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WHERE WOULD ABA BE WITHOUT EAB? AN EXAMPLE OF TRANSLATIONAL RESEARCH ON RECURRENCE OF OPERANT BEHAVIOR AND TREATMENT RELAPSE

¿DÓNDE ESTARÍA EL ACA SIN EL AEC? UN EJEMPLO DE INVESTIGACIÓN DE TRADUCCIÓN SOBRE LA RECURRENCIA DE LA CONDUCTA OPERANTE Y LA RECAÍDA DEL TRATAMIENTO

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Abstract

Treatment relapse may be defined as the recurrence of previously eliminated behavior or the failure of desired behavior to recur when the conditions of treatment change. Therefore, producing treatment effects that are durable through time and generalized across contexts is a critically important goal in applications of behavior analysis. However, traditional approaches within applied behavior analysis (ABA) in which technological development is divorced from basic findings in the experimental analysis of behavior (EAB) have yielded only modest progress towards this goal. Alternatively, translational research connecting basic science on the recurrence of operant behavior to applied problems of treatment relapse have led to improved understanding of the behavioral processes involved in relapse and technological innovations to reduce its probability and magnitude. This paper briefly contrasts the technology–driven and the translational approaches and then reviews the translational literature on recurrence and treatment relapse.

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Keywords: treatment relapse, recurrence, applied behavior analysis, experimental analysis of behavior, translational research

Resumen

La recaída del tratamiento puede definirse como la recurrencia de conducta previamente eliminada o el fracaso en que la conducta deseada recurra cuando las condiciones del tratamiento cambian. Por lo tanto, producir efectos del tratamiento que sean durables a través del tiempo y se generalicen a través de contextos es una meta críticamente importante en las aplicaciones del análisis de la conducta. Sin embargo, las aproximaciones tradicionales dentro del análisis conductual aplicado (ACA) en las cuales el desarrollo tecnológico está divorciado de los hallazgos básicos en el análisis experimental de la conducta (AEC) han resultado únicamente en progresos modestos hacia esta meta. Alternativamente, la investigación de traducción que conecta la ciencia básica sobre la recurrencia de la conducta operante a problemas aplicados de la recaída del tratamiento ha conducido a un mejor entendimiento de los procesos conductuales involucrados en la recaída y a innovaciones tecnológicas para reducir su probabilidad y su magnitud. En este trabajo se contrasta brevemente el enfoque guiado por la tecnología y el enfoque de la traducción y posteriormente se revisa la literatura de traducción sobre la recurrencia y la recaída del tratamiento.
Palabras clave: recaída del tratamiento, recurrencia, análisis conductual aplicado, análisis experimental de la conducta, investigación de traducción

Applied behavior analysis (ABA) originally developed as an extension of the principles and methods of the experimental analysis of behavior (EAB) to the analysis of socially important human behavior (Laties, 1987). In their seminal article outlining the dimensions of the new applied agenda, Baer, Wolf, and Risley (1968) described ABA and EAB as two separate but interrelated domains of a unified analytic science of behavior, their differences being merely “matters of emphasis and selection” (p. 91). Unfortunately, this enthusiastic sense of unity did not last long. Less than a decade after the publication of the first applied journal, prominent behavior analysts were discussing the potential for a divorce between ABA and EAB (Bailey, 1977; Birnbrauer, 1977; Brownstein, 1977; Catania, 1977; Michael, 1980). It was clear that applied researchers had become primarily focused on the development of behavior–modifying technology and their analytic methods were geared almost exclusively to identifying functional relations between intervention operations and behavioral change. The connection between these new technological innovations and EAB’s investigation of behavioral processes and development of basic theory was increasingly absent. The controversy engendered by the rift between ABA and EAB was first lamented (Michael, 1980) and then celebrated (Baer, 1981) in successive presidential addresses at the Association for Behavior Analysis Annual Convention. Several behavior analysts reacted to this talk of divorce with warnings of deleterious effects for the field and calls for integration between the applied and basic sectors (Hake, 1982; Hayes, 1978, 1991; Johnston, 1991; Mace, 1991, 1994). In particular, many expressed concerns that developing applied technologies without concern for developments in basic science contributed to the concentration of applications into a relatively narrow range of human problems (Friman, 2010), the proliferation of unsystematic technical jargon detached from fundamental scientific principles (Hayes, 1991), the limited effectiveness and generality of common intervention techniques (Mace, 1994), and the tendency to respond to treatment failures by resorting to intrusive and controversial default procedures (Iwata, 1988).

Nearly forty years after this discussion began, the progress of unification within the field of behavior analysis has been impressive. Research lines connecting basic laboratory studies with animals and applied studies of clinical issues (i.e., *translational research*) have led to a broad range of theoretical and practical developments. Examples include the application of matching theory to the design of function based treatments (Mace & Roberts, 1993), the development of language teaching programs based on stimulus equivalence research (e.g., Stromer, Mackay, & Stoddard, 1992), and the link between the Acceptance and Commitment Therapy psychotherapy model and basic findings on derived relational responding (Hayes, Luoma, Bond, Masuda, & Lillis, 2006), to name just a few. Publication trends also reflect this progress. Between 1993 and 1995, the *Journal of Applied Behavior Analysis* (JABA) featured a series entitled “Developments in Basic Research and Their Potential Applications” that included selected abstracts from the *Journal of the Experimental Analysis of Behavior* (JEAB) and commentaries from prominent basic and applied behavior analysts (e.g., Hineline & Wacker, 1993; Iwata & Michael, 1994; Shull & Fuqua, 1993). Special issues highlighting translational research studies have been published by both JABA (Lerman, 2003; Mace & Wacker, 1994) and JEAB (Mazur, 2010). In a recent study on coauthorship interactions between JEAB and JABA authors, Virues–Ortega, Hurtado–Parrado, Cox, and Pear (2014) found that the number of authors who have published in both journals doubled between 1980 and 2010. Additionally, the percentage of *JABA* and *JEAB* articles written by these authors tripled during the same time period. Clearly, the value of translational research and applied/basic integration within behavior analysis has become well established.

The goal of the present paper is not to dwell on the costs of disconnection between ABA and EAB, but rather to highlight the successes of the alternate path chosen by translational researchers. Specifically, several decades of translational research on the recurrence of operant behavior serve as an exemplar of what can be achieved when basic and applied researchers incorporate and synthesize their efforts towards a common goal. Translational research on recurrence has resulted in the development of basic theory and applied procedures that allow researchers to describe, predict, and control the variables involved in some of the most enduring challenges to applied behavior analysts: generalization, maintenance, and treatment relapse. The present essay briefly reviews the development and limitations of a technology–driven applied approach to these challenges, and then provides a review of the translational literature, noting not only the value of its findings but the processes by which translation has taken place and which may serve as a model for other integrative efforts that bridge the basic–applied divide.

Generalization, Maintenance, and Treatment Relapse

Applied behavior analysts have been notably successful in developing efficacious interventions to address a variety of clinical, educational, and organizational problems (Morris et al., 2001). Undoubtedly, one of the contributing factors to this success is the rigorous demand within the field of ABA that any applied technology be assessed within an experimental design that provides a clear demonstration of the functional relation between intervention and behavioral change. Most ABA interventions are therefore initially studied in controlled environments that allow researchers to produce strong and clear intervention effects that are minimally influenced by extra–experimental variables and that are stable over the time period of the study. However, for these interventions to prove meaningful beyond the research context, their effects must have sufficient durability across time and generality across contexts to meet the needs of the individuals and communities for whom they are designed to benefit. In the applied field, such durability and generality of effects are frequently referred to as *maintenance* and *generalization*, respectively, and failures to achieve either are described as instances of *treatment relapse*. Thus relapse may be considered a generic term describing instances in which the removal of treatment procedures or changes in contextual variables result in the recurrence of problem behaviors or the failure of desired behaviors to persist. Although the use of these terms is sometimes criticized and alternatives have been proposed (see Mace & Critchfield, 2010; Stokes, 1992 for discussions), the critical importance of producing durable and generalized treatment effects is widely agreed upon. Unfortunately, investigations of maintenance and generalization have been relatively infrequent in the ABA literature as compared to simple demonstrations of treatment effects in relatively narrow ranges of conditions or time (Osnes & Lieblein, 2003; Stokes & Baer, 1977; Stokes & Osnes, 1988).

In one of the earliest and most well–known commentaries on this issue, Stokes and Baer (1977) criticized the dominant practice of the time, which they described as “train and hope”, and called for the inclusion of systematic generalization programming in applied research. They also classified a variety of behavioral techniques that seemed to show promise in promoting generalization into eight categories based on the operations involved. Stokes and Osnes (1989) later expanded and refined this taxonomy based on functional categories rather than procedural ones. Additionally, they stressed the need for applied studies to demonstrate functional relations between clearly defined intervention variables and the occurrence of generalization and maintenance. Taken together, the prescriptions of Stokes and Baer (1977) and Stokes and Osnes (1989) outlined a general strategy of intervening as much as possible across diverse settings and tailoring interventions to include naturally occurring salient stimuli and available reinforcement. Although this approach has become the tradition in the field and is widely taught to practitioners (e.g., Cooper, Heron, & Heward, 2007), its evidence base has not been well established (Osnes & Lieblein, 2003). Twenty–six years after Stokes and Baer’s seminal article, Osnes and Lieblein (2003) reviewed the state of the literature to assess the progress of research on generalization and maintenance. They reported mixed results, noting that there had been an increase in studies designed to investigate the relations between treatment variables and generalization, but that, overall, generalization remained an “elusive entity” that behavior analysts still struggled to produce (Osnes & Lieblein, 2003, p. 371).

That this line of research continues to produce only modest gains may not be surprising given its exclusive focus on developing technology to promote generalization without considering more basic questions of behavioral process. As with other technology–driven approaches, the applied literature on generalization tends to lack conceptual clarity and systematic consistency with basic theory. In fact, the term *generalization* itself, as it has been historically used in the applied sector, differs from the traditional usage in basic science. In their original conceptualization of generalization, Stokes and Baer (1977) did not address this issue of terminology and chose to focus on what they called a pragmatic definition of generalization. In discussing the debate engendered by this usage, Stokes (1992) stated that “whatever the controversy, it seems one knows generalization topographically when it is seen” (p. 430). However, one problem with such a common sense, pragmatic approach is that researchers can become overly focused on recognizing expected results and may overlook other unanticipated effects. Similarly, the consequence of designing experiments solely to demonstrate a functional relation between intervention techniques and intended outcomes is that the analysis of behavioral processes that control the discriminated operant of concern is lost and potentially crucial side effects of the operation in question may be ignored. For example, many basic and translational studies on the relation between reinforcement rate and behavioral persistence (reviewed below) suggest that adding reinforcement to contexts associated with problem behavior may increase the probability and magnitude of treatment relapse (Mace et al., 2010; Nevin & Grace, 2000; Podlesnik & Shahan, 2009). These findings are counterintuitive but critically important in qualifying the common prescription of programming for generalization by training in as many contexts as possible. Such nuanced understanding of how interventions may produce immediately observable target effects but delayed side effects is unlikely when technological innovation is divorced from basic discovery research.

Translational Research on Recurrence and Relapse

Translational researchers are also concerned with the development of behavioral technology. However, they believe that technological innovation is best achieved by synthesizing a concern for fundamental principles with a concern for the achieving positive outcomes in problems of social importance (Johnston, 1991; Lerman, 2003). To be sure, the translational process of technology development can require extensive time and resources (Mace & Critchfield, 2010) and often integrates multiple stages and methods. However, the advantages of this approach are evident in its outcomes. For example, interventions grounded in basic research on behavioral principles allow practitioners to tailor their interventions to changing conditions in a dynamic environment (Mace & Roberts, 1993), to minimize unwanted side effects of otherwise effective interventions (Mace et al., 2010; Sweeney & Shahan, 2013; Wacker et al., 2011), and to adapt general intervention strategies to a broad range of clinical problems (Hayes et al., 2006).

The progress of translational lines of research has been described as bidirectional in that basic studies may inspire clinical applications and applied studies may inspire the development of basic models of clinical problems (Mace & Critchfield, 2010). Systematic extension of basic research to application often begins with replications of nonhuman studies with human subjects in laboratory environments, followed by translation of basic preparations to innovations in clinical practice, and eventually large–scale evaluations of clinical efficacy (Baron, Perone, & Galizio, 1991; Mace, 1991). However, even in controlled laboratory conditions, translating basic nonhuman research in studies with humans often requires procedural modifications to accommodate practical and ethical constraints that are unique to human experimentation (see Dube, Ahearn, Lionello–DeNolf, & McIlvane, 2009 for examples). Basic replications in natural and clinical environments require similar methodological adaptations and by definition include target responses and reinforcers germane to the environments in which the studies are conducted (e.g., Parry–Cruwys et al., 2011). Human replication therefore helps to establish not only interspecies generality but also the generality of basic principle across response topographies, environmental contexts, and consequent stimuli (Mace, 1994).

Translational research in which models of applied problems are developed in the basic laboratory have a long history in behavior analysis (e.g., Herrnstein, 1974; Overmier & Seligman, 1967). Basic models have the obvious advantage of allowing for the establishment of carefully controlled and monitored learning histories that can be used to develop behavioral patterns analogous to human behaviors of interest. In successful modeling, subsequent experimental manipulations that reliably enhance or disrupt these patterns result in the elaboration of robust findings relating replicable operations and predictable behavioral processes. These relations may then serve as basic principles upon which applied interventions may be developed and tested (Mace, 1991).

The remainder of this paper will review the current state of the translational literature on recurrence that has been achieved through these bidirectional processes. We begin by providing a brief synopsis of basic findings in nonhuman research and then describe in more detail a series of basic and applied human studies on recurrence in humans as it pertains to treatment relapse. Because the ultimate goal of translational research is innovation in application, we focus our review on recent research that models and tests methods for mitigating relapse in the clinical treatment.

Basic Models of Recurrence

Basic studies on the recurrence of operant behavior are designed to identify the effects of both present and historical conditions or contingencies on the recovery of a response that has been reduced to a zero rate (Lieving & Lattal, 2003). This is generally accomplished using a three–phase procedure in which a carefully controlled history for a discriminated operant is established in an initial training or baseline phase, followed by an elimination phase in which one or more operations that reduce response rates are implemented, and finally by a third phase in which recurrence is tested (Cançado & Lattal, 2013). Although such studies vary significantly in the specific procedures they employ, virtually all examine one or more of three general paradigms of recurrence: reinstatement, resurgence, and renewal. In reinstatement models, responding recovers in the test phase after extinction when the reinforcer that maintained baseline response rates is delivered contingent on either the response or time (Podlesnik & Shahan, 2009; Reid, 1958). Resurgence involves the reduction of a target response to a zero rate through extinction and reinforcement of an alternative response and the subsequent recovery of that target response when alternative reinforcement is discontinued and extinction remains in place for both target and alternative responses (Epstein, 1985; Leitenberg, Rawson, & Mulick, 1975). Finally, renewal occurs when a response is placed on extinction in a context that differs from the training context and then recovers despite ongoing extinction when the training context is replicated (Bouton, 2004; Grimes & Shull, 2001; Trask, Schepers, & Bouton, 2015, *this issue*).

These models of recurrence have been used to study the influence of numerous training and elimination phase variables on the probability and magnitude of response recovery in the test phase. One variable that has received significant attention is the rate of baseline responding. For example, Franks and Lattal (1976) used different training schedules to establish different response rates in rats during training and found that higher responses rates in training were associated with higher rates of recurrence in a reinstatement test phase. Subsequent investigations have shown that baseline response rates also affect the magnitude of recurrence in resurgence paradigms (Doughty, Reed, & Lattal, 2004; Reed & Morgan, 2007). Other variables that influence recurrence rates include alternative response topographies (Pacitti & Smith, 1977), number of extinction sessions (Cleland, Foster, & Temple, 2000), and length of the alternative reinforcement phase (Leitenberg et al., 1975).

Alternatively, research on recurrence based in behavioral momentum theory (BMT; Nevin & Grace, 2000; Nevin, Mandell, & Atak, 1983) has focused on reinforcement rates for target behavior in the baseline phase or alternative behavior during the elimination phase. In one of the most important studies to influence this line of research, Nevin, Tota, Torquato, and Shull (1990) used a multiple schedule arrangement to separate the effects of baseline response rates from baseline reinforcement rates and found that the persistence of responding during disruption was a function of context–reinforcer contingencies and not response–reinforcer contingencies. These findings were replicated in other species (Igaki & Sakagami, 2004; Nevin, Grace, Holland, & McLean, 2001) and using a variety of reinforcers (Mace, Mauro, Boyajian, & Eckert, 1997). In an application of the BMT model to traditional recurrence paradigms, Podlesnik and Shahan (2009) found that the magnitude of recurrence in reinstatement, resurgence, and renewal models was greater in conditions associated with higher reinforcer rates, though subsequent studies have noted that this finding does not always hold (Cançado & Lattal, 2013; Fujimaki, Lattal, & Sakagami, 2015, *this issue*). Additionally, Shahan and Sweeney (2011) extended BMT quantitative models to provide a model of recurrence that predicts recovered response rates as function of alternative reinforcement rates. As we discuss below, this model has been useful in inspiring solutions to clinical problems of treatment relapse.

Demonstrating Recurrence of Human Behavior in Basic and Applied Settings

Reid (1958) conducted one of the first replications of basic recurrence studies using human subjects. Based on previous reinstatement experiments with rats and pigeons reported in the same article, he arranged a procedure using slot machines and token reinforcers with college students. After establishing lever pulls using both continuous and variable–ratio schedules of reinforcement, extinction was implemented until responding ceased for at least 90 s. Students then were given "free" tokens and responding recurred in 12 of 13 subjects. Similar demonstrations of reinstatement were reported by Spradlin, Girardeau, and Hom (1966) and Spradlin, Fixsen, and Girarbeau (1969) in children with intellectual and developmental delays (IDD) using token and edible reinforcers. More recently, Pipkin, Vollmer and Sloman (2010, Experiment 1) used a computer–based analogue of differential reinforcement of alternative behavior (DRA) treatment with college students to investigate whether recurrence would be influenced by intermittently reinforcing problem behavior or failing to reinforce alternative behavior. These two variants of simulated treatment integrity failure (termed commission and omission errors, respectively) are analogous to the treatment failures tested in basic reinstatement and resurgence experimental paradigms. Pipkin et al. compared both the separate and combined effects of these two types of errors and found that commission errors had the strongest effect on rates of recurrent responses. Finally, Okouchi (2015, *this issue*) showed that resurgence of human responding occurred when the to–be–resurged response first was eliminated not by extinction, but by negative punishment in the form of point loss.

Applied demonstrations of recurrence in clinical and educational environments have also used a variety of experimental paradigms. Lieving, Hagopian, Long, and O'Connor (2004) examined resurgence during the clinical assessment of disruptive and aggressive behavior in two children diagnosed with IDD using response class hierarchy (RCH) analyses. An RCH is a set of topographically distinct responses that serve a common function but have differing probabilities of occurrence, and RCH analyses are generally conducted by systematically reinforcing only one response at a time while withholding reinforcement for other members of the class (Mace, Pratt, Prager, & Pritchard, 2011). In Lieving et al.'s (2004) assessments, placing one form of problem behavior on extinction reliably resulted in the resurgence of other, previously reinforced and extinguished responses in both children. Volkert, Lerman, Call, and Trosclair–Lasserre (2009) extended this clinical line of research in an examination of resurgence following the successful treatment of children with IDD. After establishing low rates of problem behavior using standard functional communication training (FCT) treatments, they simulated treatment integrity failures through sessions of extinction (Experiment 1) and abrupt reductions in reinforcement rates (Experiment 2). Across both experiments, problem behavior resurged for 5 of 6 participants, often at rates higher than pre–treatment assessment levels. Thus, Volkert et al's findings not only replicated previous basic models of resurgence by using extinction to simulate total treatment integrity failure, but they also demonstrated that relapse can occur when procedures commonly used in the latter stages of treatment (i.e., schedule thinning) are implemented too abruptly.

Pritchard, Hoerger, Mace, Penney, and Harris (2014) examined the relapse of attention–maintained problem behavior conducting tests of both reinstatement and resurgence. The function of problem behavior was determined during a functional analysis with two attention conditions correlated with two different therapists (both providing equal reinforcement for problem behavior according to VI schedules) and a control condition including near–continuous attention and no instructional demands. The attention conditions also served as a baseline for comparing response rates during test conditions. During treatment, the two different therapists reinforced requests for attention on either a rich or lean concomitant VI variable– time (VT) schedule in alternating components, with rate of reinforcement approximately four times greater in the richer condition. Once problem behavior reached near–zero rates in both components, baseline conditions were reinstated and problem behavior recurred in both components, but response rates in the rich component were 2.6 times greater than response rates in the lean component. Treatment then was repeated using reinforcement schedules identical to the prior treatment phase in order to re–establish near–zero rates of responding and a single extended extinction session was conducted to examine the influence of these schedules on the magnitude of resurgence. During extinction, the overall rate of problem behavior was again more than twice the rate in the rich component compared to the lean component. Additionally, problem behavior accelerated at a higher rate and persisted considerably longer in the rich component.

Translational Research on Preventing and Minimizing Treatment Relapse

For applied researchers and service providers, the ultimate value of translational research is its contributions to their repertoire of practical treatment strategies and procedures. Although the studies reviewed thus far may help clinicians describe and predict how treatment interventions evoke the behavioral processes at work in treatment relapse, they do not provide answers to the critical question of how to prevent or minimize relapse during the inevitable lapses of treatment integrity that occur in natural environments. Fortunately, translational studies designed specifically to identify treatment variations that mitigate relapse have proliferated in recent years in both basic and applied behavior analysis. Below we describe the current state of this research in the two areas of clinical application: in the treatment of problem behavior in individuals with IDD and/or ASD and in the treatment of substance use disorders.

Problem behavior. As several of the studies reviewed above indicate, one process that is likely to increase the persistence of problem behavior and therefore the probability and magnitude of its recurrence during lapses in treatment integrity is the strengthening of stimulus–reinforcer contingencies through the addition of reinforcers to an environment in which problem behavior previously has been or is currently reinforced. This frequently occurs during DRA and time-contingent schedule (TCS) treatments conducted in homes, schools, or clinics in which problem behavior has an established history. To date, several strategies for reducing relapse have been established based on an understanding of this persistence–strengthening process.

Mace et al. (2010) developed the first of these strategies in a translational set of studies beginning with a rat model followed by a clinical test in children with IDD. Because the initial acquisition of communication responses in language–impaired individuals often requires relatively rich reinforcement schedules, Mace et al. proposed conducting initial communication training in a different context from the primary treatment setting. Subsequently, stimuli from the initial training context and reinforcers for the established alternative response would be integrated into the primary treatment setting, thereby minimizing the "contamination" of the treatment context with large numbers of reinforcers during training (i.e., minimizing the overall stimulus–reinforcement contingency in the environment in which problem behavior occurred). They tested this hypothesis first with four rats by conducting a baseline three–component multiple concurrent schedule, with one component modeling reinforcement of target behavior alone (i.e., pretreatment), one component modeling reinforcement of alternative behavior in the same context as reinforced target behavior (i.e., conventional DRA), and the final component modeling the training of an alternative response in a separate context from the treatment setting (i.e., the two–phase treatment described above). Separate extinction tests were conducted using discriminative stimuli from the pretreatment condition, the DRA condition, and a compound of the pretreatment and alternative training conditions. Target responding was most persistent in the DRA condition for all four rats. For two rats, target responding was least persistent in the pretreatment condition, while for two others persistence did not significantly differ between the pretreatment and two–phase treatment conditions. In their subsequent clinical study, they used a parallel procedure to study the persistence–strengthening effect of DRA in the treatment of escape–maintained problem behavior in two children with IDD. Baseline and treatment component schedules comparable to the rat model were correlated with specific rooms and specific clinicians wearing colored hospital gowns to facilitate discrimination. When treatment integrity failure was simulated by extinction in all components, both children displayed high rates of problem behavior in the DRA component and low rates in the baseline and combined context conditions. Taken together, the results of Mace et al.'s (2010) basic and clinical studies indicate that conducting initial training of an alternative response in one context and then "transplanting" that response to the main treatment setting can reduce, and in some cases eliminate, the added risks of relapse related to conventional DRA methods. Additionally, the integration of discriminative stimuli from the initial training into subsequent training contexts may help to mitigate the risk of renewal effects induced by a return to the pretreatment stimulus context when clinicians seek to transfer treatment gains first obtained in a training setting to other settings correlated with established histories of reinforcement of problem behavior.

Wacker et al. (2011) developed another approach for mitigating the potential contribution of DRA to relapse based on BMT quantitative models of DRA and extinction (Nevin & Grace, 2000; Podlesnik & Shahan, 2009; Shahan & Sweeney, 2011). These models predict that the magnitude of target–behavior resurgence when reinforcement for alternative behavior is discontinued is negatively related to the total duration of combined alternative reinforcement and target–behavior extinction. This prediction is consistent with basic findings on resurgence (Leitenberg et al., 1975, Experiment 4) and suggests that clinicians could minimize the magnitude of resurgence of problem behavior by providing DRA + extinction (EXT) treatments for extended periods. Wacker et al. (2011) tested this hypothesis during FCT treatment of escape–maintained problem behavior in eight children by implementing treatment for up to 16 months. Resurgence was tested periodically during extinction sessions in which reinforcement for the trained communication responses was discontinued. Consistent with the quantitative predictions of BMT, resurgence decreased in magnitude as a function of the time spent in treatment. Additional tests of relapse were conducted using other treatment challenges resembling those that occur in natural environments including the introduction of novel tasks, reinstatement of reinforcement for problem behavior concurrent with reinforcement with communication, and the absence of communicative devices during work tasks. Relapse results in these additional tests were mixed across children and treatment challenges, underscoring the need to tailor treatment for individuals based on careful examination of the processes evoked by complex treatment operations.

A third strategy for protecting against relapse based on alternative reinforcement rates was suggested by Pritchard et al. (2014) in their clinical translation of basic models of resurgence and reinstatement. In their relapse tests, problem behavior rates were far greater in the context associated with high–rate DRA compared to low–rate DRA, but essentially equal across both components during treatment. One likely explanation for this equal effectiveness of differing rates of DRA is that prosocial behavior trained in treatment generally requires lower response effort (i.e., less caloric expenditure) and produces higher quality social reinforcement than does problem behavior (Mace & Roberts, 1993). For example, aggression typically requires considerable physical effort and results in attention in the form of reprimands, whereas card touches require little physical effort and are met with attention in the form of praise or affection. Though the combination of manipulating these variables along with DRA rates has yet to be tested in basic models (see Sweeney & Shahan, 2013 for a discussion), it seems likely based on Pritchard et al.'s results that treatments using relatively low–

rate, high quality alternative reinforcement for low effort responses are less prone to strengthening the potential for relapse.

Another recently tested method for lowering the risk of resurgence of problem behavior was inspired by basic research that showed that VT schedules of reinforcement following DRA could successfully supplant reinforcement of alternative behavior and eliminate recurrence of target behavior during resurgence tests in pigeons (Lieving & Lattal, 2003). Marsteller and St. Peter (2014) treated 4 children with a variety of psychiatric diagnoses by training appropriate communication responses and conducting DRA sessions until problem behavior was reduced to at least 80% of baseline rates. Following the DRA treatment, they compared traditional resurgence tests (i.e., concurrent EXT EXT) with a condition in which both problem behavior and communication were on extinction and reinforcers were delivered on fixed–time (FT) schedules yoked to the previous DRA schedules. During the FT phase, resurgence of problem behavior was significantly lower and maintenance of communication behavior was significantly higher than in the traditional resurgence tests. These results suggest that one way to reduce or prevent relapse might be to teach caregivers to provide reinforcers independently of communication responses during time periods when their usual attentiveness to children's requests is disrupted by other events.

Finally, Hoffman and Falcomata (2014) conducted an initial evaluation of the effects on relapse of training multiple communication responses to replace problem behavior (see also Berg et al., 2015, *this issue*). They repeated a four–phase design three times with three children. In the first phase, they trained one mand and then placed it on extinction in the second phase. Subsequently they trained a second mand and then placed it on extinction in the final phase to test for resurgence of the first mand. In 8 of 9 of the resurgence tests, the first mand recurred and this recurrence almost always preceded the recurrence of problem behavior. Although this study did not include direct treatment of problem behavior, it provides preliminary evidence that training multiple communication responses during FCT may enhance maintenance of adaptive responding and thereby reduce relapse by increasing the likelihood that mands will contact reinforcement prior to the recurrence of problem behavior.

Substance abuse treatment. One promising adjunctive procedure in the treatment of substance abuse is augmenting residential and treatment environments with stimuli that enhance sensory, social, and motor functioning (Rosenzweig, 1966). Commonly referred to as *environmental enrichment* (EE), this strategy reduces the reinforcing effects of drugs and drug–seeking behavior (Solinas, Thiriet, El Rawas, Lardeux, & Jaber, 2009). Solinas, Chauvet, Thiriet, El Rawas, and Jaber (2008) used an animal model of EE to test whether it might also reduce relapse. They first conditioned place preferences in mice by repeatedly pairing cocaine injections with a specific compartment within the experimental apparatus. Once stable preferences for these drug–correlated contexts were established, they then were extinguished through daily sessions of exposure to the compartment without injections. During this 10–day extinction phase, the mice were housed between sessions in either standard or enriched environments. Although the groups did not differ in the rate at which place preference extinguished, only the mice housed in the enriched environment showed no recurrence of place preference when cocaine injections were briefly reinstated. From a clinical perspective, these results suggest that environmental enrichment may reduce the likelihood that brief reinstatement conditions (i.e., single or intermittent lapses in drug abstinence) evoke a return to drug–correlated environments and subsequent full–fledged relapse.

In another study of adjunctive procedures designed to reduce the recurrence of drug use, Zlebnik, Anker, Gliddon, and Carroll (2010) examined the influence of making wheel running available to mice during the extinction and reinstatement of self–administration of intravenous cocaine. Concurrent access to wheel running during the reinstatement phase significantly reduced cocaine–seeking behavior. Although neither the findings of Solinas et al. (2008) nor Zlebnik et al. (2010) have been replicated in clinical studies, they suggest that some procedures already in use as adjuncts to core behavioral treatments for addiction (e.g., contingency management) may not only enhance immediate treatment effects but provide some protection against relapse. Moreover, adding enriching stimuli and programmed exercise to treatment environments are relatively inexpensive and technically simple approaches, which greatly increases the feasibility of their widespread implementation as relapse prevention strategies.

Summary and Conclusion

Reducing treatment relapse through the development of behavioral technologies that produce durable and generalized performance gains remains a critically important goal for applied behavior analysts. The translational research studies discussed above suggest that such development is best achieved through a bidirectional process in which technological innovation is inspired by advances in basic discovery research and basic studies are designed to investigate the behavioral processes involved in complex clinical problems. Several lines of research on the basic processes involved in the recurrence of operant behavior have yielded important knowledge about the potential effects of present and historical conditions on the maintenance of desired behavior and the recovery of unwanted behavior. This knowledge has improved the predictions of translational researchers about the conditions under which recurrence is most probable and to design interventions that mitigate the likelihood and magnitude of treatment relapse during treatment integrity failures. However, there are many directions in which continued translational research might be directed. Differing basic accounts have alternatively identified the influence of reinforcer rates and the influence of response rates on recurrence, and these accounts have yet to be resolved. Clinical translations are still at an early stage and require replications and extension to a broader array of behavior topographies and treatment contexts. There is much work to be done. We suggest that it is best done within a unified field of behavior analysis in which EAB and ABA participate together.

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