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THEORETICAL ARTICLE

Do Pavlovian Processes Really Mediate Behavioral Momentum? Some Conflicting Issues

Joseph R. Troisi II[1] · Benjamin C. Mauro[2]

Abstract According to the behavioral momentum theory of response strength (Nevin et al., *Journal of the Experimental Analysis of Behavior*, *53*, 359–379, 1990), steady-state responding reflects the contingency between a response and a reinforcer (response–reinforcer relationship), whereas behavior's resistance to change is mediated by a contingency between a stimulus and the reinforcer (stimulus–reinforcer relationship). It is further presumed in this theory that a Pavlovian conditioned stimulus (CS)–unconditioned stimulus (US) contingency overlaps with the discriminative stimulus (S^D), signaling a primary reinforcer (S^{R+}) within the 3-term contingency (S^D: response [R]–S^{R+}). The mere arranging of a stimulus–reinforcer relation in an operant preparation, however, does not necessarily imply that the resulting behavioral process *is* Pavlovian. This article questions how important such Pavlovian CS–S^{R+} relations really are in governing operant behavior and its resistance to change in view of evidence from the operant and Pavlovian literatures showing dissociation between Pavlovian and operant stimulus control. To this end, we highlight studies published in the Pavlovian associative literature (Holman and Mackintosh, *The Quarterly Journal of Experimental Psychology Section B: Comparative and Physiological Psychology*, *33*, 21–31, 1981; Rescorla, *Current Directions in Psychological Science*, *1*, 66–70, 1992b) as well as at least 1 seldom-cited study published in the *Journal of the Experimental Analysis of Behavior* (Marcucella, *Journal of the Experimental Analysis of Behavior*, *36*, 51–60, 1981) supporting the view that CS relations embedded in the 3-term operant contingency can act independently of the discriminative stimulus functions of the S^D. These CS relations appear to be neither necessary nor sufficient for sustaining operant discriminative control. Pavlovian relations are likely to be artifacts of operant conditioning—*not* causal mediators. It is suggested that continued and excessive focus on Pavlovian processes that only have meager influence on operant behavior in general, and behavioral momentum more specifically, will likely be an empirical cul-de-sac for improvement of behavioral management for addiction relapse and other behavioral disorders.

Keywords Behavioral momentum · Pavlovian stimulus control

✉ Joseph R. Troisi, II
jtroisi@anselm.edu

[1] Department of Psychology, Saint Anselm College, Manchester, NH 03102, USA

[2] Center for Applied Behavior Analysis, The Sage Colleges, Albany, NY, USA

In establishing the experimental analysis of behavior (EAB), Skinner (1938) suggested that the strength of an operant response under both steady-state and transient-state conditions can be measured by its empirical probability of occurrence (e.g., the rate of response per minute): the greater or lesser the response rate, the greater or lesser the response strength, respectively. The changes in response strength are explained by a singular principle of operant reinforcement (i.e., behavior is determined by its consequences). The interrelated expressions of the three-term contingency (discriminative stimulus, behavior, and its consequences) are defined by this most fundamental principle of operant conditioning and learning.

In more recent times, the behavioral momentum theory of response strength (Nevin 1984; Nevin et al. 1983, 1990) suggests that steady-state responding reflects the contingency

between the response and the reinforcer (response–reinforcer relationship), whereas behavior's resistance to change is mediated by a Pavlovian conditioned stimulus–unconditioned stimulus (CS>US) contingency (stimulus–reinforcer relationship). Behavior resists change as a function of the original context-specific rate of reinforcement and the manner in which the contingency between the response and the reinforcer is degraded or disrupted (e.g., by satiation or extinction). Thus, *behavioral mass* is an element of *behavioral momentum* that stands as a second component in measuring response strength.

Catania ([2013]) makes a useful distinction between an environmental operation and a behavioral process. An operation involves the systematic arrangement of environmental stimuli (e.g., stimulus–reinforcer and response–reinforcer relations), whereas a behavioral process is the result of the environmental operation (e.g., change in the likelihood of an operant or Pavlovian response). The mere arranging of a stimulus–reinforcer relation in an operant preparation does not necessarily imply that the resulting behavioral process is Pavlovian. Nevin et al. ([1990]) recognized that the greater behavioral mass (i.e., greater behavioral persistence) given by a higher rate of context-specific reinforcement was not necessarily Pavlovian in nature. These authors stated that specific (i.e., CS eliciting a conditional response [CR]) and/or nonspecific (i.e., CS suppresses or accelerates the rate of an operant response) Pavlovian effects may have modulated operant behavior during resistance to change tests (i.e., disrupting responding through operant extinction or satiation). However, they also indicated that this account of behavioral persistence remains a hypothesis because they did not directly measure such Pavlovian processes. Similarly, Mauro and Mace ([1996]) deliberately omitted an interpretation of behavioral mass in terms of Pavlovian processes and kept their interpretation of behavioral mass at the level of environmental operations. Subsequent behavioral momentum research has not fully heeded these cautions (see the next section, Imputations of Pavlovian Processes in Behavioral Momentum).

The objective of this article is not to exhaustively review the details of the methods and results of the many studies published on behavioral momentum theory, although it does provide a review of the momentum literature to highlight references to Pavlovian processes in behavioral momentum. Of greater emphasis, this article questions how important such Pavlovian CS–primary reinforcer (S^{R+}) relations really are in governing operant behavior and its resistance to change in view of literatures showing dissociation between Pavlovian and operant stimulus control. To this end, we highlight studies published in the Pavlovian associative literature as well as in at least one seldom-cited study published in the *Journal of the Experimental Analysis of Behavior* (*JEAB*) supporting the view that CS relations embedded in the *three-term operant contingency* [S^D]: [R]–S^{R+}) can act independently of the

discriminative stimulus functions of the S^D—and appear to be neither necessary nor sufficient for sustaining operant discriminative control. At best, the influence of a CS over operant responding is relatively weak and ineffective.

Imputations of Pavlovian Processes in Behavioral Momentum

Early Research on Behavioral Momentum

Nevin et al.'s ([1983]) experiment was an early procedural attempt at testing the validity of the behavioral momentum metaphor (i.e., allegorically extending the physicist's notion of momentum to behavior). They used a two-component multiple schedule of reinforcement with a rich and lean schedule of food reinforcement alternating across time, with each component schedule signaled by its own unique exteroceptive stimulus (i.e., a successive discrimination between red and green keys). The response disruptors used to assess resistance to change of the pigeon's key pecking was either the discontinuation of reinforcement (i.e., extinction) or the presentation of noncontingent food reinforcement between the components of the multiple schedules (i.e., satiation). They demonstrated that behavior's resistance to change is greater in the stimulus-specific situation with the higher rate of food reinforcement (i.e., greater behavioral mass in the component signaling the higher rate of food reinforcement). However, it was unclear at this point if the increase in behavioral mass was attributable to operant or Pavlovian contingencies.

Nevin et al. ([1990]) subsequently determined if differences in behavior's resistance to change were attributable to the response–reinforcer relation (i.e., the operant contingency) or the stimulus–reinforcer relation (the Pavlovian contingency). During baseline, they systematically presented food reinforcement as an alternative to a food-reinforced target response. This alternative reinforcement was presented either independent of the target response (Experiment 1) or contingent upon some response alternative to the target response (Experiment 2). In both experiments, Nevin et al. ([1990]) conducted tests of behavioral persistence following baseline conditions. These demonstrated that the persistence of a response (pigeons pecking a circular disc) in the presence of a stimulus depended more on the stimulus–reinforcer relation (Pavlovian contingency) than on the response–reinforcer relation (operant contingency). This momentum effect was demonstrated irrespective of the source of alternative reinforcement (i.e., irrespective of noncontingent or contingent alternative reinforcement). These experimental preparations (especially Experiment 2 in Nevin et al. [1990]) have not only served as the foundation for advancing behavioral momentum theory within EAB but have also often been cited in the clinical and applied research literature supporting a behavioral momentum interpretation of treatment relapse

(Podlesnik et al. 2012) and other behavioral disorders (Mace et al. 2010; Pritchard et al. 2014).

Allusions to Pavlovian Processes

Despite earlier cautions (Mauro and Mace 1996; Nevin et al. 1990), references to Pavlovian processes in behavioral momentum endure in review, conceptual, and experimental research articles (Grace and Nevin 1997; Nevin 2009; Nevin and Grace 1999, 2000; Nevin and Shahan 2011; Podlesnik et al. 2013; Podlesnik and Kelley 2015). To quote Podlesnik et al. (2013), "the Pavlovian relation between a discriminative-stimulus context and reinforcement determines resistance to disruption (i.e., stimulus-reinforcer)" (p. 27). This quote echoes a similar statement from a prior study (Podlesnik et al. 2012, pp. 169–170). Unfortunately, the repeated references to such Pavlovian involvement may erroneously perpetuate the untested hypothesis that Pavlovian processes mediate resistance to change of operant behavior under specific schedule control; that is, "resistance to change is a function of Pavlovian stimulus–reinforcer relations and not operant response–reinforcer relations" (Podlesnik et al. 2012, p. 169). The word *is* in the preceding quote suggests that Pavlovian processes are solely responsible for modulation of resistance to extinction of operant behavior, but it may be premature to rule out other procedural means (S^D–S^{R+} relation) of promoting the end result (i.e., differences in behavior's resistance to change). Moreover, in their conceptual paper on translational research and treatment relapse, Podlesnik and Kelley (2015) point out that Pavlovian processes define behavior's resistance to disruption in at least three separate instances.

Dissociating Pavlovian and Operant Stimulus Control

Isolating CS and S^D Functions

In two experiments, Holman and Mackintosh (1981) functionally isolated Pavlovian CS and operant S^D functions of antecedent exteroceptive stimuli embedded in the three-term operant contingency by using the Kamin (1968) blocking procedure. In the first experiment, two groups of rats initially underwent an equal number of operant S^D sessions and Pavlovian CS sessions with alternate CSs and S^Ds (noise or tone) that were counterbalanced across animals. The reinforcement density was held constant by a within-subject yoked design from the operant to the Pavlovian sessions. In the first phase, a clicker first functioned as a CS and was paired with noncontingent food delivery as the Pavlovian US for one group of rats. For a second group, the clicker functioned as an operant S^D that set the occasion for lever pressing that was maintained by the same food reinforcer. In the second phase, a light (novel to both groups) was added to the clicker to form a clicker–light compound CS

that was paired with the food US for both groups. During a test phase, the light evoked little conditioned responding as measured by magazine entry (i.e., initial conditioning to the clicker "blocked" further conditioning to the light) in the group for which the clicker first functioned as a CS—but not for the group for which it functioned as an operant S^D, in which case there was considerable responding to the light.

In the second experiment (Holman and Mackintosh 1981), the initial training for the first phase was identical to that in the first experiment. In the first phase, a tone first functioned as an S^D for lever pressing for one group of rats; for a second group, it functioned as a CS. During the second phase, a light was added to the tone, and the compound functioned as an S^D for both groups. Under these conditions, the light alone evoked lever pressing only for the group for which the tone first functioned as a CS in Phase 1, but not for the group for which the tone first functioned as an S^D. The first experiment demonstrates that the S^D in the first phase did not acquire CS functions to block such CS functions to the light in the second phase. Despite pre-existing CS functions of the tone element within the tone–light compound, the light alone functioned effectively as an S^D; that is, blocking the development of CS functions does not impede operant discriminative control. Interestingly, the S^D function of the tone blocked such functions of the light—not as a function of CS–US contingencies, but rather because of hierarchical control that the tone acquired over the lever–S^{R+} relationship that disrupted that ability of the light. Taken together, these experiments illustrate the relative independence of operant S^D control from elicited Pavlovian CS control. A Pavlovian CS–US relation is not necessary for the development of operant discriminative functions.

To quote Holman and Mackintosh (1981):

> The results find little encouragement for the view that discriminative stimuli inevitably become classical CSs for the instrumental reinforcer whose availability they signal, let alone for the stronger claim that it is by virtue of their status as CSs that they come to control instrumental responding. (p. 29)

Their statement has strong implications for a behavioral momentum theory of response strength (Nevin et al. 1990). If an S^D is unlikely to serve as a conventional CS, then its role as a Pavlovian CS in determining the resistance to change of operant responding (i.e., behavioral mass) becomes questionable.

Hierarchical Function of S^D in Altering Response–Reinforcer Relation

The work of Rescorla and Colwill (Colwill and Rescorla 1988, 1990; Rescorla 1990, 1992a, 1994, 1995; Rescorla

and Colwill 1989) has demonstrated that the operant S^D functions *hierarchically* in modulating the R–S^{R+} relationship (e.g., see Rescorla 1992b, for a review) and that the S^D–S^{R+} relation within the operant three-term relationship is not reducible to a CS–US relationship (Rescorla 1994). Presenting the S^D alone (Pavlovian extinction) does not impair discriminative control; extinction of the R–S^{R+} relationship alone without the S^D present does not disrupt discriminative control by the S^D; and transfer analyses reveal that extinction of an R_1–S^{R+} relationship with an alternative S^{DA} that occasioned the same reinforcer for a different response (R_2–S^{R+}) does not disrupt discriminative control by the original S^{DO} over the R_1–S^{R+} relationship. This final effect suggests that the S^D–R relationship is more critical for discriminative control than the S^D–S^{R+} relationship. Finally, CSs have less impact on operant responding during transfer than operant S^Ds. Similar to the work by Holman and Mackintosh (1981), the research on hierarchical control raises considerable doubt about the role of Pavlovian processes in determining operant behavior's resistance to change.

CS and S^D Act Independently in the Three-Term Operant Contingency

A seldom-cited (for one of seven citations, see Hineline 1986) but rather interesting set of studies by Marcucella (1981) has considerable relevance to a behavioral momentum theory of response strength. This author demonstrated comparable results to those obtained by Holman and Mackintosh (1981) in terms of dissociating operant and Pavlovian stimulus functions. With pigeons, these studies used one key light (rather than two) that changed color for various durations during mixed schedules (i.e., two reinforcement schedules alternating during the same exteroceptive stimulus) to study behavioral contrast.

Experiment 1 (Condition 1) During the initial condition, a white key light was present continuously during mixed variable interval (VI) 1-min schedules. A brief 1.5-s interval of extinction occurred between each of the two VI schedules. Pecking during these brief 1.5-s intervals did not result in food reinforcement, although the meeting of the schedule requirements for each of the two VI schedules was consequated by brief access to grain. The transitions between VI reinforcement and extinction were indistinguishable, at least from the pigeon's perspective (i.e., the white lights remained illuminated throughout the mixed-schedule procedure).

Experiment 1 (Condition 2) During the second condition, the key light during the 1.5-s interval was illuminated red and transitioned to the white VI 1-min schedule. Responding during the red (or green) remained without consequence (Pavlovian pecking). Responding to white on the VI schedule resulted in grain delivery (operant pecking). The key light was then illuminated green for 1.5 s and again transitioned to the other white VI 1-min schedule, which also resulted in grain. Responding to red and green decreased to near-zero rates during this condition.

Experiment 1 (Condition 3) During the third condition, responding to white that was preceded by green was extinguished, but responding to white that was preceded by red was not. Initially, responding to green decreased to near-zero, but responding to red (Pavlovian pecking) increased dramatically (thus showing behavioral contrast). Later during this condition, there was an increase in responding to white that was preceded by red (operant responding), but responding to white that was preceded by green diminished modestly and gradually showed operant behavioral contrast. Thus, despite extinction of the green's S–S relation to food, operant responding to white persisted during extinction and only gradually diminished.

Experiment 1 (Condition 4) Most interestingly, in the fourth condition, green was illuminated for 60 s, but pecking remained nonreinforced. Under this condition, responding to the 1.5-s red stimulus (i.e., the Pavlovian activity) *decreased* precipitously, but responding to white that was preceded by red (operant activity) increased. Here, extinction of *all* Pavlovian activity increased the rate of operant activity instead of decreasing it.

Synthesis of Experiment 1 with Experiment 2 The effect and the dissociation were even more pronounced in a second experiment with shape stimuli in lieu of red and green with different birds. Collectively, these studies not only showed that behavioral contrast promoted by Pavlovian and operant contingencies function independently; they also elegantly demonstrated that despite extinction of Pavlovian stimulus control, operant behavior with the same response topography persisted. The findings appear to be inconsistent with the premise that CS–S^{R+} relations causally mediate resistance to change as asserted in behavioral momentum theory. Of course, behavioral momentum experiments employ multiple schedules rather than mixed schedules, and Pavlovian contingencies may likely differ considerably on those. Nevertheless, this point is open to further experimental work.

Operant–Pavlovian Interactions

Thus far, several diverse studies from two extant literatures revealed that operant and Pavlovian relations are dissociated. Under the circumstances given by these studies, Pavlovian relations can affect the ongoing rate of free-operant responding. The first demonstration of this, of course, was noted by Estes and Skinner (1941), who showed that an aversive CS

suppressed appetitive lever pressing in rats. This assay has been a staple in the classical conditioning literature (i.e., conditioned suppression). Similar studies have also revealed that appetitive Pavlovian CSs increase the rate of operant levels—commonly referred to as Pavlovian–instrumental transfer (PIT; e.g., Holland 2004). A PIT study conducted by the first author (Troisi 2006) first trained rats to lever-press on a VI 1-min schedule. During a second phase, the levers were removed and noncontingent food was presented on a variable time (VT) 1-min schedule. During 10 sessions, presession administration of nicotine predicted food delivery (CS+ drug), and during 10 other intermixed sessions, EtOH (alcohol) predicted nonreinforcement (CS− drug). The drug roles were counterbalanced across two squads of rats. When the levers were protracted, the CS+ drug evoked significantly more lever pressing compared to the CS− drug condition, showing PIT. However, the results were not that robust in promoting a strong discrimination index (approximately 74% CS+ responding) compared to operant drug discriminations (promoting more than 85% S^D responding) with only 14 training sessions (Troisi 2006). In fact, when the drugs were later established as operant S^Ds in a second experiment, there was substantially more separation in rates of responding, and the discrimination index increased to 95%. These results showed that Pavlovian interoceptive CSs have less impact on operant behavior compared to operant S^Ds (see Troisi 2013a, b, for other examples). If the CS effect is minimized, then it is less likely for one to argue that it would play much of a role in influencing behavior's resistance to change (i.e., behavioral mass within behavioral momentum theory).

However, even under circumstances in which the "representation" of the US by the CS is disrupted, the rate of operant responding can go unchanged. For example, in one investigation, Parkinson et al. (2005) initially paired a 5-s light with an appetitive sucrose reinforcer in rats. In the second phase, lever pressing was acquired and maintained by the "conditioned reinforcing" function of the light (new response method). Responding on only one of two levers (the active lever) illuminated the light. In the third phase, the US was "devalued" by lithium chloride (i.e., an abolishing operation). Despite this US devaluation, the light continued to maintain lever pressing. Thus, the conditioned reinforcing effect of the Pavlovian CS was not necessarily sustained by evoking an original "representation" of the US, for when this representation was abolished, the original R–CS relationship remained intact.

In a related study, Corbit and Balleine (2003) trained rats to respond on a heterogeneous operant chain that was maintained by one of two reinforcing outcomes (food pellets or sucrose). The rats were either sated or not. A Pavlovian appetitive CS increased the rate of responding of the proximal—but not distal—response when rats were food restricted. Under satiety, the impact was reversed. This effect was specific to a CS that was previously paired with the food reinforcer but not with the

CS previously paired with sucrose. These results showed that Pavlovian stimuli have varied effects on different responses within an operant chain depending on where the response is in relation to the primary reinforcer and whether or not the specific reinforcer was "devalued" (rat sated). Pavlovian and instrumental "incentive learning" act independently (Troisi et al. 2012).

Synthesis of Research and Clinical Implications

By now, it should be evident that (a) Pavlovian CS–US contingencies are dissociated within the operant three-term relationship, (b) Pavlovian contingencies are neither necessary nor sufficient for operant discriminative control, and (c) operant discriminative stimuli have more dramatic impacts on operant behavior compared to Pavlovian CSs. From a clinical perspective, the critical question is: Just how important are Pavlovian stimuli really in modulating resistance to extinction of operant behavior when compared to antecedent S^Ds that were embedded in the three-term relation? Behavioral momentum theory has increased in popularity as a working model to study resistance to change of dysfunctional behavioral repertoires (e.g., overeating, drug abuse, gambling, and other compulsive behavioral disorders; e.g., MacDonald et al. 2013; Nevin 1993). At least from the standpoint of understanding relapse, operant S^Ds, unlike Pavlovian stimulus–reinforcer relations, have been shown to reinstate extinguished operant responding when presented contingently and noncontingently on behavior. By contrast, Pavlovian CSs reinstate extinguished operant responding *only* if presented contingently. For example, Di Ciano and Everitt (2003) conducted a study in which an exteroceptive S^D occasioned operant responding in rats that was maintained by intravenous heroin administration. For a second group, a CS was paired with the heroin following completion of the schedule. Operant extinction was then carried out. The S^D reinstated extinguished responding when presented either contingently on responding or when presented noncontingently. The CS, however, only reinstated responding when presented contingently. A prior investigation by McFarland and Ettenberg (1997) produced similar results. These studies showed that the operant S^D has a more robust modulatory impact on extinguished operant behavior than the Pavlovian S–S relations. The data also suggest that Pavlovian stimuli are rather weak secondary reinforcers (see Troisi 2013a, for more detailed discussions of these issues).

Of course, noncontingent reinforcement presented during acquisition of operant responding certainly weakens the response–reinforcer contingency (Hammond 1980). By contrast, Nevin et al. (1990) imposed such noncontingent delivery of the primary reinforcer (alternative reinforcement) during extinction of responding in a multiple schedule. This arrangement not only weakened the response–reinforcer relationship but also presumably promoted the emergence of a Pavlovian S–S^{R+}

relationship between the S^D and the reinforcer and between the context and the reinforcer. Imposing such presumed Pavlovian contingencies on ongoing operant activity may retard extinction; however, it does not logically follow that such Pavlovian contingencies naturally emerge during acquisition of the three-term contingency within a multiple schedule. Just as CS–US relations can affect instrumental responding, as in PIT, imposing such contingencies may be but one means to promote resistance to change during operant extinction. Hypothetically, if one were to impose an alternative S^D linked to the same reinforcer for an alternative and topographically different response during extinction (one in which responding was not extinguished), would such a stimulus not have a more powerful effect on impeding the rate of change as measured by proportion of baseline responding compared to a Pavlovian CS that was merely paired with the US? Second, following extinction, which stimulus would be expected to promote more recovery of responding when presented contingently or noncontingently? The studies summarized earlier suggest that the S^D would have a more robust effect than the CS in promoting resistance and also in promoting recovery of responding—but not because of an existing stimulus–reinforcer relationship. Furthermore, if one were to carry out a blocking design to block CS–US relations of an operant S^D, would such an S^D, when superimposed on free operant responding, promote more resistance to extinction compared to an S^D that did not have CS functions blocked first or compared to a Pavlovian CS—all of which presented noncontingently versus contingently on responding?

It could be that the presumed Pavlovian relations governing resistance to change in typical behavioral momentum studies are peculiar to the methods imposed rather than categorical demonstrations that Pavlovian stimulus–reinforcer relations per se are the culprits of resistance to change and relapse—as implicitly suggested by Shahan et al. (published in *JEAB*; see Podlesnik et al. 2013, for reviews). On balance, perhaps the methods that promote behavioral momentum represent a very peculiar instance of PIT. But if this is true, then such demonstrations may require more extensive between-group comparisons with stimuli that are randomly correlated with the reinforcer or explicitly unpaired to rule out pseudoconditioning and other nonassociative phenomena that affect the rate of operant responding (e.g., Rescorla 1967). Moreover, if other contextual stimuli promote Pavlovian stimulus–reinforcer relations that mediate resistance to change, then mere exposure to the context by removal of operant response manipulanda theoretically should extinguish the context–reinforcer relationship according to the standard models of associative learning (e.g., the Rescorla–Wagner model) such that when the response manipulanda are reintroduced to the organism, recovery is imminent. Bouton et al. Bouton et al. 2011 Experiment 4) conducted this study and found that direct extinction of the context in which lever pressing was acquired had no impact on renewal of extinguished lever pressing that was carried out in a different

context (applied behavior analysis [ABA] renewal). This suggests that stimulus control by the context in which operant extinction is carried out does not affect the response rate merely by a direct relationship with the reinforcer (i.e., stimulus–reinforcer relationship) but rather in a more hierarchical occasion-setting manner (see Bouton and Swartzentruber 1986, 1989); that is, the context sets the occasion for an R–S^{R+} relationship. When the manipulanda are reinserted and the discriminative stimuli that occasioned operant activity are presented, recovery of responding is renewed. It is unclear whether the presumed stimulus–reinforcer relations, as suggested by Nevin et al. (1990), are CS–US in nature or more hierarchical occasion setting–like stimuli. Nevin (1993) suggested that extinction of operant activity may be more clinically useful if conducted outside of the context in which it was established. However, returning to the original context would likely promote ABA operant renewal through the occasion-setting function of the context.

Concluding Comments

To conclude, Pavlovian relations are likely to be artifacts of operant conditioning—*not* causal mediators. Expanding the extent to which other sorts of operant stimuli control phenomena (e.g., stimulus equivalence; see Dougher et al. 1994) that promote resistance to change in operant behavior will only enhance clinical translation—certainly for substance abuse relapse (Troisi 2013a, b, 2015). Moreover, an overstatement of the role of Pavlovian processes may have misleading implications for other ABA treatments for problematic behavior such as the high-probability treatment of noncompliance (Mace et al. 1988) and the deleterious, persistence-altering effect of differential reinforcement of alternative behavior (Mace et al. 2010). Continued and excessive focus on Pavlovian processes that only have a meager impact on operant behavior in general, and behavioral momentum specifically, will likely be an empirical cul-de-sac for behavioral management.

References

Bouton, M. E., & Swartzentruber, D. (1986). Analysis of the associative and occasion-setting properties of contexts participating in a

Pavlovian discrimination. *Journal of Experimental Psychology: Animal Behavior Processes, 12*, 333–350. https://doi.org/10.1037/0097-7403.12.4.333.

Bouton, M. E., & Swartzentruber, D. (1989). Slow reacquisition following extinction: Context, encoding, and retrieval mechanisms. *Journal of Experimental Psychology: Animal Behavior Processes, 15*, 43–53. https://doi.org/10.1037/0097-7403.15.1.43.

Bouton, M. E., Todd, T. P., Vurbic, D., & Winterbauer, N. E. (2011). Renewal after the extinction of free operant behavior. *Learning & Behavior, 39*, 57–67.

Catania, A. C. (2013). *Learning* (5th ed.). Cornwall-on-Hudson: Sloan Publishing.

Colwill, R. M., & Rescorla, R. A. (1988). Associations between the discriminative stimulus and the reinforcer in instrumental learning. *Journal of Experimental Psychology: Animal Behavior Processes, 14*, 155–164. https://doi.org/10.1037/0097-7403.14.2.155.

Colwill, R. M., & Rescorla, R. A. (1990). Evidence for the hierarchical structure of instrumental learning. *Animal Learning & Behavior, 18*, 71–82.

Corbit, L. H., & Balleine, B. W. (2003). Instrumental and Pavlovian incentive processes have dissociable effects on components of a heterogeneous instrumental chain. *Journal of Experimental Psychology: Animal Behavior Processes, 29*, 99–106. https://doi.org/10.1037/0097-7403.29.2.99.

Di Ciano, P., & Everitt, B. (2003). Differential control over drug-seeking behavior by drug-associated conditioned reinforcers and discriminative stimuli predictive of drug availability. *Behavioral Neuroscience, 117*, 952–960.

Dougher, M. J., Augustson, E. M., Markham, M. R., Greenway, D., & Wulfert, E. (1994). The transfer of respondent eliciting and extinction functions through stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior, 62*, 331–335.

Estes, W. K., & Skinner, B. F. (1941). Some quantitative properties of anxiety. *Journal of Experimental Psychology, 29*, 390–400.

Grace, R. C., & Nevin, J. A. (1997). On the relation between preference and resistance to change. *Journal of the Experimental Analysis of Behavior, 67*, 43–65.

Hammond, L. J. (1980). The effect of contingency upon the appetitive conditioning of free-operant behavior. *Journal of the Experimental Analysis of Behavior, 34*, 297–304.

Hineline, P. N. (1986). Re-tuning the operant-respondent distinction. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and integration of behavioral units* (pp. 55–79). Hillsdale: Erlbaum.

Holland, P. C. (2004). Relations between Pavlovian-instrumental transfer and reinforcer devaluation. *Journal of Experimental Psychology: Animal Behavior Processes, 30*, 104–117. https://doi.org/10.1037/0097-7403.30.2.104.

Holman, J. G., & Mackintosh, N. J. (1981). The control of appetitive instrumental responding does not depend upon classical conditioning to the discriminative stimulus. *The Quarterly Journal of Experimental Psychology Section B: Comparative and Physiological Psychology, 33*, 21–31.

Kamin, L. J. (1968). 'Attention-like' processes in classical conditioning. In M. R. Jones (Ed.), *Miami symposium on the prediction of behavior: Aversive stimulation* (pp. 9–33). Miami: University of Miami Press.

MacDonald, J. M., Ahearn, W. H., Parry-Cruwys, D., Bancroft, S., & Dube, W. V. (2013). Persistence during extinction: Examining the effects of continuous and intermittent reinforcement on problem behavior. *Journal of Applied Behavior Analysis, 46*, 333–338. https://doi.org/10.1002/jaba.3.

Mace, F. C., Hock, M. L., Lalli, J. S., West, B. J., Belfiore, P., Pinter, E., & Brown, D. K. (1988). Behavioral momentum in the treatment of noncompliance. *Journal of Applied Behavior Analysis, 21*, 123–141.

Mace, F. C., McComas, J. J., Mauro, B. C., Progar, P. R., Taylor, B., Ervin, R., & Zangrillo, A. N. (2010). Differential reinforcement of alternative behavior increases resistance to extinction: Clinical demonstration, animal modeling, and clinical test of one solution. *Journal of the Experimental Analysis of Behavior, 93*, 349–367.

Marcucella, H. (1981). Stimulus control of respondent and operant key pecking: A single key procedure. *Journal of the Experimental Analysis of Behavior, 36*, 51–60.

Mauro, B. C., & Mace, F. (1996). Differences in the effect of Pavlovian contingencies upon behavioral momentum using auditory versus visual stimuli. *Journal of the Experimental Analysis of Behavior, 65*, 389–399.

McFarland, K., & Ettenberg, A. A. (1997). Reinstatement of drug-seeking behavior produced by heroin-predictive environmental stimuli. *Psychopharmacology, 131*, 86–92.

Nevin, J. A. (1984). Pavlovian determiners of behavioral momentum. *Animal Learning & Behavior, 12*, 363–370. https://doi.org/10.3758/BF03199981.

Nevin, J. A. (1993). Behavioural momentum: Implications for clinical practice. *Behaviour Change, 10*, 162–168.

Nevin, J. (2009). Stimuli, reinforcers, and the persistence of behavior. *The Behavior Analyst, 32*, 285–291.

Nevin, J. A., & Grace, R. C. (1999). Does the context of reinforcement affect resistance to change? *Journal of Experimental Psychology: Animal Behavior Processes, 25*, 256–268. https://doi.org/10.1037/0097-7403.25.2.256.

Nevin, J. A., & Grace, R. C. (2000). Behavioral momentum and the law of effect. *Behavioral and Brain Sciences, 23*, 73–130.

Nevin, J. A., & Shahan, T. A. (2011). Behavioral momentum theory: Equations and applications. *Journal of Applied Behavior Analysis, 44*, 877–895. https://doi.org/10.1901/jaba.2011.44-877.

Nevin, J. A., Mandell, C., & Atak, J. R. (1983). The analysis of behavioral momentum. *Journal of the Experimental Analysis of Behavior, 39*, 49–59.

Nevin, J. A., Tota, M. E., Torquato, R. D., & Shull, R. L. (1990). Alternative reinforcement increases resistance to change: Pavlovian or operant contingencies? *Journal of the Experimental Analysis of Behavior, 53*, 359–379. https://doi.org/10.1901/jeab.1990.53-359.

Parkinson, J. A., Roberts, A. C., Everitt, B. J., & Di Ciano, P. P. (2005). Acquisition of instrumental conditioned reinforcement is resistant to the devaluation of the unconditioned stimulus. *The Quarterly Journal of Experimental Psychology Section B: Comparative and Physiological Psychology, 58*, 19–30. https://doi.org/10.1080/02724990444000023.

Podlesnik, C. A., & Kelley, M. E. (2015). Translational research on the relapse of operant behavior. *Mexican Journal of Behavior Analysis, 41*, 226–251.

Podlesnik, C. A., Bai, J. H., & Elliffe, D. (2012). Resistance to extinction and relapse in combined stimulus contexts. *Journal of the Experimental Analysis of Behavior, 98*, 169–189. https://doi.org/10.1901/jeab.2012.98-169.

Podlesnik, C. A., Jimenez-Gomez, C., & Shahan, T. A. (2013). Are preference and resistance to change convergent expressions of stimulus value? *Journal of the Experimental Analysis of Behavior, 100*, 27–48. https://doi.org/10.1002/jeab.33.

Pritchard, D., Hoerger, M., Mace, F. C., Penney, H., & Harris, B. (2014). Clinical translation of animal models of treatment relapse. *Journal of the Experimental Analysis of Behavior, 101*, 442–449.

Rescorla, R. A. (1967). Pavlovian conditioning and its proper control procedures. *Psychological Review, 74*, 71–80. https://doi.org/10.1037/h0024109.

Rescorla, R. A. (1990). Evidence for an association between the discriminative stimulus and the response-outcome association in instrumental learning. *Journal of Experimental Psychology: Animal Behavior Processes, 16*, 326–334.

Rescorla, R. A. (1992a). Associations between an instrumental discriminative stimulus and multiple outcomes. *Journal of Experimental Psychology: Animal Behavior Processes, 18*, 95–104.

Rescorla, R. A. (1992b). Hierarchical associative relations in Pavlovian conditioning and instrumental training. *Current Directions in Psychological Science, 1*, 66–70. https://doi.org/10.1111/1467-8721.ep11509749.

Rescorla, R. A. (1994). Control of instrumental performance by Pavlovian and instrumental stimuli. *Journal of Experimental Psychology: Animal Behavior Processes, 20*, 44–50. https://doi.org/10.1037/0097-7403.20.1.44.

Rescorla, R. A. (1995). Full preservation of a response–outcome association through training with a second outcome. *Quarterly Journal of Experimental Psychology, 48*, 252–261.

Rescorla, R. A., & Colwill, R. M. (1989). Associations with anticipated and obtained outcomes in instrumental learning. *Animal Learning & Behavior, 17*, 291–303. https://doi.org/10.3758/BF03209802.

Skinner, B. F. (1938). *The behavior of organisms*. New York: Appleton-Century-Crofts.

Troisi II, J. R. (2006). Pavlovian-instrumental transfer of the discriminative stimulus effects of nicotine and ethanol in rats. *The Psychological Record, 56*, 499–512.

Troisi II, J. R. (2013a). Perhaps more consideration of Pavlovian–operant interaction may improve the clinical efficacy of behaviorally based drug treatment programs. *The Psychological Record, 63*, 863–894.

Troisi II, J. R. (2013b). The Pavlovian vs. operant interoceptive stimulus effects of EtOH: Commentary on Besheer, Fisher, & Durant (2012). *Alcohol, 47*, 433–436.

Troisi II, J. R. (2015). Sensation within the skin. *ACS Chemical Neuroscience, 6*, 209–210. https://doi.org/10.1021/cn500300a.

Troisi II, J. R., Bryant, E., & Kane, J. (2012). Extinction of the discriminative stimulus effects of nicotine with a devalued reinforcer: Recovery following revaluation. *The Psychological Record, 62*, 707–718.