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Contingent Reinforcement in Context

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Catania has described the essential features of contingent reinforcement with his usual precision and clarity. What we would like to contribute to this discussion is to draw attention to contingent reinforcement in its broader context. To a large extent, it is this broader context that influences the effect contingent reinforcement has on behavior. This broader context is defined by the familiar topics in learning theory of *performance*, *learning*, and *motivation* (Nevin & Grace, 2000), and more contemporaneously as the Matching Law, Response Strength or Behavioral Momentum, and Motivating Operations. Together these contexts operate to affect relative response rates and resistance to change as products of contingent reinforcement.

The Matching Law

Herrnstein's seminal work on the Matching Law demonstrated that the effects of contingent reinforcement were best considered as relative rather than absolute (Herrnstein, 1961; 1970). His work explicitly recognized that virtually all environments contain multiple sources of reinforcement. Some of these are experimentally arranged in the course of an experiment, while other sources of reinforcement are extraneous and often cannot be controlled. Nonetheless, these other sources of reinforcement compete with experimental contingencies to strengthen behaviors other than those that activate experimental manipulanda. And as these other sources increase in frequency or value, there is proportionally less behavior directed toward the manipulandum. This holds true whether the experiment arranges a single schedule of reinforcement or two or more schedules of reinforcement concurrently. The distribution of responding across available alternatives can be understood as measures of *performance*.

This lawful relation extends even more broadly. When reinforcers are delivered independent of responding at the same time one or more schedules of contingent reinforcement are available (e.g., a variable interval, variable time schedule—VI VT), the response rates producing contingent reinforcement are predictably reduced (Mace, Lalli, Shea, Lalli, West, Roberts, & Nevin, 1990; Nevin, Tota, Torquato, & Shull, 1990; Rachlin & Baum, 1972). The influence further extends to sources of reinforcement available in temporally different contexts. The phenomenon known as *behavioral contrast* occurs in a multiple schedule of reinforcement when a change of reinforcement in one schedule component influences responding in other schedule components that were unchanged (Reynolds, 1961). Thus, the effects of any given reinforcement schedule are influenced considerably by alternative sources of reinforcement, be they available concurrently or temporally distant from present performance. This is a powerfully significant context in which contingent reinforcement must be understood.

Perhaps the most significant implication of Herrnstein's formulation for applied behavior analysts is the conceptualization of all operant behavior as *choice behavior*. Because the goal of many ABA interventions is to change socially meaningful behavior, the applied behavior analyst is now compelled to identify multiple target behaviors for change. Some of these target behaviors will be undesirable in the client's social context, while others may be chosen because they are both socially desirable and to produce reinforcers that are functionally equivalent or of greater value

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than those that reinforced the undesirable target behavior(s). This is the logic that underpins differential reinforcement of alternative behavior (DRA), in general, and that is exemplified in Functional Communication Training (FCT), one of the most widely used interventions for reducing undesirable behavior in children and individuals with developmental disabilities (Carr & Durand, 1985).

Baum (1974) further developed Herrnstein's Matching Law equation to accommodate asymmetrical choices, known as the Generalized Matching Law. Response alternatives may differ with respect to the response requirements necessary to produce reinforcement and on various dimensions of reinforcement, such as reinforcer frequency, reinforcer delay, reinforcer quality, and reinforcer amount. Baum's work has had important implications for practitioners and applied researchers. In natural human environments, nearly all response alternatives or choices are asymmetrical. Choices commonly differ in terms of what they produce, how often and how much they produce, and how long one has to wait for the desired outcome. And response requirements for most response alternatives are nearly always different in terms of the cognitive activity required and/or the caloric expenditure exchanged for reinforcers (Neef, Bicard, Endo, Coury, & Aman, 2005). All of these variables combine to define the *value* of each response alternative, which in turn affects relative performance. Thus, to be in a position to predict the effect a given contingent reinforcement operation will have on behavior, it is critical to understand it within the context of the relative value of available response alternatives.

Response Strength and Behavioral Momentum

The term *response strength* in operant psychology has traditionally referred to the resistance of responding to change when the relationship between the response and the reinforcer is challenged by a disruptive operation of some kind (Nevin, 1974, 1979). It is a key dimension of reinforced behavior and reflects the durability of performance following repeated exposure to contingent reinforcement, commonly referred to as *learning* (Nevin & Grace, 2000). Resistance to change is often studied using multiple schedules of reinforcement. Following stable baseline responding in the components of the multiple schedule, a challenge or disruptor is introduced. Common disruptors include extinction, satiation, pre-session feeding, dark-key food deliveries, distraction, psychoactive drugs, punishment, alternative contingent reinforcement, and response independent reinforcer deliveries. The relative resistance of baseline response rates to change is examined in the presence of these disruptors.

Nevin proposed an analogy between the momentum of objects in motion subject to an opposing force and the momentum of free operant behavior in the presence of a discriminative stimulus when the response-reinforcer relation is disrupted (Nevin, Mandel, & Atak, 1983). In Newton's physics, the momentum of objects in motion is a product of mass and velocity. In Nevin's metaphor, response rate is analogous to behavioral velocity and the resistance to change of its velocity is behavioral mass. Nevin et al. (1990) later demonstrated that resistance to change, or behavioral mass, is a function of all sources of reinforcement obtained in the context that the reinforced behavior occurs. That is, the momentum of Behavior A maintained by contingent reinforcement increases as the rate of contingent reinforcement for Behavior A increases. However, the momentum of Behavior A also increases as the sum of reinforcement increases in the context that Behavior A is reinforced. This could include reinforcement for Behavior B, Behavior C, and so on, and noncontingent reinforcer deliveries occurring in the same context.

Nevin and Grace (2000) presented a unifying theory of choice and behavioral momentum. A main thesis of this theory is that the variables that are functionally related to choice are also those that determine relative resistance to change. In other words, the variables that contribute to the value of response alternatives are the same as those that contribute to response strength. For Nevin and Grace, the unifying construct that affects both *performance* and *learning* is behavioral mass. Mace, Mauro, Boyajian, and Eckert (1997) provided indirect support for this unifying theory. Mace et al. found that the high-probability (high-p) instructional sequence (an intervention inspired by the momentum metaphor) was ineffective for improving compliance to some instructions. In an attempt to increase the procedure's effectiveness, an additional high quality reinforcer (food) was supplied for compliance to high-p instructions. This modification to the high-p treatment resulted in improved compliance. Knowing that reinforcer quality affects choice, we reasoned that it would also increase the momentum of compliance. In a subsequent experiment, Mace et al. (1997) presented rats with equal VI VI multiple schedules but one component used a sucrose solution as the reinforcer while the other component used a saline solution. As Nevin and Grace would have predicted, resistance to extinction was greater in the component with the preferred sucrose solution.

Like choice, resistance to change must be understood in the broader context of the relative value of response alternatives. However, these relative values are not static. They are affected greatly by the dynamic change in variables related to motivation.

Motivating Operations

Most of our knowledge of basic behavioral processes has been derived from laboratory experiments using predominantly pigeons and rats as subjects. The principal focus of many of these experiments was the effects different schedules of reinforcement or other operations had on performance. Although its was recognized that *'motivation'* to respond to the arranged operations could impact significantly on the response patterns obtained, for the most part, motivation was viewed as a potential confound to be held constant. Hence, experimenters generally deprived their experimental subjects of food until the animals reached some proportion of their free-feeding body weight (e.g., 80%) in order to keep them motivated to respond in the most efficient pattern to obtain food. Although some experiments directly examined schedule effects at different levels of deprivation (Ferster & Skinner, 1957), concentrated study of the effects of motivation on contingent reinforcement was for the most part scant.

This began to change when Keller and Schoenfeld (1950) introduced the term *Establishing Operation* to refer to events and operations separate from the 3-term contingency ($S^{D \text{ or } \Delta}$ – Response – $S^{R+ \text{ or } R-}$ or $S^{P+ \text{ or } P-}$) that could alter the effectiveness of the consequences of a response. But it was Jack Michael who pursued a comprehensive conceptual framework for understanding motivation from a behavior analytic perspective (Laraway, Syncerski, Michael, & Poling, 2003; Michael, 1982, 1993).

Michael's initial treatment of motivation was to differentiate the discriminative from the motivational effects stimuli or events have on behavior. For example, if while attending a meeting at noon with colleagues someone sets a pizza box in the middle of the table, the behavior of many at the meeting is likely to change. There may be salivation, thoughts related to pizza, and sooner or later someone will likely act to access the pizza inside. Certainly the pizza box will have discriminative properties because its presence increased the availability of pizza and will occasion access behaviors. But does the box also have motivational effects on behavior, or perhaps both? In this example, it is difficult to conclude definitively that the effects are discriminative, motivational, or both. However, if in a subsequent meeting, the empty pizza box is still present in the room, someone may say 'Shall we order a pizza?'. The empty box has not altered the availability of pizza, but it may have motivated behavior to acquire pizza.

In Michael's most recent treatment of motivation (Laraway et al., 2003), motivating operations (MOs) are seen as having both *value altering* and *behavior altering effects.* Value altering effects refer to a change in the effectiveness of a consequence to either reinforce or punish behavior. There are two types of value altering effects: An MO can either *establish* or *abolish* the effectiveness of a given consequence on behavior. Behavior altering effects refer to either the increase or decrease in response probability that the MO produces. When the MO increases responding, its effects are *evocative*, and when an MO decreases responding, its effects are *abative*. Finally, within this overall framework, MOs and their value and behavior altering effects can either be unlearned (*unconditioned*) or learned through experience (*conditioned*).

Michael emphasizes that nearly all MO effects are *momentary* and that a single MO can affect *multiple behaviors and consequences simultaneously*. Some of these effects can be sudden as when we touch a hot pan. The effectiveness of cooking as a positive reinforcer is temporarily abolished, while the effectiveness of dropping the pan and obtaining ice as negative reinforcers is temporarily established. And the behaviors related to these consequences (cooking, dropping the pan, and obtaining ice) decrease and increase accordingly. While some MO effects are sudden, others accrue over hours, days, months, and even years. For example, the motivational effects of deprivation of food and certain types of food, contact with friends, preferred leisure activities, exercise, intellectual stimulation, and vacations can wax and wane depending on the frequency and recency of contact with them.

Implications for Understanding Contingent Reinforcement

Our goal has been to highlight that the effects of contingent reinforcement, in the form of the 3-term contingency, are highly dependent on the broader context in which the contingency operates. The value of response alternatives, the availability of alternative sources of reinforcement present and past, and the momentary conditions of motivation are all relative and in continuous motion. In one sense, this notion is overwhelming and portends poorly for our practical ability to predict and control human behavior in complex and ever-changing natural environments. On the other hand, we should as a discipline be pleased that our science and the conceptualizations it has spawned have matured to a point in which we have clear paradigms and frameworks that, when considered together, begin to approach the capacity to grasp the complex human behavior that surrounds us.

We see two practical implications that follow from this analysis. First, the variables of which choice, resistance to change, and motivation are a function are very likely to interact synergistically in ways that are yet unknown because these topics are most commonly treated separately. Needed is the basic research to examine how, in Nevin and Grace's model, behavioral mass and motivation interact to affect performance and learning. Because these are questions inspired by the goal of understanding human behavior in natural environments, human EAB research may be most likely to occur and seems appropriate to the task.

A second practical implication relates to ABA practice and research in clinical and educational settings. A point Catania has emphasized in all editions of his *Learning* text is the distinction between operation and process. In our experience, most practitioners have the expectation that, having identified an effective reinforcer, using it in a reinforcement operation will increase the behavior subject to contingent reinforcement. But we have learned from Catania that a reinforcement operation will not necessarily invoke a reinforcement process (i.e., increase responding). It seems the task then for practitioners is to exhaust their search for the conditions necessary and sufficient for a positive reinforcement intervention to increase desired behavior. These conditions are likely to be found by examining the factors that influence choice, persistence, and motivation. However, rather than examine them in isolation, we suggest consideration of them in combination to maximize the likelihood that a positive reinforcement-based intervention will be effective.

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