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# Behavior Analytic Contributions to the Study of Creativity

ABSTRACT

As researchers continue to study creativity, a behavior analytic perspective may provide new vistas by offering an additional perspective. Contemporary behavior analysis began with B. F. Skinner and offers a selectionist approach to the scientific investigation of creativity. Behavior analysis contributes to the study of creativity by investigating the controlling variables for novel behavior that people often times designate as creative. Specific environment-behavior relations producing novelty include imitation, instructions, variability, interconnection of repertoires and contingency adduction.

## INTRODUCTION

Of the many accomplishments in Lewis Terman's (1877-1956) career, perhaps people remember him best for his longitudinal work studying "genius" children. Terman aspired to investigate a wide range of characteristics of gifted children that included physical, mental and personality traits. Terman studied hundreds of children, and reported the results in the first volume of a series called *Genetic Studies of Genius* (1926). Terman's research of the genius children's progression through life documented some interesting findings. For instance, he dispelled the myth that gifted children "burn out" in their middle years (Terman & Oden, 1959).

Terman and Oden (1959) reported other achievements about the children such as their financial successes, their professions, and their accomplishments (e.g., scientific papers published, novels written). After his death, however, his obituary etched a curious portrait of Terman's findings: "His bright children grew up healthier, slightly wealthier, and better employed than the average child, but the group contained no mathematicians of truly first rank, no university president . . . gives no promises of contributing any Aristotles, Newtons, Tolstoys" (Time, December 31, 1956, as cited in Gerow, 1988, p. 45).

Apparently, Terman's genius children lacked conspicuous displays of creativity. Creativity, presumably in the sense that Terman's children needed, consists of the original, rare, and celebrated products or ideas of people that result in a historical precedent. Examples of this type of creativity include Stravinsky's "Firebird Suite," Picasso's "Guernica," Einstein's theory of relativity, and Watson and Crick's double helix of DNA. Clearly, defining creativity in an eminent manner has great value at both the individual and societal level.

*A closer look at creativity.* At the individual level, a person faces problems during work, and other daily pursuits (Sternberg & Lubart, 1996). Creativity allows a person to enjoy solutions with life enhancing results. For example, a mother who faces the task of changing her child's diaper comes up with a solution that hastens the sequence of events through a novel product or process (e.g., a baby changing cart with specially designed features that facilitate cleaning and removal of the soiled product).

At the societal, or cultural level, people throughout the world face a multitude of problems such as population growth, war, pollution, new health problems, poverty, and criminal behaviors. Creativity may offer lasting remedies and solutions to local, state, national, and worldwide social and environmental problems. It appears the distinction of creativity, in the individual and societal level, lies on the continuum of perceived value or importance. The more valuable or important the idea or product, the more likely people will call it creative.

Equating creativity with only eminent ideas or products circumscribes whom we call creative. For instance, Csikszentmihalyi (1996) states: "Children cannot be creative, but all creative adults were once children" (p. 157). In this view, precocious, or gifted children do not exhibit creativity even if their ideas or products differ considerably from their same age peers. Although others may disagree with this viewpoint, Csikszentmihalyi's proposition suggests an important distinction: giftedness does not parallel creativity. The use of terms such as "giftedness" may express a likelihood for future accomplishments, but it does not suggest a tendency for creative productions (Gardner, 1988).

Expanding upon whom may receive label creative, Ripple (1989) describes “ordinary creativity” as people who can generate many ideas and possess a certain imaginativeness, can solve problems with wit and cunning, and appear willing to accept more risks than others. In addition, Weisberg (1986) has indicated, creativity stems from ordinary processes of ordinary people. Viewed in this context, the scope and origins of creativity, and its likelihood for occurrence, involves a greater segment of the general population.

The apparent discrepancies between the two previous perspectives fit neatly into what Gardner (1993) calls “big C” and “little C” creativity. “Big C” creativity refers to the rare creations such as the work produced by the Aristotles, Newtons, and Tolstoys. “Little C” creativity refers to the less prominent innovations done by less recognized people. For instance, the world will probably not remember the name of the woman or man who creatively designed a new and useful cart for carrying garbage from the house to the sidewalk.

The contrast between “big C” and “little C” creations does help distinguish who and what we call creative. The discovery of calculus or a new mathematical system would unequivocally fall into the category of “big C” creativity. A child who has just discovered how to factor algebraic equations without any prior instructions would subsequently qualify as “little C” creativity. Yet, if a child generated a correct algorithm before others had discovered those algorithms, the response would qualify as “big C” creativity. Researchers (Amabile et al., 1996; Epstein, 1996) have discussed the distinction of labeling products creative particular to their historical context. In the previous example, the child set a historical precedent by generating an appropriate and original algorithm. These creations fall under the category of “big C” creativity without much debate.

Ideas such as ordinary creativity, “big C” and “little C” creativity, among others, offer intriguing distinctions as what we should call creative. The dimensions many use to define creativity share a consensual, core definition. These two basic elements found contain the following requirements: emergence of novel product and the novel product has a corresponding appropriateness or value (Amabile et al., 1996; Ripple, 1989; Stein, 1953; Sternberg & Lubart, 1996; Weisberg, 1993).

This definition of creativity offers much to those who research creativity. First, it presents an opportunity for promoting critical dialogue between researchers with different theoretical backgrounds. As Gardner (1988) noted, certain areas in science have become increasingly more sensitive to the benefits of "interdisciplinary cooperation." The development of interdisciplinary cooperation may ultimately allow researchers to make rapid discoveries by considering new variables, accelerating awareness of other disciplines' research bases, and communicating with others presenting different perspectives and interpretations of previous research.

Second, the definition provides common ground for scientific analysis, ultimately offering prediction and control of the subject matter. Researchers may one day discover principles allowing people to create novel products appropriately addressing some need. Subsequently, issues such as determining whether to categorize products or ideas into "big C" or "little C" will develop more readily because of the resulting product and knowledge of the process behind it. The very definition of creativity and the biologic and environmental rules that govern its occurrence provide an opportunity for the rapprochement of various disciplines.

Behavior analysis, a discipline devoted to scientifically studying behavior (Cooper, Heron, & Heward, 1987), contributes much to both an interdisciplinary approach and the basic definition of creativity. Namely, it offers natural scientific procedures and an established database for identifying variables affecting behavior which may culminate in creative products or ideas. Through its short history, behavior analysis has discovered variables that consistently affect behavior in lawful processes. These operations, called functional relations, possess generality and have expanded understanding of human behavior. This knowledge, as well as contemporary efforts, provides unique opportunities to discovering new variables and functional relations related to creativity. This paper offers a perspective from behavior analysis and suggests ways it may contribute to the scientific study of creativity.

## FUNDAMENTALS OF BEHAVIOR ANALYSIS

The heritage of contemporary behavior analysis began with B. F. Skinner. He advocated a philosophy called radical behaviorism. His form of behaviorism differed from other varieties (e.g., methodological behaviorism, structuralism) by not requiring truth by agreement from two observers and by accepting and encouraging the study of private events, or thoughts and feelings, in the study of human behavior (Skinner, 1945, 1953, 1963, 1974). Subsequently, this position has permitted behavior analysts to investigate and conduct applied interventions with subject matter spanning the full range of human behavior.

*Selectionism*. Skinner's advocacy of selectionism also set apart his form of behaviorism from others. Skinner described human behavior as a confluence of "contingencies of survival" and "contingencies of reinforcement." Contingencies of survival govern the natural selection of a species. The contingencies of reinforcement impel the repertoires the members acquire. The contingencies of reinforcement also encompass distinctive contingencies which appeared as a result of the social environment (Skinner, 1981a).

Environmental selection accounts for behavior occurring at levels called phylogeny, ontogeny, and culture. Selection at the phylogenic level includes behavior related to the "internal economy" of a person and that people accept as "inherited" (Skinner, 1982). For instance, phylogenic behaviors such as startle reflexes have developed after many years of environmental variation and selection. For changes in a species' phylogenic repertoire, sometimes thousands and millions of years must pass.

Ontogenic selection pertains to operant behaviors acquired during the lifetime of an individual. Operant behavior refers to those responses affected by environmental contingencies such as reinforcement, punishment or extinction. Thousands of basic and applied studies have shown that behavior occurring under certain conditions will produce similar behavioral patterns. These behavioral processes account for much of the fascinating and mundane behavior people may exhibit. A person experiences changes in an ontogenic repertoire across a lifetime and through moment-to-moment interactions with the environment.

The last type of selection occurs at the level of the culture. Cultural practices begin with the individual but their effect on the group eventually determines its selection by the culture (Skinner, 1981a). Cultural selection allows members of a society to benefit from the verbal behavior, or communication, of a person, or people, through written or oral transmission. Although individual members or an entire culture may die, future generations learn from the previous experiences of others without having to directly experience the conditions that generated the original learning.

*Contingency*. Skinner's (1981a) integration of selectionism and contingency played an important role in the philosophy of human science, radical behaviorism, the basic science actualized as the experimental analysis of behavior, and the practical science or applied behavior analysis. In the most general sense, contingency refers to "a relation in which the occurrence of one event depends on the occurrence of another event" (Donahoe & Palmer, 1994 p. 355). The analyses of contingencies set the precedent for analyzing behavior. Contingencies occur at phylogenic, ontogenic, and cultural levels. Explicating these relations leads to a clear understanding of the phenomenon under study.

Researchers from other disciplines, such as Gould (1989), have noted the importance of contingency:

> Historical explanations take the form of narrative: E, the phenomenon to be explained, arose because D came before, preceded by C, B, and A. If any of these earlier stages had not occurred, or had transpired in a different way, then E would not exist (or would be present in a substantially altered form, E', requiring a different explanation) . . . I am not speaking of randomness (for E had to arise, as a consequence of A through D), but of the central principle of all history- *contingency.* (p. 283 emphasis in the orignal).

Gould (1989) discussed the importance of contingent relations as a part of a historical science. Behavior analysis, similar to sciences like paleontology and evolutionary biology, shares the distinction of using historical evidence to understand complexity and diversity. Past evidence combined with contemporary studies leads to a more accurate understanding of current events. Behavior analysis investigates behavioral relations by examining contingencies that demonstrate lawfulness and order with behavior.

The study of contingencies in behavior analysis has generated behavioral principles. One such contingent relation, reinforcement, describes an environmental relation where a stimulus increases the probability of a response it follows (Cooper, Heron, & Heward, 1987). In a selectionist account of behavior, reinforcement serves as the selection mechanism (Donahoe, 1991; Donahoe & Palmer, 1994).

The following example demonstrates how reinforcement selects a behavior. Joaquin, described as a child with emotional and behavioral disorders, seldomly smiled at people. The school psychologist, Dr. Cartman, used a procedure where he and other teachers would praise Joaquin if he smiled at another person. This procedure increased the frequency at which Joaquin smiled at other people. The praise served to increase the probability that Joaquin would smile at people.

After using the reinforcement procedure for a month Dr. Cartman faded the use of the conditioned reinforcer. Joaquin would smile at other people who in turn smiled back at him. Occasionally smiles from other people also came with greetings and conversation. Smiling at other people underwent selection by reinforcement.

The previous illustration of reinforcement provides an example of a contingent relation that, when similar conditions arise, affect the future probability of a behavior's occurrence. The interplay between the effects of reinforcement, punishment, and extinction help to account for the behaviors a person has in her repertoire. Such accounts of behavior lie at the foundation for the understanding of human behavior. Through the processes of environmental selection, behavior analysis offers a unique analysis of verbal and nonverbal behavior displayed by humans.

## A BEHAVIORAL PERSPECTIVE ON CREATIVITY

Behavior analysis, like other disciplines investigating creativity, has studied the subject matter from different vantage points. Both applied, and basic behavioral researchers have approached the analysis of creativity in a common manner, by investigating the controlling variables and functional relations characteristic of a particular behavior. Specifically, behavior analysts studying creative behavior would investigate it the same manner as any other behavior, as an operant (Winston & Baker, 1985). Behavior analysis suggests that the environment plays an important role in selecting operant behaviors.

The original conception of operant behavior, or behavior that "operates" on the environment, began with Skinner. Although a very creative person himself, Skinner did not study creativity in depth (Epstein, 1991). Skinner (1956, 1957, 1966, 1970, 1972, 1974, 1981b) did discuss creativity but only in a limited fashion (Epstein, 1991). Skinner (1974) and his selectionist position:

> Operant conditioning solves the problem more or less as natural selection solved a similar problem in evolutionary theory. As accidental traits, arising from mutations, are selected by their contribution to survival, so accidental variations in behavior are selected by their reinforcing consequences . . . creative thinking is largely concerned with the productions of "mutations." Explicit ways of making it more likely that original behavior will occur by introducing "mutations" are familiar to writers, artists, composers, mathematicians, scientists, and inventors.

> Either the setting or the topography of behavior may be deliberately varied. The painter varies his colors, brushes, and surfaces to produce new textures and forms. The composer generates new rhythms, scales, melodies, and harmonic sequences, sometimes through the systematic permutation of older forms, possibly with the help of mathematical or mechanical devices. The mathematician explores the results of changing a set of axioms (p. 126-127).

Mutations can produce creative behavior. As Skinner pointed out people have manipulated conditions associated with creative thinking to advance novelty. But, Epstein (1991) observed, reliance solely on mutations does not provide a full account for all instances of complexity and novelty viewed in behavior. A more extensive elaboration of environment-behavior relations provides additional considerations for diverse, complex and novel behaviors.

Defining creativity, per se, creates problems because it represents a judgment given by people on either a behavior or a product (Epstein, 1986; Marr, 2003). Epstein points out these judgments do not appear as the most desirable subject for laboratory study. On the other hand, studying novelty constitutes a suitable subject because people must choose part, or all of the novel behavior, before describing it as creative (Epstein, 1986). Therefore, non-behavioral researchers using a common definition of creativity (i.e., emergence of novelty and a corresponding appropriateness) may find a behavioral perspective useful for its treatment of novel behavior.

Epstein (1986) identifies four sources of novelty for study in the behavioral laboratory. The four sources consist of imitation, instructions, variation, and interconnection of repertoires. In addition, a fifth category, contingency adduction, also deserves consideration. All sources of novel behavior allow a researcher to control the subject matter by understanding and identifying the sources of controlling variables. The following section will describe the five environment-behavior relations and provide an example of research done in the area.

*Imitation.* Cooper, Heron, and Heward, (1987) identify three states that must occur to learn how to imitate; 1. demonstration of a model; 2. after demonstration of the model the occurrence of imitative behavior; and 3. reinforcement of the imitative behavior. Once imitation has occurred, the person can imitate behaviors that serve a variety of functions (e.g., playing games, avoiding danger, solving problems).

Imitation has obvious survival value. For instance, in our distant past a person might have successfully gathered a source of nourishment from grubs or mushrooms by turning over logs and rocks. Another person imitating this behavior extends his ability to gather food. Without imitative responses the person might have never discovered a particular method for gathering food. Here behaving like another behaves has reinforcing consequences. This makes an imitative repertoire valuable and more likely to occur again in the future.

Baer, Peterson, and Sherman (1967) conducted what many behavior analysts consider a classic study demonstrating the development of imitative behaviors in nonimitative children. In the first part of the procedure children learned discriminated operants, or a contingency involving an occasion for response differentially correlated with reinforcement, a response, and a consequence. The experimenter would say "Lift your arm" while he lifted his arm. If the child performed this behavior immediately following the command the experimenter would reinforce the child's behavior with small pieces of food. This behavior did not first occur spontaneously, so the experimenter shaped the response (e.g., successively guide and reinforce to a terminal behavior).

After the children acquired imitation skills, new behaviors imitated correctly on the first trial did not receive reinforcement. This allowed the experimenters to probe for development of an imitative repertoire. The experimenters proceeded to reinforce more complex chains of imitative behavior and eventually, verbal behavior. This, and other studies, has demonstrated an effect known as "generalized imitation" (Sherman, Clark, & Kelly 1977). Generalization imitation refers to the ability to imitate without direct instruction or reinforcement (Sherman et al., 1977). The ability to imitate represents a fundamental skill taught to students who have not acquired it through normal development (Lovaas, 2003; Sundberg & Partington, 1998).

Most typically developing children possess generalized imitative repertoires and can readily imitate a wide variety of behaviors. This environment-behavior relation forms a source of novel behaviors that appear limitless. In art class, a child may make a series of brush strokes that reveal a complicated, novel piece of work. A casual observation may lead some viewers to describe the piece as creative. A closer inspection, however, reveals the child has imitated a piece of work painted by an older child. Although the young child's piece of art qualifies as novel, the verbal community would not classify an imitated behavior as creative. Instances of imitative behavior may produce novel behavior for an individual, but in almost all circumstances imitative behavior wouldn't qualify as creative behavior.

*Instructions.* Instructions provide an account of stimuli related to a contingency (Malott, Malott & Trojan, 2000; Skinner, 1966). Verbally, one person may tell another what to do, or not do, in certain situations. Telling a person how to take the fastest route to a deli is an example of instruction. When given in textual format, instruction informs by specifying behavior leading to an outcome otherwise improbable, time consuming, or unlikely to occur through casual observation such as lawnmower assembly instructions, or map reading.

Instructions work because humans have the capacity for advanced verbal behavior or communication. Instructions supply a substantial benefit by permitting a person to not make direct contact with certain contingencies of behavior (e.g., contingencies that take the form of dangerous situations). For example, a traveler in Washington DC hears from another not to travel down a certain street at during late hours. By following these instructions the person then increases their chances that they can avoid an area associated with criminal activity. The results benefit the person because he or she can act in ways which otherwise would only occur under the contingency shaping effects of a direct interaction with the stimuli inherent to the situation.

A study by Baker and Winston (1985) illustrates how instructions increase novel behavior. In their study, six children between the ages of 5 and 6 served as participants. Low scores on a pretest measuring diverse and novel drawings and stories functioned as a screening device for selecting children as research participants. In the baseline condition children drew pictures and wrote a story about what they created. For the intervention, the children learned how to use self-instructions in the form of asking themselves questions, and answering their own questions before beginning their work (e.g., "What am I to do today? Draw a picture. What should I make? Maybe a new car driving around town). Results from the intervention, conducted with a multiple baseline design (Cooper, et al., 1987), demonstrated that when the children used the self instructions they generated more diverse and novel drawings and stories. A six-week follow up on the intervention indicated the results maintained.

Behavioral studies such as the Baker and Winston (1985) study demonstrate one potential use of using instructions to increase novel behavior. Other types of interventions may follow suit by specifying the steps needed to diversify or create novel behaviors related to a task. For example, a general writing strategy may involve coming up with a number of potential story lines or main ideas. Then, for each particular story line, writing down and analyzing the option that will produce the most, and best, ideas. Over time, these types of instructions may stay the same, improve, or generalize to other skills such as generating ideas and solutions to logic or math problems. In all, teaching general or specific instructions will provide a person with the ability to generate novel behavior in many situations.

Providing instructions has limitations. Namely, certain contingency shaped behavior does not lend itself to description (Skinner, 1966). Behaviors involving motoric skills tend to oppose smooth translation into instructions. As an example, creating new steps or sequences to fashion a new dance. Although the instructions may allow a person to follow the steps in an established dance, the emergence of a new dance seems to defy codification. Rules and instructions state ways to diversify certain behaviors thus creating novel behaviors. The extent of rule success will always depend on the type and amount of contingency shaped behavior a person has in his or her repertoire.

*Variability*. In a selectionist paradigm, variability forms an essential characteristic of an account of behavior. Whether the contingencies happen at the level of phylogeny, ontogeny or culture, variation must take place first in order for selection to occur. Species that behaved in a stereotypical manner and did not exhibit variability in the face of environmental changes no longer exist (Sidman, 1960).

Many behavior analytic researchers who study the emergence of novel behaviors within context of creativity have used reinforcement to increase variability and novelty. The principle of reinforcement provides a means to produce variations in a widespread class of behaviors such as academic, vocational, social, and leisure pursuits. More specifically, the withdrawal or delivery of reinforcers increases variability of responses (Epstein, 1985; Goetz & Baer, 1973; Marr, 2003). For example, Goetz and Baer (1973) performed an often-cited study in behavior analysis that used reinforcement to foster diversity and novelty with preschool children. The participants of the study involved three 4-year-old preschool girls. During baseline, the teacher observed the children building blocks. The children remained in baseline until new block constructions stabilized. In the intervention phase, teachers reinforced the appearance of new block forms with social praise. The result of the experiment, the children increased the form diversity of the block constructions. While Amabile (1983) and others have questioned this study, the merits of the discussion fall beyond the scope of this paper.

Fostering variability of responding has limits in terms of the scope of novel responses. Specifically, how much can a person's behavior vary? If we arrange appropriate conditions to foster variability, will a person eventually come up with the equation for Einstein's theory of relativity? It seems unlikely variability alone explains the full dimensions of novel behaviors. Rather variability demonstrates a method for increasing novel responses. The skills and information a person has in their repertoire will ultimately circumscribe how many responses show up resulting from reinforcement procedures.

Through imitation, instructions, and variability, research has shown how novel behaviors appear. What distinguishes these forms of novel behavior? People ascribe credit, or give value, to behaviors by examining the conditions under which they occur (Skinner, 1971). For example, if knowing the boy-scout received a payment for assisting an elderly person cross a street, we would not credit the boy scout with certain virtues. Indeed, we may question the boy-scout's intentions. On the other hand, if we discovered he performed his task because he enjoyed helping people, we would credit him with a noble deed, and value his behavior.

How people attribute credit, or value, novel behavior follows a similar account. If we watch a person imitate a complex behavior we would qualify it as novel, but we would not value it much because it does not demonstrate originality. If a person reads instructions and demonstrates a novel behavior we again would agree on the novelty of the behavior but would tend to value it less because of the derived source of originality.

Promoting variability alone does not ensure or explain the production of novel effects in all people. Interconnection of repertoires, and contingency adduction, provides a descriptive account of how more dramatic novel effects occur. Further, novel behavior resulting from interconnection of repertoires or contingency adduction promotes attributing value and credit due to the hidden nature of processes leading up to the behavior.

## Interconnection of Repertoires

A repertoire describes skills and behaviors people perform. Specific skills and behaviors, particularly operants, result from interactions with the environment. Because people experience environment-behavior interactions differing in both time and place, we all possess unique repertoires. These unique repertoires have accumulated over the span of time and do not readily reveal themselves when analyzed for contributions to current behavior. Through controlled studies, the isolation of specific repertoires demonstrates their contributions to complex repertoires. The following section on interconnection of repertoires describes such research based on experiments with pigeons.

From basic research, we have learned the astonishing and dramatic appearance of novel behavior may occur because of phenomenon known as "interconnection of repertoires" (Epstein, 1985a). Interconnection of repertoires describes a process where certain behaviors in a repertoire combine to produce novel sequences. Once combined, the novel sequences produce new behavior that can undergo selection.

Epstein, Kirshnit, Lanza, and Rubin (1984) conducted an experiment that demonstrated the effects of the interconnection of repertoires. Pigeons served as research subjects in a systematic replication of Köhler's (1925) classic experiment with chimpanzees. The goal of the experiment, similar to Köhler's experiment, called for the terminal behavior of a complex solution: pushing a box underneath a suspended banana, climbing up on the box, and then pecking the banana. None of the pigeons received explicit training on performing the terminal behavior. Also, they did not receive training on pushing the box under the banana nor did they ever have the chance to experience the testing situation requiring an untrained composite behavior, until after training of all the component behaviors.

Each of the pigeons learned certain component behaviors. Those having successfully mastered all three behaviors of directional pushing, climbing on a box, and pecking the suspended banana emitted the correct solution within minutes as Köhler's chimpanzee did. The pigeon's that did not receive training on all components behavior did not generate a correct solution.

## Contingency Adduction

The last category of novel behavior, contingency adduction, appears somewhat similar to the phenomenon of interconnection of repertoires. Contingency adduction, refers to the process where repertoires established in certain conditions recombine with other repertoires to produce new forms and behavioral sequences (Johnson & Layng, 1992). This process has both basic and applied support (Andronis, Layng & Goldiamond, 1997, Johnson & Layng, 1992, 1994).

Johnson and Layng (1992) provide an example of contingency adduction with four college students attending a summer program for College. All students attempted fraction word problems as part of an instructional sequence. The best of all the students scored 7 out of 14 correct, or 50%. These students demonstrated comparable deficiencies in word problems at a lower level involving whole number completion.

As part of the students' mathematics program, they all received instruction on problem solving and calculations with whole numbers and computation practice with fractions. They practiced these component behaviors until the reached a "fluent" level. The four students then took a test similar to the one they had taken before they reached fluency. The lowest of the scores afterwards: 13 correct and 1 incorrect. The other three students answered all questions at 100% accuracy. None of the students ever received instruction on fraction word problems. The students adduced repertoires allowed them to solve the problems correctly.

Contingency adduction appears similar to the interconnection of repertoires because in both cases established component repertoires combine to form novel composite repertoires. However, a difference between the two exists in the scope of each process. When component repertoires, or behaviors, interconnect, as in the Epstein, et al. (1984) experiment, the repertoires come together and meet with the same reinforcement contingency as when shaped separately (Andronis, Layng & Goldiamond, 1997). When component repertoires adduce, they do not necessarily come from an "automatic chain" as in interconnection (Andronis, et al., 1997). Rather, a repertoire " . . . may be recruited by quite a different set of conditions into a new function and eventually into a radically new repertoire" (Johnson & Layng, 1992, p. 1487).

Studies extending the generality of interconnection of repertoires and contingency adduction require more experiments with human participants to elucidate the subtle and dramatic differences between the two processes. Until then, it seems reasonable to propose that both processes remain centrally important to the explanation of consequential instances of novel behavior.

Contributions from Behavior Analysis

Table 1 displays environment-behavior relations that result in the emergence of a novel behavior. But, how does this, and the information presented so far, aid researchers from non-behavioral orientations? First, Table 1 shows that behavior analysis has more to offer the study of creativity than just reinforcement. For instance, Joussemet and Koestner (1999) stated: "Behaviorists treat creativity like any other performance dimension and state that reinforcement will increase its frequency" (p. 231). Second, the elements of the common definition of creativity, the emergence of a novel product and a corresponding appropriateness for a situation, constitute a starting point for further study. A behavioral perspective offers a research base and divergent methods for producing novel products possibly demonstrating creativity.

Clearly all listed environment-behavior relations can produce novel behavior or products in many situations. Which performances or products do we select as creative? Identifying the sources of control for a novel and appropriate product helps in two ways. First, it facilitates understanding of how a person

TABLE 1. Environment-behavior relations, sources of control, and response outcomes associated with the emergence of novel behaviors or products labeled creative.

| **Environment-Behavior Relation** | **Source of Control** | **Response Outcomes** |
|---|---|---|
| Imitation | Some type of model | Identical or very similar novel behavior and/or product from a model |
| Instructions | Textual or verbal rules or instructions | Novel behavior and/or product approximated from textual or verbal stimuli |
| Variability | Reinforcement | Novel behavior and/or product from variations in a person's repertoire |
| Interconnection of repertoires | Situation requiring new behavior | Novel behavior and/or product resulting from component repertoires established under conditions serving similar contingency requirements |
| Contingency adduction | Situation requiring new behavior | Novel behavior and/or product resulting from component repertoires established under conditions serving different contingency requirements |

came to produce such an act and with sufficient information we can predict and control the desired novelty. Second, by better identifying the sources of control we position ourselves to make the determination of "creativity." It appears that imitation, instructions, and variability typify conceptions such as "little C" creativity or "ordinary creativity." Interconnection of repertoires, contingency adduction, and sometimes, possibly, variability, epitomize "big C" creations.

Another, more pragmatic question that arises: What can we do to facilitate creativity? Research has demonstrated an orderly process whereby behavior established under certain situations may recombine and emerge to form dramatic instances of new behavior (Andronis, Layng & Goldiamond, 1997; Epstein, 1996; Johnson & Layng, 1992; Layng & Andronis, 1984). Fostering the emergence of conspicuous and eminent instances of novel behavior involves understanding the repertoires and underlying processes contributing to such displays.

Johnson and Layng (1992) noted the importance of one such criteria of performances: fluency. Engendering fluent performances means using certain practice strategies that will effect instruction and student learning (Binder, 1996, Johnson & Layng, 1996; Kubina & Morrison, 2000). Building fluency, however, predicates itself upon the knowledge of the component repertoires or behaviors that will recombine. Currently, we posses limited knowledge of instructional sequences that produce interconnection of repertoires and contingency adduction for behaviors qualifying as big C creations.

What future prospects may arise from a behavior analytic perspective on creativity? Refining studies producing variability will allow other avenues for controlling the emergence of novel behavior. This paper discussed the use of reinforcement to bring about variability. Other basic processes exist that also affect variability such extinction and extinction-induced resurgence (Epstein, 1985b). Further, the experiments performed with interconnection of repertoires and contingency adduction requires both direct and systematic replication to determine their generality as functional relations of behavior.

## CONCLUSION

In the future, as research in behavior analysis progresses and increasingly focuses on issues such as novelty and creativity, a close and productive link can form between those interested in the results from a science of behavior. The rapprochement has already begun to occur between behavior analysis and other disciplines. For instance, Palmer and Donahoe (1992) state: "Behavior analysts are well advised to consider those cognitive analyses that are selectionist and question any behaviorist analyses that smack of essentialism" (p. 1344). The selectionist approach to behavior may one day unite diverse disciplines and facilitate a wide spread interdisciplinary effort.

For the present community of researchers studying creativity, a behavioral perspective immediately widens and diversifies the field by adding methodological and analytic procedures. For example, Amabile et al., (1996) discusses the value of "ipsative" assessments of creativity. Behavior analysis offers a wealth of successful experimental designs exploiting individual differences. Further, the experiments conducted in behavior analysis appear to support and lend additional interpretations to issues such as domain specificity of creativity.

The conditions responsible for "big C" and "little C" creations lurk in a person's history of reinforcement. A direct observation of those conditions will forever escape us. Yet, we can conduct experimental analyses allowing us to infer certain variables or histories leading to certain behavioral outputs. With this information we position the research community to systematically replicate and validate procedures predicting and controlling "big C" and "little C" creations.

The perspective offered from behavior analysis may differ theoretically from other disciplines. In fact the subject matter may diametrically oppose those studied by others (e.g., observable behavior versus mental processes). Nevertheless, an interdisciplinary approach has appeal. Behavior analysis offers a number of highly desirable procedures for studying creativity. These procedures add to the collective knowledge base of variables that control the creative process, thus allowing researchers to manipulate these effects and make creativity more likely to occur in the future. Conversely, the wealth of information generated by non-behavioral researchers can direct behavior analysts into new territories.

Unlocking the key to the creative process offers a grand prize: the heralding of an age where scientific procedures allow people to make incredible discoveries and products. This process may come from a rapid or slow progression of scientific discoveries. At either rate, it will most likely come from a person, or people, knowledgeable about the various approaches to the study of creativity.

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