show how clinical applications can be based on and/or interpreted via BMT, and we conclude with an example of how the applied questions we ask are based on BMT.

3.1. DRA Treatment for Severe Problem Behavior and Behavioral Persistence

Lawrence was a 3-year-old boy referred for assessment and treatment of severe problem behavior including aggression (hitting, scratching others). Lawrence functioned in the severe to profound range of intellectual disability. He did not have any formal augmentative or alternative communication system in place prior to the study, and did not communicate through recognizable vocalizations.

Lawrence's problem behavior and use of an alternative augmentative communication (AAC) device (microswitch) were evaluated across three phases as shown in Figure 1. Baseline (Phase A) data depict responding during the tangible sessions of Lawrence's functional analysis of problem behavior. During this phase, problem behavior resulted in 30 s of access to preferred items on a fixed ratio (FR) 1 schedule. Problem behavior occurred at an average rate of 0.8 responses per minute (RPM; range, 0.4 to 1.4 RPM). During the first implementation of FCT (Phase B), problem behavior was placed on extinction and activation of the microswitch resulted in the same programmed reinforcer (i.e., 30 s of access to preferred items) delivered during baseline. Problem behavior decreased to 0 during every session of this phase (10 sessions). Microswitch activation (not displayed but available from the third author upon request) occurred at an average rate of 2.4 RPM (range, 1.1 to 4.1 RPM). Following FCT, extinction was implemented for microswitch activation while problem behavior remained on extinction (Phase C). This is a very common challenge in applied situations, in which the device is not available, is not responded to, or does not work properly. For treatment to have durable results, problem behavior cannot show immediate persistence when one of these challenges briefly occurs. Unfortunately, as shown in Figure 1 (first extinction phase), problem behavior immediately returned to levels exceeding what was observed during baseline ($M = 4.2$ RPM; range, 1.4 RPM to 6.8 RPM). Although problem behavior was on a downward trend across the four sessions, the immediate persistence of severe problem behavior shows that maintenance of treatment effects failed to occur. This is a very common clinical finding; initial treatment effects are strong and occur very quickly with the onset of treatment, but the effects do not maintain during brief challenges to the treatment and problem behavior recurs just as quickly.

We repeated Phases B (FCT) and C (extinction) with Lawrence. During the return to FCT, problem behavior again immediately decreased to 0 RPM and remained at that level for five sessions. Microswitch activation was exhibited at a rate similar to the previous FCT phase ($M = 1.9$ RPM; range, 1.7 to 2.3 RPM). When extinction was re-implemented, persistence of problem behavior was again immediately observed at levels higher than baseline, but similar

to the previous implementation of extinction ($M = 4.2$ RPM; range 0.4 to 6.6 RPM). Unlike the initial implementation of extinction, problem behavior was not on a downward trend during the five sessions of this implementation of extinction.

These results support previous findings (e.g., Volkert et al., 2009) by demonstrating that problem behavior can re-emerge quickly following successful implementation of FCT, and can occur even following multiple sessions with problem behavior at or near zero occurrence. During the 16 total sessions of FCT, the rate of Lawrence's problem behavior was reduced by 100% relative to baseline. However, even with this type of large and consistent reduction over a number of sessions, problem behavior resurged during the first or second session during which communication did not result in reinforcement, thus demonstrating a failure of maintenance.

The results from the case example provided in Figure 1, taken from Ringdahl, Berg, and Wacker (2012) show that in at least some applied cases, the strengthening of alternative behavior via reinforcement may not be sufficient, at least initially, for reducing the persistence of problem behavior during challenges to treatment such as during brief periods of extinction. However, it seemed possible that the results in Figure 1 may have been partially due to the specific topography (severe problem behavior) of the target behavior. Most of the treatment studies based on BMT, including those by Mace et al. (2010) and Wacker et al. (2011) were conducted with very similar target behaviors (aggression or self-injury), populations (severe disabilities), and settings (home or clinic settings). Thus, we wondered if similar problems would occur relative to persistence with treatment programs conducted with more mild problem behavior, with higher functioning individuals, and in a different setting.

3.2. DRA Treatment for Compliance and Behavioral Persistence

To further evaluate the applied generality of the above findings, we implemented a DRA treatment for compliance on math tasks for a teenager with high functioning autism in a school setting. We evaluated how the effects of increased amounts of reinforcement for target behavior affected both compliance and problem behavior.

Sam was a 12-year-old boy who was diagnosed with an autism spectrum disorder. He attended the sixth grade in a general education classroom with special education support. Prior to this evaluation, he had an individualized education plan (IEP) for academic performance in math and problem behaviors displayed in the classroom. At the time of this evaluation, his IEP goal related to math performance had been discontinued because he met the goal and was functioning academically at grade level. Thus, his IEP was for behavioral concerns only, which consisted of noncompliance such as engaging in other activities (i.e., reading a book, playing on the computer) when instructed to complete math tasks.

Sam's problem behavior and academic performance in math were evaluated across three conditions as shown in Figure 2. During baseline, Sam was presented with two math worksheets and instructed to complete as many of the 40 math problems as he could within the 5-min session. There were no programmed consequences for task completion or problem behavior. Results of this phase showed that Sam attempted (Figure 2, top panel) on average

57% (range, 50% – 70%) of the math problems presented to him, problem behavior (Figure 2, bottom panel) did not occur, and percentage of correct responses (of problems attempted; not displayed) averaged 78% (range, 61% – 86%).

During the second condition of this evaluation (contingent positive reinforcement; contingent Sr+), task set-up was conducted in the same manner as in baseline (instructed to complete 40 math problems). However, task attempts and correct responses resulted in contingent access to positive reinforcement (time on an iPad to play a preferred game). Specifically, reinforcement included 15 s if all problems within a row (4 problems) were attempted and an additional 15 s if all problems within the row were correct. Thus, within a 5-min session, Sam could earn a total of 5 min of access to the iPad if all 40 problems were attempted and correct. During the first implementation of contingent Sr+, Sam attempted on average 94% (range, 83% to 100%) of the math problems, problem behavior occurred on average during 2% (range, 0% – 13%) of the session intervals, and percentage of correct responses averaged 83% (range, 68% – 95%).

To determine the effects of contingent Sr+ on the persistence of task attempts, the baseline condition was re-implemented, and results showed that task attempts averaged 74% (range, 65% – 85%), which was higher than levels observed during the initial baseline ($M = 57\%$, range, 50% – 70%). In addition, problem behavior did not occur during the return to baseline and the percentage of correct responses continued to increase ($M = 93\%$, range, 88% – 100%). Given that Wacker et al. (2011) showed greater persistence over longer periods of time in treatment, we continued to implement the contingent Sr+ condition followed by intermittent baseline probes to determine if greater persistence of task attempts occurred over time. During the second implementation of contingent Sr+, task attempts averaged 87% (range, 70% – 100%), problem behavior occurred during an average of 7% of intervals (range, 6% – 8%), and correct responses averaged 88% (range, 78% – 100%). When we returned to baseline, persistence of task attempts continued to slightly increase ($M = 77\%$, range, 71% – 90%) when compared to previous baseline conditions ($M = 57\%$ & 74% for the first and second baseline conditions, respectively). Unfortunately, problem behavior also continued to increase ($M = 13\%$, range, 8% – 22%), whereas correct responses continued at similar levels ($M = 93\%$, range, 83% – 100%). During the third implementation of contingent Sr+, task attempts, problem behavior, and correct responses continued to remain at approximately the same levels ($M = 94\%$, range, 77% – 100%), ($M = 4\%$, range, 0% – 9%), ($M = 87\%$, range, 78% – 95%) as previous implementations, respectively.

Given that Sam sometimes, but not always, attempted all tasks and problem behavior continued to occur, we conducted a bonus contingent positive reinforcement (bonus Sr+) condition to determine if Sam's performance could be further improved with added contingent positive reinforcement. In this condition, all procedures were conducted in the same manner as the contingent Sr+ condition, except that Sam could earn an extra 15 s of access to the iPad for accurately completing one signaled (highlighted) math problem in each row. Thus, with the added contingent positive reinforcement, Sam could earn up to 7.5 min on the iPad during each session. During the first bonus Sr+ condition, Sam attempted 100% of the math problems presented. Problem behavior continued to occur ($M = 6\%$, range, 0% – 16%) and his accuracy remained at an average of 90% (range, 82% – 96%).

Following the implementation of bonus Sr+, we returned to baseline, and results showed that Sam attempted an average of 85% (range, 74% – 96%) of math problems presented, problem behavior occurred during an average of 8% (range, 2% – 16%) of intervals, and the percentage of correct responses averaged 95% (range, 88% – 100%). When bonus Sr+ was re-implemented, similar results were obtained with 100% of tasks attempted, problem behavior occurred on average during 9% (range, 6% – 12%) of intervals, and accuracy averaged 96% (range, 91% – 100%).

The results of this evaluation demonstrated that persistence of appropriate academic behavior (task attempts), albeit small, could be obtained over time following positive reinforcement, which replicates the findings of Wacker et al. (2011). Unfortunately, we also observed the continued occurrence of problem behavior, during both sessions in which positive reinforcement was earned as well as sessions when reinforcement was removed. These results suggest that problem behavior was strengthened during a DRA treatment that was implemented within the context in which problem behavior had a history of reinforcement, and thus, replicates Mace et al. (2010). Although we achieved slight persistence of appropriate academic behavior in the absence of treatment following contingent positive reinforcement, problem behavior was also strengthened and was showing greater persistence than when treatment was first initiated. The small persistence effects of appropriate academic behavior achieved with Sam are similar to those achieved by Romani et al. (2016). Romani et al. discussed that the small differences may have been attributed to (a) the overall obtained rates of reinforcement which were smaller than the programmed rates of most controlled studies, and (b) the uncontrolled history of negative reinforcement experienced outside of experimental sessions. Relative to Sam, earning up to 5 min (contingent Sr+) or 7.5 min (bonus Sr+) at the end of a session for engaging in appropriate academic behavior (task attempts, accuracy) may not have been discrepant enough from the more immediate reinforcement he received for engaging in problem behavior within a session. Additionally, all sessions were conducted after school one day per week. Thus, it is likely that Sam continued to receive reinforcement within the school environment by engaging in problem behavior. Considering Sam's results and those of Romani et al., obtaining small persistence effects in applied situations may be a common finding. However, in both studies, persistence effects were achieved despite the smaller obtained rates of reinforcement and uncontrolled reinforcement histories.

The results from the clinical case studies of Lawrence and Sam suggest two findings: (a) the concerns associated with DRA treatment relative to the unintended strengthening of problem behavior may be very common, and (b) strengthening appropriate behavior via reinforcement may be a necessary but not sufficient approach to treatment unless treatment will continue for a relatively long period of time. Therefore, we wondered if maintenance of treatment effects was also related to the exposures problem behavior encountered with extinction. To further evaluate the effects of extinction, we re-examined the results of 5 of the participants in the Wacker et al. (2011) study to specifically determine one aspect of the effects of extinction; the exposure of problem behavior to extinction early in treatment. As mentioned previously, DRA treatments often result in very quick suppression of problem behavior. When suppression occurs too quickly, such as in the case of Lawrence, problem behavior may not be sufficiently weakened and thus shows very quick resurgence.

3.3. Evaluation of the Role Between Exposures to Extinction and Reinforcement

As discussed by Sweeney and Shahan (2013), problem behavior-extinction pairings lead to the weakening of problem behavior, which in turn leads to reductions in resurgence. Thus, resurgence is reduced as the number of problem behavior-extinction pairings is increased. When conducting DRA treatments, applied researchers may often focus almost exclusively on the role of reinforcement, and thus may miss the role of extinction, and specifically the role of extinction in facilitating maintenance. Many DRA treatments such as FCT provide very rich schedules of reinforcement and at least initially require minimal effort to obtain reinforcement by using procedures such as demand fading. This approach to treatment often has very quick effects in reducing problem behavior but may be counter-therapeutic relative to the maintenance of treatment effects because the quick reductions of problem behavior severely limits its contact with extinction.

We conducted a retrospective analysis of this possibility using data from five participants in Wacker et al. (2011). The purpose of this analysis was to determine the relation between the number of FCT sessions required to consistently achieve a 90% reduction of problem behavior during FCT with the number of extinction sessions needed before resurgence failed to occur during an extinction (of alternative behavior) challenge condition. Three of the 8 participants from the Wacker et al. study were excluded from this analysis for the following reasons: (a) Bud was excluded from the quantitative analysis in the 2011 study and continued to be excluded from this analysis, (b) Juan never displayed target problem behavior in any condition following the initial baseline, and (c) Rose failed to achieve a stable 90% reduction in target problem behavior during extinction.

All FCT sessions were first inspected to identify the first session that each participant showed and maintained a 90% reduction in target problem behavior from baseline levels for the remainder of the study. Extinction sessions, which were interspersed with FCT sessions, were then inspected to determine the first extinction session without the occurrence of problem behavior. A Pearson correlation coefficient was calculated between the number of sessions needed to reach and maintain a 90% reduction in problem behavior during FCT and the number of extinction challenge sessions needed before problem behavior failed to recur. The results of the Pearson correlation showed a negative correlation of 0.8723 (Figure 3) between the number of FCT sessions (and, thus the number of exposures to extinction) needed for a 90% reduction in problem behavior and the number of extinction challenge sessions needed for problem behavior to extinguish. These results support Sweeney and Shahan (2013) in suggesting that exposure to extinction is related to the persistence of behavior.

Specifically, Shahan and Sweeney (2011) and Sweeney and Shahan (2013) proposed and showed that as exposure to extinction and alternative reinforcement increased, resurgence decreased each time reinforcement for the alternative response was removed, which supported Leitenberg, Rawson, and Mulick (1975). Relative to our analysis, results showed that as the number of sessions during FCT increased to reach a stable reduction in problem behavior, the number of sessions needed to maintain that stable reduction of problem behavior in the absence of FCT (during a return to the baseline extinction condition) was reduced (e.g., 41 sessions during FCT, 1 session during a return to baseline extinction). In

contrast, when the number of sessions needed during FCT to maintain a stable reduction in problem behavior was lower, the number of sessions needed to maintain the stable reduction during the return to baseline extinction increased (e.g., 16 sessions during FCT, 8 sessions during extinction). These results appear to add to the results obtained by Leitenberg et al. and Sweeney and Shahan.

Additionally, these results suggest that DRA treatments can have the second unintended effect of too quickly reducing problem behavior-extinction pairings which may increase the overall time needed in treatment to achieve maintenance (Nevin & Wacker, 2013). However, the interpretation of these results should be conducted cautiously given that this analysis was both retrospective and correlational. Related to these results, other applied researchers have begun to look at the independent role of extinction in reinforcement-based treatments. For example, Saini, Fisher, and Pisman (in press) evaluated the effects of noncontingent reinforcement with and without extinction on the persistence of behavior when reinforcement was discontinued. Results showed greater persistence following noncontingent reinforcement without extinction, suggesting that exposures to extinction during reinforcement-based treatments may be important for decreasing the magnitude of persistence over time, which is consistent with the model proposed by Shahan and Sweeney (2011). Studies on the role of extinction have been conducted in the basic literature (e.g., Sweeney & Shahan, 2013) and applied analyses such as the one conducted by Saini et al. are warranted. To determine the independent effects of reinforcement and extinction on the persistence of problem behavior and long-term maintenance of treatment effects, future research might evaluate the correlation between exposures to extinction and reinforcement at both the beginning and end of treatment. Is there an ideal ratio of reinforcement to extinction that is critical to obtain durable treatment effects, and does this ratio change over the course of treatment such that extinction is relatively more important earlier rather than later in treatment?

4. Conclusion

The definition, analysis, and clinical procedures associated with the maintenance of treatment effects for problem behavior are altered when based on BMT. The altered definition of maintenance (i.e., persistence of treatment effects during challenges to treatment) leads directly to changes in the way maintenance is analyzed. Rather than conducting only descriptive probes of target behavior during the prevailing conditions of treatment, or showing a lack of treatment effects when treatment is withdrawn, challenges to treatment are conducted throughout treatment to show when maintenance has occurred. In addition, the components of the treatment package, such as the specific effects of extinction, are analyzed in novel ways, such as the timing and amount of the effects of separate components during treatment. The lack of maintenance, most commonly shown via the persistence of problem behavior during treatment challenges and also as a lack of persistence of the alternative behaviors across contexts, then leads to alterations in the way treatment is conducted. These changes, such as the initiation of treatment in a context that is separate from the context associated with problem behavior, may be different than typical clinical practice because they are based on underlying behavioral processes rather than conventional wisdom. The results of the analyses not only alter clinical practice but also our

more basic understanding of phenomenon such as behavioral persistence. For this reason, these studies are often of almost equal interest to basic and applied researchers (e.g., as represented by the number of behavioral persistence articles in the *Journal of Applied Behavior Analysis* and the *Journal of the Experimental Analysis of Behavior*) and thus represent current examples of translational research that Hake (1982) referred to as bridge studies. Using maintenance as the case in point, translational studies can lead directly to improved clinical outcomes.

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Highlights

- Tying applied treatments to basic behavioral processes may address the problems in those treatments
- Alternative behavior and problem behavior are strengthened during DRA treatments
- DRA treatments may suppress problem behavior too quickly
- Basing applied treatments on basic behavioral processes may lead to new evaluations
- Extinction and reinforcement are critical in the persistence of DRA treatment effects

Figure 1.
Responses per minute of problem behavior for Lawrence. BL = baseline; FCT = functional communication training; EXT = extinction.

Figure 2. Percentage of tasks attempted (top panel) and percentage of intervals of problem behavior (bottom panel) for Sam. BL = baseline; Sr+ = positive reinforcement; Cont. Sr+ = contingent positive reinforcement; Dashed lines = mean percentage of tasks attempted

Figure 3. Number of sessions to reach a stable 90% reduction during FCT and EXT for 5 participants in the Wacker et al. (2011) study. FCT = functional communication training; EXT = extinction

Table 1

Summary of applied translational research on behavioral persistence.

Study	Participant Characteristics	Study Characteristics	Results
Mace et al. (1988)	Age: 36–45 years Dx: DS, Severe ID	DV: Compliance Training Context: High-p request sequence Persistence Tests: Low-p requests	Greater persistence of compliance during conditions with increased response and reinforcement rates
Mace & Belfiore (1990)	Age: 38 years Dx: Severe ID	DV: Stereotypy, Compliance Training Context: High-p request sequence Persistence Tests: Low-p requests, Extinction	Greater persistence of compliance during conditions with increased response and reinforcement rates
Mace et al. (1990)	Age: 38–45 years Dx: Low Average-Severe ID	DV: Task Completion Training Context: Rich and lean reinforcement schedules Persistence Tests: Distracting Stimulus	Greater persistence of task completion during conditions with higher rates of reinforcement
Davis et al. (1992)	Age: 5–7 years Dx: ASD, DS, Severe ID	DV: Compliance Training Context: High-p request sequence Persistence Tests: Extinction, Novel People	Greater persistence of compliance following increased response & reinforcement rates
Mace et al. (1997) <i>Experiment 2</i>	Age: 16 years Dx: Moderate ID	DV: Compliance Training Context: High-p request sequence Persistence Tests: Quality of reinforcer	Greater persistence of compliance during conditions with a higher quality reinforcer
Ahearn et al. (2003)	Age: 4–9 years Dx: ASD	DV: Stereotypy Training Context: Access to preferred stimulus Persistence Tests: Distracting Stimulus	Greater persistence of stereotypy following access to preferred stimuli
Dube et al. (2003)	Age: 7–20 years Dx: ADHD, ASD, DD, Moderate-Severe ID, ODD	DV: Computer Responses Training Context: Rich and lean Reinforcement Schedules Persistence Tests: Distracting Stimulus	Greater persistence of computer responses under conditions associated with higher rates of reinforcement
Lionello-DeNolf et al. (2010)	Age: 9–20 years Dx: ASD, Severe ID	DV: Task Responses Training Context: Rich and lean reinforcement schedules Persistence Tests: Alternative Stimulus, Distracting Stimulus, Pre-Feeding, Presence of Someone Delivering NCR	Greater persistence of task responses during conditions with higher rates of reinforcement when an alternative stimulus was present
Mace et al. (2010) <i>Experiment 1</i>	Age: 4–7 years Dx: ADHD, ASD, DS, Severe ID	DV: Problem Behavior Training Context: DRA Persistence Tests: Extinction	Greater persistence of problem behavior following DRA
Milo et al. (2010)	Age: 6–10 years Dx: ASD	DV: Manding Training Context: Reinforcement schedule Persistence Tests: Distracting Stimulus	Greater persistence of manding during conditions with increased reinforcement rates
Parry-Cruwys et al. (2011)	Age: 4–13 years Dx: ADHD, ASD, OCD	DV: Task Responses Training Context: Rich and lean reinforcement schedules Persistence Tests: Distracting Stimulus	Greater persistence of task responses during conditions with higher rates of reinforcement
Wacker et al. (2011)	Age: 2–4 years Dx: DD	DV: Problem Behavior, Manding, Task Completion Training Context: DRA Persistence Tests: Extinction, Novel Task, Competing Reinforcement, No Switch	Greater persistence of manding and task completion following extended periods of time in treatment
MacDonald et al. (2013)	Age: Unknown Dx: ASD	DV: Problem Behavior Training Context: DRA under rich and lean reinforcement schedules Persistence Tests: Extinction	Greater persistence of problem behavior following increased reinforcement rates

Study	Participant Characteristics	Study Characteristics	Results
Berg et al. (2015)	Age: 3–69 years Dx: DD, Moderate-Severe ID	DV: Manding Training Context: DRA Persistence Tests: Extinction	Greater persistence of manding following increased reinforcement rates
Vargo et al. (2015) <i>Experiments 2–4</i>	Age: 3–4 years Dx: None	DV: Task Responses Training Context: Conditioned reinforcement Persistence Tests: Extinction, Distracting Stimulus, Pre-Feeding	Greater persistence of task responses under conditioned reinforcement conditions when disrupted by extinction or distracting stimulus Greater persistence of task responses under unconditioned reinforcement conditions when disrupted by pre-feeding
Romani et al. (2016)	Age: 3–7 years Dx: ADHD, ASD, Disruptive Behavior, Dyslexia, Dysnomia	DV: Problem Behavior, Task Completion Training Context: DRA, Rich and lean reinforcement schedules Persistence Tests: Extinction	Greater persistence of task completion following increased reinforcement rates
Nevin et al. (2016) <i>Experiment 2</i>	Age: 8–14 years Dx: ADHD, ASD, Moderate- Severe ID, Stereotypic Movement Disorder with Self-injury	DV: Problem Behavior Training Context: DRA signaled on rich and lean reinforcement schedules Persistence Tests: Extinction	Greater persistence of problem behavior during signaled conditions with increased reinforcement rates

Note. Dx = diagnoses; ADHD = attention deficit hyperactivity disorder; ASD = autism spectrum disorder; DD = developmental disability; DS = Down Syndrome; ID = intellectual disability; OCD = obsessive compulsive disorder; and ODD = oppositional defiant disorder; DV = dependent variable; DRA = differential reinforcement of alternative behavior; NCR = noncontingent reinforcement