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Investigating the Effects of Applied Learning Principles on the “Create” Response in Atlantic Bottlenose Dolphins (*Tursiops truncatus*)

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When analyzing animal behavior, it is important to consider the influence of learning principles. The *create* response of bottlenose dolphins, elicited by a discriminative stimulus, or an SD (visual cue presented to an animal by a trainer), has been described as an elective, often novel response based on arbitrary preferences of individual animals. The goal of this study was to identify the potential influence of reinforcement theory, response class, and primacy and recency on the create responses of bottlenose dolphins. Three, male subjects with an established mastery of the create paradigm, identified in this study as a non-specific, non-repeat contingency, were assessed over the course of two months while under stimulus control (*pre-assessment*), followed by evaluations of the create response (*create assessment*) using a double-blind sampling model. During the pre- and create assessments, each response was quantified regarding response class, frequency of request, and reinforcement type, frequency, and magnitude. When presented with the create SD, the dolphins elected to produce behaviors predominantly associated with the more recent training context (create assessment) versus behaviors associated with training that occurred months prior (pre-assessment), which may demonstrate the effects of primacy versus recency. Additionally, the create trials were associated with reinforcement on a high frequency and magnitude, fixed, low ratio schedule, and the subjects most often performed the behaviors associated with the greatest magnitude of primary reinforcement, which highlights the influence of reinforcement and the law of effects. Lastly, two subjects never responded with high energy behaviors in the create contingency, and one subject performed significantly more low and medium energy responses when compared to high energy behaviors, capturing the effects of a response class characterized by intensity under a fixed ratio reinforcement schedule. Thus, the create response was not represented by arbitrary elective preferences but rather, partially driven by the learning theories examined.

The ability to exhibit new or novel behaviors in response to changing environmental conditions is considered a sign of intelligence and an advanced cognitive capacity, with an adaptive function (e.g., Bailey, McDaniel, & Thomas, 2007; Herman, 2006). Research suggests that marine mammals possess this quality, and dolphins have an exceptional capacity for short-term memory (Kuczaj & Eskelinen, 2014; Mercado, Murray, Uyeyama, Pack, & Herman, 1998), with the ability to consider those details in future decision-making scenarios (e.g., Beach & Herman, 1972; Forestell & Herman, 1988; Mercado & DeLong, 2010).

The expression of novel behaviors can be elicited in an experimental setting on cue in a non-specific context (i.e., the performance of any behavior), colloquially referred to as the *create* response (Krieger et al., 1989; Pryor, Haag, & O'Reilly, 1969). This behavior has been applied broadly in the management of cetaceans in managed care, particularly since reinforcing variability has been shown to encourage cognitive plasticity and foster learning (Grunow & Neuringer, 2002; Neuringer, 2004; Neuringer & Jensen, 2012). The create behavior paradigm was originally described by Pryor et al. (1969), who trained two rough-toothed dolphins (*Steno bredanensis*) to perform innovative behaviors. During training sessions, the dolphins were asked to respond non-specifically on cue and received reinforcement after exhibiting any novel behavior. The model was later elaborated upon by Krieger et al. (1989), who used the create cue to reinforce innovative behavior among

dolphins and pinnipeds. In their paradigm, animals were reinforced for exhibiting any behavior, even those already in their repertoires, as long as the behavior was not repeated within a single session. This paradigm then became a variable, non-repeat contingency, later described as a *vary task* by Kuczaj and Eskelinen (2014), in which the animals could emit truly novel behaviors, those within their current repertoire, and new behaviors characterized by slight variations in the topography of non-novel behaviors.

Behavior is influenced by operant contingencies, first identified by Thorndike (1898) and later described by Skinner (1938), which is based on the theory that responses are modifiable by immediate consequences. The principles of operant conditioning are strategically utilized in zoological settings to modify animal behavior. The type of consequence (i.e., reinforcing or punishing) will influence whether or not that behavior will increase or decrease in frequency, intensity and/or duration, thus, creating predictability in the recurrence of specific behaviors under specific contexts (e.g., Wyckoff, 1959; for review see Malott, 2008; McSweeney, 1999). A thorough consideration of these principles, including how they may influence an animal's responses, may provide insight into the phenomenon of *imagination*, *cleverness*, or *spontaneity* to a generalized cue (Krieger et al., 1989, Pryor et al., 1969). It is possible that animals responding under a non-contingent model (i.e., the create behavior), who are reinforced for varying their responses to a single cue, may in fact exhibit behaviors previously influenced under specific learning contexts.

The learning principles that likely influence the variability in response to a create cue include but are not limited to reinforcement theory (frequency, magnitude, and schedule of delivery), the function of response class, and the primacy and recency effect. Reinforcement is differentiated as either primary or secondary (for review see Skinner 1974, 1981, 1984), with varying schedules of delivery producing different and predictable rates of response (see Ferster & Skinner, 1957). In theory, reinforcers with a high reinforcement value, broadly a reflection of access (i.e., frequency of rehearsal – see Siemann, Delius, & Wright, 1996) and magnitude, delivered on a variable and fixed ratio schedule will produce the highest rates of response (Ferster & Skinner, 1957). The associated history or experience with these reinforcers and schedules of delivery may dictate how an animal responds in varied contexts (e.g., variation in delivery, magnitude, and time delay of reinforcement). For example, Stahlman and Blaisdell (2011) trained pigeons (*Columba livia*) to peck at points on a screen, and points were associated with different reinforcement magnitudes and delivery. Over a short period of time, the pigeons produced less variation in pecking when the magnitude of reinforcement was high and delivery was fast relative to specific points. Similarly, if the animal in question is required to expend greater versus lesser energy to access reinforcement, it is possible those behaviors requiring less energy will be exhibited more frequently under a non-specific context with similar reinforcement value. The energy required to access reinforcement captures the influence of response classes (e.g., low vs. high energy behaviors), defined by the intensity and topography of different types of behaviors that result in similar consequences (see Malott, 2008). In terms of energetics, animals are likely to default to the scenario with the greatest amount of reinforcement and the least energetic expenditure.

Lastly, the serial position effect, first defined by Ebbinghaus (1902) and later elaborated upon by Murdock (1962), is characterized by high rates of recall of the first and last items in a list, also known as the effects of primacy and recency. This cognitive phenomenon has been documented in humans (e.g., Jensen, 1962; Murdock, 1962), rhesus monkeys (*Macaca mulatta*; Sands & Wright, 1980), and bottlenose dolphins (*Tursiops truncatus*; Herman, 2010; Kuczaj & Eskelinen, 2014; Pearce, 2008; Thompson & Herman, 1977). As such, it is possible that behaviors rehearsed most recently by bottlenose dolphins are more commonly exhibited under a positively reinforced create paradigm when compared to those with longer periods of non-rehearsal.

The objective of the study was to investigate the effects of specific learning principles, namely reinforcement theory, response class, and the primacy and recency effect, on the create responses of bottlenose dolphins.

Method

Study Location and Subjects

The resident Atlantic bottlenose dolphin (*Tursiops truncatus*) population at the zoological facility Dolphins Plus Bayside was evaluated under the guidance of their training, research, and curatorial staff. Dolphins Plus Bayside is a marine mammal education, interaction, and research facility in Key Largo, Florida, located adjacent to the Florida Bay, with an emphasis on behavior analysis and modification achieved through operant conditioning with positive reinforcement. This natural seawater facility includes a circular lagoon that ranges in depths from 1 to 6 m, with a mean depth of 5.4 m (\pm 1.2 m), and encompassing an area of approximately 1,858 m². At the time of the study, Dolphins Plus Bayside housed eight Atlantic bottlenose dolphins ranging in age from calf to adult. The study subjects were selected on the basis of their training history, specifically those exhibiting a mastery of the create cue (i.e., a discriminative stimulus, SD), and included two adult males (“Alfonz” and “Kimbit”) and one sub-adult male (“Leo”). Test trials were defined by Kuczaj and Eskelinen (2014), and mastery was characterized as the ability to complete four successive create training sessions in which three or more behaviors were offered without a repeat (i.e., create, non-repeat behavior), and all three subjects exhibited at > 90% successful response rate for three months prior to the study.

Materials and Procedure

A create trial entailed the repeated presentation of the create SD (discriminative stimulus; a unique hand signal, characterized by the crossing and uncrossing of the trainer’s arms at shoulder height) and reinforcement on a Fixed Ratio of 1 schedule with reinforcement variety, including access to other behaviors under the Premack principle (i.e., the use of behaviors to reinforce preceding behaviors – see Premack, 1959). The trial was terminated when an animal repeated a behavior, at which point the trainer applied the least reinforcing scenario, which is characterized by a 3-s neutral response (Scarpuzzi, Lacinak, Turner, Tompkins, & Force, 1991). As such, the animals were sequentially reinforced with primary and/or secondary reinforcers (e.g., tactile, praise, other behaviors, access to enrichment tools and devices) using a non-specific contingency and the lack of repetition among responses in a single series of requests (i.e., one trial).

In this study, a *pre-assessment* (PA) was utilized to evaluate the potential influence of learning principles associated with specific behaviors exhibited in the *create assessment* (CA). The PA involved 50, 10-min video recordings of 25 randomly selected interactive and husbandry training sessions, conducted as part of standard operating procedures, from June to July 2012 (i.e., 1–2 months prior to the CA), using a double blind methodology, resulting in a total of 500 min of video for each subject. Video data were captured using two GoPro Hero digital cameras with underwater housings and a waterproof Canon PowerShot D10 digital camera. Data for the current study were collected four months prior to Kuczaj and Eskelinen’s (2014) investigation.

Video analyses for the PA included documentation of the following: requested behavior and relevant response class (i.e., high, medium, or low energy behaviors), request/performance frequency, the delivery or withholding of reinforcement (primary and/or secondary), and reinforcement frequency and magnitude. A specific SD defined each behavior. When two SDs were provided in sequence (e.g., layback + double pectoral fin wave), the behaviors and consequences were considered independently. Thus, if the animal completed two, sequential behaviors correctly, the assumption was that the Premack effect acted as reinforcement for the second behavior (i.e., secondary reinforcement via the Premack principle – see Premack, 1959), and the second behavior was reinforced with the bridge + additional reinforcers (primary and/or secondary). The response class was broadly defined as high, medium, or low energy and characterized by the speed and topography of each behavior, including changing planes in the water column, aerials, and the rate of fluke pumping.

In terms of reinforcement, primary reinforcement was delivered utilizing a variety of fish types that were part of the dolphins’ regular diets, including fatty herring, lean herring, pacific herring, smelt, sardines, capelin, and silversides. Secondary reinforcement at Dolphins Plus Bayside included, but was not limited to, the use of: access to enrichment devices and tools (e.g., balls, hoops, and swim noodles), tactile (i.e., rubs), verbal (i.e., praise), oral (i.e., ice and gelatin), and other behaviors. The magnitude of reinforcement was evaluated by the duration (in s) of the applied secondary reinforcer. The magnitude of primary reinforcement was defined quantitatively on a scale of 0–3, with 0 representing the lowest magnitude and 3 representing the highest magnitude. For primary reinforcement, magnitude was related to fish type and quantity as follows: 0: no primary reinforcement, 1: a single non-herring fish (< 22.68 g), 2: 2–4 non-herring fish (< 113.40 g), and 3: 1+ herring and/or 5+ non-herring fish (\geq 113.40 g).

The CA trials were also video documented using a double-blind methodology, including 119 separate create series requests (i.e., trials) per subject conducted between August and September of 2012. The specific behaviors exhibited by each dolphin in response to the repeated create SD under a non-specific, non-repeat contingency (i.e., a response was considered “incorrect” and the trial terminated only when an animal repeated a behavior already performed within that trial) were documented, as well as the frequency of each behavior, the delivery or withholding of reinforcement, reinforcement frequency and magnitude, and response class, using the same criteria described for the PA.

The behaviors analyzed in this study included those offered ≥ 25 times in the CA, because responses performed less frequently were considered unreliable as a metric for analyzing learning theory due to the properties of acquisition (negatively accelerated) and learning speed (see Hull 1943, 1952). Chi-square goodness of fit tests and z -scores were utilized to identify relationships and the influence of various learning principles on the create responses. All statistical analyses were conducted using JMP (versions 11.0 and 12.0) and SPSS (version 21.0) software.

Results

Throughout the course of the PA, 69 individually distinct behaviors, or those associated with a single, unique SD ($n_{\text{Alfonz}} = 54$, $n_{\text{Kimbit}} = 57$, $n_{\text{Leo}} = 56$), were recorded occurring at various frequencies for a total of 4,399 behaviors emitted during the sampling period. The CA consisted of 119 trials per subject ($N = 357$), within which the subjects performed 48 individually distinct behaviors ($n_{\text{Alfonz}} = 28$, $n_{\text{Kimbit}} = 22$, $n_{\text{Leo}} = 39$) at various frequencies for a total of 2,547 behaviors emitted during the create trials. However, only 32.14%, 36.36%, and 25.64% of the individual behaviors in the CA were executed ≥ 25 times for Alfonz, Kimbit, and Leo, respectively ($n_{\text{Alfonz}} = 9$, $n_{\text{Kimbit}} = 8$, $n_{\text{Leo}} = 10$). Of the 48 individually distinct behaviors exhibited by all subjects during the CA, 27 (56.25%) occurred in the PA, with the remaining behaviors identified as known components of each subject’s learned repertoire (i.e., previously observed) or behaviors in the facility’s training repertoire not yet under stimulus control, excluding novel vocalizations emitted by Leo and Alfonz ($n = 15$; Figure 1). In addition, 25.0%, 27.27%, and 33.33% of the responses documented in the CA by Alfonz, Kimbit, and Leo, respectively, did not occur in the PA. Leo performed the longest response to the create series, including a single chain of 19 behaviors that occurred without repetition.

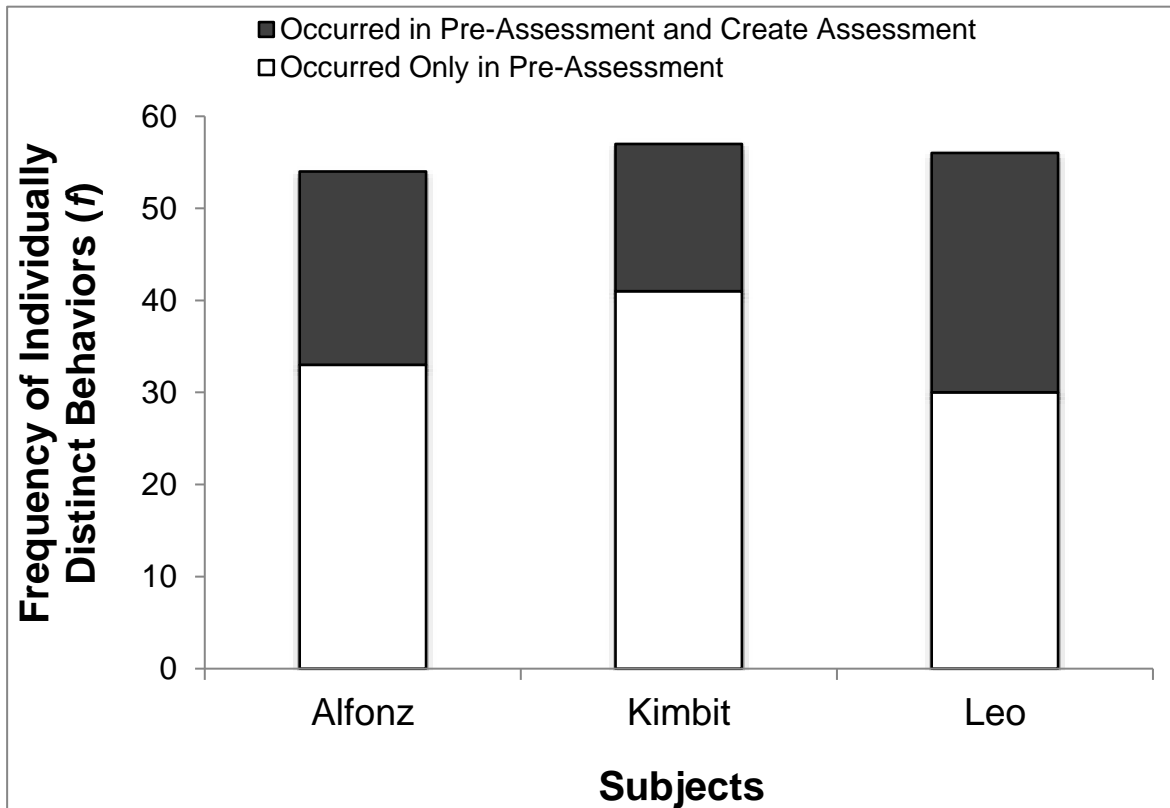


Figure 1. The number of individually distinct behaviors cued in the pre-assessment, including those also exhibited in the create assessment (indicated in dark grey).

There were no significant relationships identified between the behaviors associated with high frequency and magnitude of reinforcement in the PA and those offered by the subjects in the CA. However, for individual behaviors identified in both the PA and CA (66.7%), there was a significantly greater magnitude of reinforcement applied for 12 of the 18 behaviors in the CA versus the PA ($p < 0.05$). In addition, the behaviors exhibited most frequently in the CA were those associated with the highest magnitude of primary reinforcement delivered without supplemental secondary reinforcement in the CA, and many of these behaviors were emitted at high frequencies, particularly when compared to the PA (i.e., 50.7 – 100% of all recorded occurrences were in the CA). Also, during the CA, Leo, who was the only subject to emit high, medium and low response class behaviors, exhibited high response class behaviors significantly less than medium and low response class behaviors, $\chi^2(2, N = 1167) = 13.76, p = 0.001$ (Figure 2). Kimbit and Alfonz never emitted high energy behaviors in the CA, with all recorded behaviors characterized as low or medium energy.

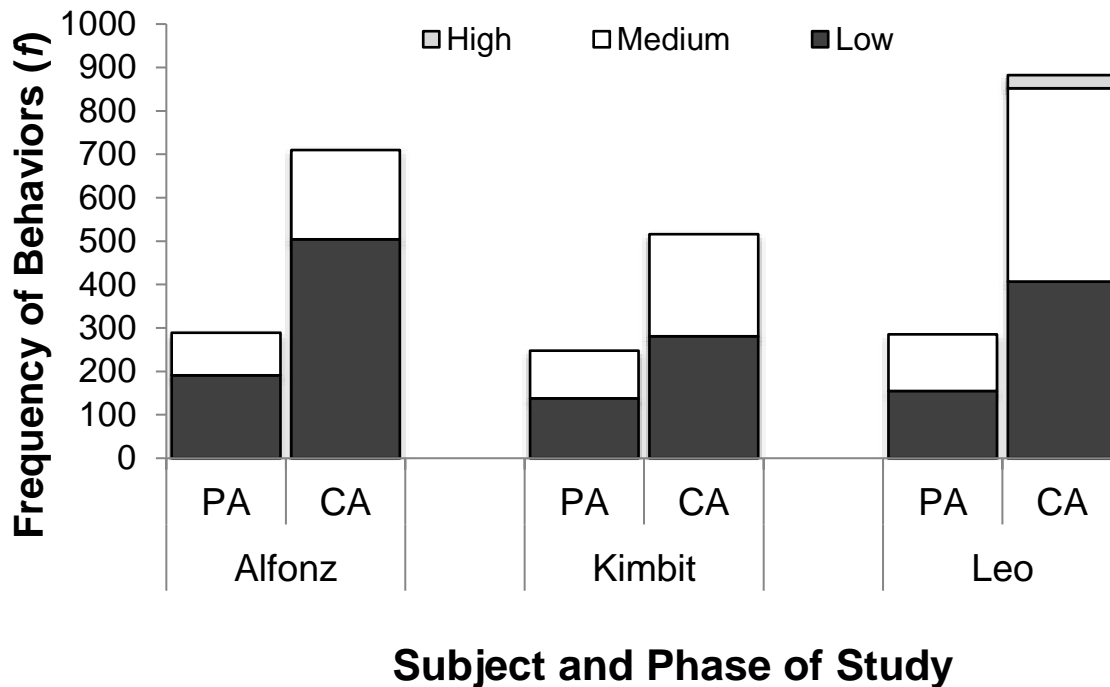


Figure 2. The response class distribution of high (indicated in light grey), medium (indicated in white), and low (indicated in dark grey) energy behaviors in the pre-assessment (PA) and the create assessment (CA).

Discussion

The only novel responses recorded during the CA were undocumented vocalizations. Although each animal chained behaviors in unique sequences during a single create response and also performed behaviors not yet under stimulus control, the behavioral components they offered were rarely novel. These findings suggest, in contrast to the findings of Pryor et al. (1969), that eliciting novel behaviors on cue is challenging, as the subjects will likely default to their learned repertoire. Additionally, under a non-specific context, animals may exhibit random sampling, during which they offer a variety of behaviors in order to gain access to reinforcement (e.g., Turner, Feucht, & Turner, 2009).

Within a successful create trial, even if the behaviors were reinforced on a variable ratio schedule with reinforcement variety (Force & Butcher, 1985), the trial was characterized by reinforcement delivered on a fixed, low ratio schedule due to the Premack principle (Premack, 1959). Since a repetition was the only “incorrect” response, each behavior could have been reinforced by the subsequent response, cued in a sequence by trainers until repetition occurred. According to Ferster and Skinner (1957), fixed ratio schedules of reinforcement lead to high response rates, and reinforcement frequency and magnitude were consistently high during the CA. These findings support the influence of reinforcement theory in the create response. In addition, a decrease in opportunities to perform certain behaviors can lead to deterioration in those skills, which in turn may lead to decreased opportunities for reinforcement (Siemann et al., 1996). In this study, the inverse was apparent, as increased frequency and performance of behaviors in the CA was associated with increased opportunities for reinforcement, which may also explain why some behaviors occurred in the CA only.

When cued to respond to the create SD, the subjects elected to produce behaviors predominantly associated with the CA context versus the PA, which demonstrates the effect of primacy versus recency on the create response (Murdock, 1962). Thus, primacy versus recency may play a role when considering the effects of reinforcement, in that reinforcement associated with the CA (i.e., more recent) appeared to have a greater influence on create responses than the reinforcement associated with the PA (i.e., less recent).

Furthermore, Herrnstein's (1961) matching law suggests that when rates of response are associated with two, different schedules of reinforcement, responses will be higher for the behavior(s) on the schedule that provides greater access to reinforcement. Consistent with the matching law, the reinforcement magnitude associated with each behavior was, in many cases, significantly greater during the CA when compared to the PA (Herrnstein, 1961). As suggested by Stahlman and Blaisdell (2011), when an animal adapts their behavior to gain access to the maximum reinforcement possible, one can assume that learning is occurring.

When asked to perform any behavior, with the opportunity to receive reinforcement in a non-repeat contingency, all subjects were more likely to respond with behaviors that required less energy. Low and medium response class behaviors do not require large energy expenditures, and these behaviors resulted in similar consequences when compared to high energy behaviors (i.e., access to reinforcement). So, although subjects were capable of offering any number of high energy behaviors, they repeatedly offered low and medium energy behaviors more frequently. These findings may suggest the role of learning and the influence of energetics with respect to response classes, in which the subjects defaulted to the less costly behaviors in a non-specific reinforcement contingency. Bottlenose dolphin mothers were noted to utilize acoustic versus physical cues to retrieve their calves in a non-emergency recall context (Kuczaj, Eskelinen, Jones, & Borger-Turner, 2015), which also exemplifies the use of the least costly method to achieve a desired outcome in this species.

In future studies, a more fine-scale analysis of primary and secondary reinforcement should be utilized to evaluate create responses. The analyses of reinforcement in the CA indicated that behaviors associated with primary reinforcement alone versus primary and secondary reinforcement were emitted under a non-specific context most frequently, suggesting that some of the secondary reinforcers were not conditioned effectively. Reinforcing value varies among individuals, and some environmental enrichment devices, which may be used as secondary or learned reinforcers, may not actually be reinforcing to animals (Delfour & Beyer, 2012; Eskelinen, Winship, & Borger-Turner, 2015). Although an arduous task, identifying what was reinforcing to each study subject, specifically in terms of secondary reinforcement, may have influenced the findings of this study. It is likely that reinforcement value, individual differences in learning and responses noted to persist over time (e.g., Highfill & Kuczaj, 2007; Kuczaj, Highfill, & Byerly, 2012), and the learning environment function in synergy in terms of influencing animal responses.

In conclusion, the create response was partly explained by the learning principles examined in this study, indicating that the animals' responses were not arbitrary but influenced by learning (Skinner, 1974). Any discrepancies may reflect the influence of learning theories not analyzed, inherent limitations in sampling design, or individual differences that occur as a result of cumulative learning events. The results of this study contribute to an improved understanding of the concept of creative behavior and theorized innovation as it relates to applied learning principles.

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