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BEHAVIORAL CUSPS, BASIC BEHAVIORAL REPERTOIRES, AND CUMULATIVE-HIERARCHICAL LEARNING

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Much behavior development is cumulative and hierarchical in that subsequent learning is dependent on prior learning. The behavior or behavioral changes that produce subsequent important behavioral changes are referred to as basic behavioral repertoires or behavioral cusps. This progression of learning is called "cumulative-hierarchical learning," and it may be an important concept for understanding much complex human behavior. Despite its potential importance, there has been little systematic study of the concept within behavior analysis or psychology in general, which limits our understanding of complex human behavior. One reason for the lack of research may be the difficulty in studying cumulative-hierarchical learning and identifying behavioral cusps. Methods to study cumulative-hierarchical learning are described.

> Complex forms are often built by a much simpler (often a very simple) system of generating factors. Parts are connected in intricate ways through growth, and alteration of one may resound through the entire organism and change it in a variety of unsuspected ways. (Gould, 1980, p. 42)

In behavior analysis, complex behavior is explained by selectionist principles (e.g., Donahoe & Palmer, 1994; Skinner, 1987, chap. 4; 1990). In operant conditioning and natural selection, variations in complex phenomena are produced through the action of a simple selectionist mechanism. In natural selection, variations in the characteristics of organisms are selected by what might be called a "reproductive consequence," while in operant conditioning variations in behavior are selected by a reinforcing consequence. Both levels of selection are used to account for the diversity and complexity of their subject matters (Donahoe & Palmer, 1994), but this complexity can be understood only by

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considering the cumulative effects of the selectionist principles. For example, according to evolutionary theory, feathers in birds were probably initially selected for their insulating properties, but once selected they could undergo further selection for their utility in flight (Donahoe & Palmer, 1994). Likewise, in behavioral selection, previously selected responses determine the variations of behavior that are available for further selection (shaping is a simple example), and, more importantly, the acquisition of certain behaviors may result in access to new contingencies that further develop a person's behavioral repertoire. The purpose of the present paper is to highlight the cumulative nature of behavioral selection, to demonstrate its possible significance for understanding and controlling complex human behavior, and to discuss methods for the study of cumulative-hierarchical learning.

Cumulative-Hierarchical Learning

Behavior analysts consider behavior to be the product of current variables and learning history; therefore, both can be considered independent variables. Like learning history, a repertoire of behavior can be viewed as a cause (independent variable) and, as an effect (dependent variable) (Staats, 1968):

> Thus, the behaviors that we acquire are learned. But these behaviors then contribute to the quality of our adjustment and learning in later situations. Our total behaviors, personality, if you will, is an effect. But it is also a cause of how we will later do, and how our later behavior (personality) will be formed. (p. 292)

In the following quote, Staats (1968) illustrates the concept using imitation as an example:

> Traditionally, imitation has been considered to be a basic propensity of "human nature" which is not analyzable into lower-level principles. As such the concept of imitation was used to explain behavior—which in one manner of speaking is quite acceptable. That is, as a constituent of the basic behavioral repertoire, imitation skills will indeed determine how the child will learn in many different situations. Thus, the varying quality of children's imitational repertoires could be selected as an independent variable in a study to see what the effect of the independent variable would be on cognitive learning, sensory-motor learning, social learning, and so on.
>
> However, the imitation repertoire is itself explainable on the basis of the higher-level basic laws of conditioning. (pp. 425-426)

Staats (1975) illustrates the role of the repertoire, which he calls the basic behavioral repertoire (BBR), and its effects in Figure 1.

In this model the behavior in the current situation is a function of the

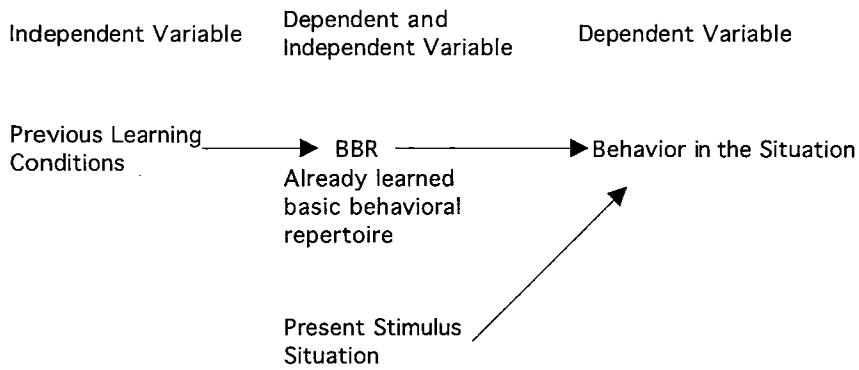

Figure 1. Staats's conceptualization of the cumulative learning process. *Note.* From *Social Behaviorism* by A. W. Staats, 1975, Homewood, IL: Dorsey. Copyright 1975 by A.W. Staats. Adapted with permission.

present stimulus conditions and the basic behavioral repertoire, and the basic behavioral repertoire is a function of the previous learning conditions. Figure 1 illustrates cumulative-hierarchical learning by indicating that behavior in the current situation is partly the product of the basic behavioral repertoire (and, hence, is the product of previous learning). The basic behavioral repertoire could be seen as an intervening variable, but Staats says it must be specified into what it is and how it functions (Staats, 1996).[1]

Perhaps a better way of illustrating the importance of the environment in cumulative-hierarchical learning is the diagram in Figure 2.

This diagram highlights the repeated cycles of the selectionist

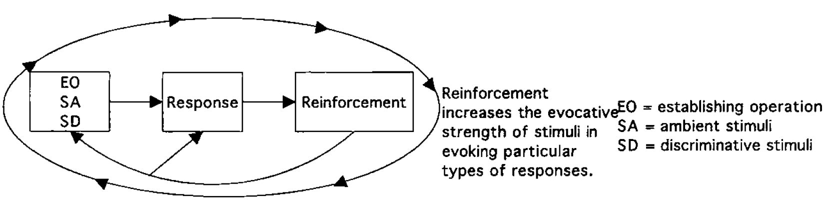

Figure 2. Another conceptualization of the cumulative learning process.

[1]Staats's multilevel theory of human behavior is called *psychological behaviorism* (Staats, 1996). Although Staats says that all parts of the theory must be specified, he and some of his followers are guilty of inferring causal events (e.g., in particular, parts of the psychological behaviorism analysis of emotion–see Staats, 1996) based on observations of environment-behavior relations (see Minke, 1990, for a description of this method). This is no different than the inferred-process approach that characterizes much of psychology (Donahoe & Palmer, 1994). Many behavior analysts prefer inferences or interpretations to be constrained by principles that have been identified through prior experimental analyses (e.g., Donahoe & Palmer, 1994). In spite of this feature of psychological behaviorism, there is much in the theory that eliminates the need for these inferred processes.

principles of behavior analysis. Reinforcement brings behavior under the control of the current stimulus conditions and the relevant establishing operation (EO) (e.g., food reinforcement brings the response under the evocative control of food deprivation) (Donahoe, Palmer, & Burgos, 1997; Michael, Hixson, & Clark, 1997). When the EO and the stimuli are later present, the reinforced response is evoked. Repeated cycles of this process under a variety of stimulus conditions and EOs produce repertoires of behavior consisting of responses controlled by various stimuli. For instance, reinforcement contingencies can establish an imitative repertoire consisting of stimuli from the behavior of another person evoking the same behavior in the observer. The repeated cycles of the selectionist process highlight the fact that a previously conditioned response may partially determine the contingencies to which an organism is later exposed. Learning to walk, for example, allows infants to access a new array of reinforcers that further develop their behavioral repertoires, and it is this that defines *cumulative-hierarchical learning*. The terms "behavioral cusps" (Rosales-Ruiz & Baer, 1997) and "basic behavioral repertoires" have been used to describe the behavior or behavioral changes that permit access to these new contingencies.

According to Rosales-Ruiz and Baer (1997, p. 533): "A behavioral cusp . . . is any behavior change that brings the organism's behavior into contact with new contingencies that have even more far-reaching consequences." They discussed learning to walk and generalized imitation as behavioral cusps. Behavioral cusps are distinguished from other behavioral changes by the fact that a behavioral cusp "exposes the individual's repertoire to new environments, . . . new contingencies, and new communities of maintaining or destructive contingencies" (p. 534). This may in turn lead to further behavior development and the acquisition of new behavioral cusps (see Rosales-Ruiz & Baer, 1997 for further explanation of behavioral cusps).

The definition of behavioral cusps is similar to that of the "basic behavioral repertoire" (BBR). A repertoire is called a BBR when it provides "a foundation for additional learning" (Staats, 1975, p. 63). Similarly, after discussing a number of BBRs, such as attention, imitation, motivation, and language skills, Staats says, "Each of the basic behavioral repertoires of skill that has been discussed herein is given that term because such a repertoire will be important in the acquisition of more advanced skills" (1971, p. 288). The term "cumulative-hierarchical learning," which was coined by Staats, refers to the fact that much learning depends on a history of previous learning. The previous learning that permits later learning is the acquired behavioral cusps and BBRs.

Like Staats, Rosales-Ruiz and Baer (1997) include behavioral cusps, in addition to contingencies of reinforcement, as causal variables:

> It [the behavioral cusp concept] points out that certain changes cause subsequent broad or important behavior changes, in the sense of making those subsequent changes available. If we want

> to explain those subsequent changes, we need to know the contingencies that shape them and the cusp that makes them available for that shaping. (p. 536)

The argument is that both the current contingencies and the cusp (the current behavioral repertoire) must be known to understand complex human behavior. Additionally, the contingencies that produced the cusp must be known. In this sense, the past contingencies of reinforcement are the ultimate cause and the behavioral cusp is a proximate one. There may be other ways to describe such causal events, but the basic point is that there are repertoires in human behavior development that are important for further behavior development. Examples of some repertoires that are probably important in human behavior development are listed in Table 1. More research is needed on most of these repertoires in terms of their composition from a behavioral perspective and how they access new contingencies. There are also many more behavioral cusps that need to be identified and studied, but there are some possibly serious problems in conducting and interpreting research on behavioral cusps and cumulative-hierarchical learning.

Table 1

Behavioral Cusp Examples

Behavioral Cusp	Why it is a behavioral cusp	Example/Reference
Imitation: echoic, fine and gross motor	It permits rapid learning of new behavior, which accesses new contingencies.	Lovaas (1977) found that first teaching an echoic repertoire resulted in faster tact response acquisition than shaping individual tact responses.
Automatic conditioned reinforcers (speech sounds, and probably many others) and punishers	When speech sounds function as automatic conditioned reinforcers, the babbling sounds of the infant will be shaped into the sounds of the community's language.	Smith, Michael, and Sundberg (1996) found that pairing phonemes with tickling resulted in an increase in the infant making those sounds.
Reading decoding	It is necessary for reading comprehension (see below).	For a review of effective methods for teaching decoding, see Carnine, Silbert, and Kameenui (1997).
Repertoires that facilitate learning to decode: letter-sound knowledge, blending, phonemic awareness	These repertoires permit or facilitate reading decoding, which is a behavioral cusp.	For evidence that these are behavioral cusps for decoding, see The Center for the Future of Teaching and Learning (1996), National Reading Panel (2000).
Repertoires other than decoding which permit reading comprehension: intraverbal repertoire, listener repertoire, fluent reading	These repertoires permit or facilitate reading comprehension, which is a behavioral cusp.	For a review, see Carnine, et al. (1997), National Reading Panel (2000).

Reading comprehension (reacting to what was read in ways that demonstrate understanding)	It permits rapid learning of new behavior, which accesses new contingencies.	For a review of effective comprehension strategies, see Carnine et al. (1997).
Components of a problem-solving repertoire	An organism with a repertoire rich with the component skills to solve problems is likely to solve many such problems.	Epstein (1996) describes a series of experiments on teaching problem-solving repertoires to pigeons.
Relational responding	It enables possibly appropriate responding to novel stimulus configurations, or produces new stimulus functions without direct training.	Lowenkron (1988, 1998), Lowenkron and Colvin (1992, 1995)
"Naming" repertoire	It allows rapid learning of new tacts and listener behavior.	Horne and Lowe (1996)
"Persisting at an arduous task": could be continued responding on a thin reinforcement schedule and/or reduced effectiveness of punishers associated with task.	The completion of academic tasks is often effortful and may require larger and larger behavior investments for a relatively small payoff. Children with experience overcoming tasks of greater difficulty are probably more likely to exhibit good persistence at other tasks.	Staats (1968) found that the implementation of a token economy with disadvantaged children, gradually improved their persistence at academic tasks, which accelerated their learning rates.
Generalization between language repertoires (receptive & expressive; mand & tact)	It allows rapid development of verbal repertoire without direct training of each verbal relation.	More research is needed to determine when and why such generalization occurs. Guess (1969), Guess and Baer (1973), Hall and Sundberg (1987), Wynn (1996)
Mutual exclusivity bias	It permits rapid learning of tacts.	When children hear a novel name in the presence of one novel object, they tend to acquire the tact of that object (see Merriman & Bowman, 1989 for a review). More research is needed to determine when and why such generalization occurs.
"Fluent component skills"	Precision teachers have found that if students learn component academic skills to a high rate, then they are more likely to apply those skills to solve more complex academic problems.	Binder (1993). Johnson and Layng (1992) describe a case in which teaching basic arithmetic skills to a fluent rate with a young adult produced successful performance with fractions with no direct training.
Repertoires That Interfere with Subsequent Behavior Development or Develop Undesirable Repertoires		
Over-reliance on contextual cues as a strategy for decoding words	It interferes with learning to read.	Research cited by the Center for the Future of Teaching and Learning (1996) found that teaching children to use context

		and prediction as strategies for word recognition, rather than phonetic skills, produced more students with reading disabilities.
Tantrumming, nonresponsivity, noncompliance	These types of behavior interfere with the acquisition of further behavioral repertoires because the person does not attend to the instructional stimuli or emit responses that could then be reinforced or corrected.	Drash and Tudor (1993) "by preventing the occurrence of reinforceable verbal behaviors, disruptive behavior is a major factor contributing to language delay" (p. 21). Other research has also highlighted the negative effect that disruptive behavior can have on the acquisition of other behavior (e.g., Drash, 1997, chap. 8; Koegel & Covert, 1972; Lovaas, 1977, Staats, Brewer, & Gross, 1970).
Antisocial repertoire	Not following teacher directions interferes with learning which results in later lower paying jobs and increased risk of criminal activity. Rejection by normal peer group, but acceptance by deviant peer group who reinforce antisocial behavior also increases risk of delinquency.	Antisocial children are more likely as adults to have lower paying jobs and to be in unhappy marriages (Patterson, Reid, & Dishion, 1992). Antisocial children spend less time academically engaged (Walker, Shinn, O'Neill, & Ramsey 1987). Antisocial repertoire causes peer rejection (Patterson, DeBaryshe, & Ramsey, 1989). The antisocial peer group contributes to later delinquency and substance abuse (Elliot & Huizinga, 1985, as cited in Patterson et al., 1992).

Problems in Conducting Research on Cumulative-Hierarchical Learning

One problem in conducting research on the effects of previous learning on subsequent learning is merely practical. Long-term studies will be required that measure multiple behaviors. Rosales-Ruiz and Baer (1996) call the multiple responses "First Behavior" and "Second Behavior," where first behavior is a prerequisite to second behavior. With some exceptions, typical research in behavior analysis involves the study of single responses over a relatively brief period of time.

Because a behavioral cusp results in access to new contingencies, it is probably impossible to repeatedly train and remove a behavioral cusp, which makes a withdrawal design inappropriate. Multiple-baseline designs may be used to overcome this problem.

The acquisition of behavior is often gradual. This could be a problem in evaluating whether first behavior really is a prerequisite for second behavior because there will be no immediate change from the absence to the presence of first behavior. Another problem is that the acquisition of second behavior may also be gradual. The problem of the gradual acquisition of behavior is not unique to this type of research, however. The effects of instruction in social skills (which requires many sessions) on the antisocial behavior of children may be gradual and delayed, which makes detecting an effect more difficult.

Finally, and, perhaps, most seriously, even though we may be able to experimentally manipulate first behavior through a multiple-baseline design, we will only have shown the sufficiency (or insufficiency) of first behavior but not its necessity (Rosales-Ruiz & Baer, 1996). Perhaps other events or behaviors could produce second behavior. To this Rosales-Ruiz and Baer (1996) reply that we "may still build a developmental psychology on our increasing knowledge of the specific First Behaviors that are sufficient, even if not prerequisite, for Second Behaviors" (p. 174). The following section will discuss methods that appear promising for the study of cumulative-hierarchical learning.

How to Study Behavior Development

The typical research methods in psychology are inadequate for studying cumulative-hierarchical learning. Experimental-group designs, for example, in which the behavior of subjects is briefly measured under varying conditions do not lend themselves to understanding behavior development and the cumulative-hierarchical learning process. Even correlational-longitudinal research is unsatisfactory because the observed changes in behavior over time are difficult to relate to specific causal events. Staats (1996) discussed the importance of studying cumulative-hierarchical learning and a research methodology called "experimental-longitudinal research" for its study:

> The essential fact is that a child only acquires repertoires—language repertoires, reading, writing, number skills—over years of time. Without experimental-longitudinal research on the actual learning process traditional researchers are misled .... Short-term studies of relatively simple behaviors do not reveal the importance of learning for the development of human behavior and differences in behavior. (p. 162)

In experimental longitudinal research, all of the stimuli, responses, and consequences are recorded. According to Staats (1996):

> When every stimulus and response is recorded . . . the detailed nature of the learning process is there to see. For example, the relative difficulty of parts of complex training materials can be seen. Also the various skills that emerge from the learning can also be seen with detailed study of individual subjects . . . . Moreover, how one type of training can aid in the development of the next can be studied, as well as how new abilities emerge through each type of training. (pp. 161-162)

The experimental-longitudinal research methodology is illustrated in Staats's research on teaching disadvantaged preschool children and in studying child intelligence. In these cases, multiple behaviors were taught and measured, and all of the antecedent and consequent stimuli were recorded. Staats (1968) developed his training and research methods with his own children to teach reading, arithmetic, and motor skill repertoires at an accelerated rate. Some experimental rigor was lost because the training conditions were changed, multiple behaviors were changing, some of the behaviors changed rapidly and others gradually, and the focus was often on skill acquisition—which made a withdrawal condition inappropriate. Also, because the behaviors were observed over an extended period of time, perhaps there were other environmental or biological changes that produced the changes in behavior. After the procedures were developed with his children, the standardized teaching procedures were applied to the academic behavior of disadvantaged preschoolers in a single-subject experimental design (Staats, 1968). Staats found that, at least initially, the older children and those with higher IQs learned faster than younger children and those with lower IQs. At face value, the results supported a biological-maturational view of learning. The younger children's nervous systems may not have been "ready" to learn certain academic skills. But observation of the children's behavior found that the brighter and older students had repertoires that facilitated learning. Specifically, these children were better at attending, following directions, and persisting at arduous tasks. Staats and colleagues found that once the other children acquired these skills they learned just as rapidly. These results further strengthened the confidence in the independent variables, but some threats to internal validity remained, such as the gradual changes in behavior over time. To address these concerns, an experimental pretest-posttest group design was implemented with a control and an experimental group. The experimental group made significantly greater gains in academic achievement than the control group (Staats, Minke, & Butts, 1970). This final study exhibited strong experimental control, but it lacked the detailed specification of the learning conditions and behavior of the earlier research. Considering the research sequence in totality, the results strongly suggested the importance of teaching basic repertoires to subsequent complex skill development. The stepwise development of the procedures and experimental rigor is characteristic of the experimental-longitudinal research of Staats (Staats, 1977).

Other studies in behavior analysis demonstrate a more powerful methodology for the study of cumulative-hierarchical learning than the experimental-longitudinal research method. In particular, the research of Epstein, Skinner, and colleagues on problem solving employed research methods particularly suited to the study of cumulative-hierarchical learning.

In one of these experiments (Epstein, Kirschnit, Lanza, & Rubin, 1984), pigeons were faced with a classic problem taken from Kohler's research on insight with apes (Kohler, 1925). In the original research, a banana was hung high in the apes' chamber and a small wooden box was placed in the corner. After approximately 5 minutes of unsuccessful jumps, one of the apes moved the box under the banana, leaped from the box, and grabbed the banana. Instead of attributing the ape's performance to insight, Epstein and colleagues hypothesized that the successful ape had learned certain repertoires that, when evoked under proper conditions, permitted a solution to the problem. They, therefore, trained pigeons to various degrees with the presumed prerequisite repertoires. The successful birds had the following history: (1) The behavior of climbing on a small box and pecking a toy banana hung from the ceiling was reinforced. (2) Concurrently, the birds were trained to push the small box toward a green dot that was randomly placed throughout the chamber. This training produced a "directional pushing" repertoire. The banana was not in the chamber during this training. (3) The birds were placed in the cage alone with the banana (no box) and the behavior of jumping and flying to the box were extinguished. In the test situation, the toy banana was hung from the ceiling and the small cardboard box was placed near an edge of the chamber. Epstein et al. described the performance of the birds given the above training as follows:

> At first each pigeon appeared to be 'confused'; it stretched and turned beneath the banana, looked back and forth from banana to box, and so on. Then each subject began rather suddenly to push the box in what was clearly the direction of the banana. Each subject sighted the banana as it pushed and readjusted the box as necessary to move it towards the banana. Each subject stopped pushing in the appropriate place, climbed and pecked the banana. (p. 61)

Birds trained to peck the banana, but not to climb did not solve the problem, nor did birds trained to climb and peck but not to push. Two birds trained to climb and peck and in "nondirectional" pushing (i.e., not trained to push the box toward the green dot), pushed the box aimlessly around the chamber during the test session. One of these birds solved the problem, but it took over 14 minutes. The results of this research demonstrated the importance of learning history in determining current performance. Furthermore, not only was the history outlined, but also the repertoires—that is, climbing, pecking, and directional pushing. The research method involved testing the pigeons before and after training in each component of the presumed problem-solving repertoire. In this way they were able to demonstrate the sufficiency of the repertoires for solving the problem, but, as previously discussed, they could not prove the repertoires' necessity.

Lowenkron used the same research method to demonstrate the importance of certain basic repertoires for relational responding (see Lowenkron, 1998, for a review). In one study, Lowenkron (1988) first taught children with mental retardation to make four different handsigns when presented with four distinct sample shapes. Next, the subjects were taught to maintain the handsigns over a delay interval, and then to select from an array the comparison shape that was identical to the sample (i.e., identity matching). Next, the children were tested on an identity matching task with novel shapes. The subjects showed little generalized identity matching with the novel sample shapes. Finally, subjects were taught handsigns to each of the novel sample stimuli. This produced immediate accurate performance on the generalized identity task for all but 1 subject. This subject was the only one who did not maintain the handsigns during the delay interval. Lowenkron's analysis is that subjects learned to select the object that was under "joint contol." That is, subjects selected the comparison that evoked the handsign (as a tact) and that was currently (jointly) being emitted as an echoic (i.e., being emitted over the delay interval) (Lowenkron, 1998). Because relational responding only occurred after the training with the original sample stimuli and learning the handsigns to the new stimuli, Lowenkron demonstrated the sufficiency of these to produce relational responding (generalized identity matching in this experiment). Relational responding in the natural environment probably results in access to new reinforcers, which indicates that the development of this type of stimulus control is a behavioral cusp.

Precision teachers have found that building fluency (rate) on component skills increases the likelihood of successful performance on more complex skills. Although these results have been described in various places (e.g., Binder & Watkins, 1990; Haughton, 1972; Johnson & Layng, 1992), little information is available on the actual experimental conditions and controls (but see the *Journal of Precision Teaching and Celeration*). Information from the descriptions of these projects makes it clear that initially unsuccessful teaching efforts were made successful through rate building on component skills. Such a research methodology is essentially an AB or pretest-posttest experimental design. Greater internal validity could be achieved with direct replications using a multiple-baseline or a control group, but the research suggests relationships between the fluency of basic skills and successful performance on complex tasks.

In summary, there are two basic methods that have been used to study the effects of previous learning. In Staats's experimental-longitudinal research method approach, all of the antecedent stimuli, responses, and consequences are recorded. Within and across subjects an experimenter is able to use this information to see the effects of various training methods and the effects of teaching particular skills on subsequent learning. This is not the most experimentally rigorous method of studying cumulative-hierarchical learning, but direct and indirect replications may be used to strengthen or weaken the conclusions one draws. A second method is to measure a complex skill (second behavior) before and after teaching a presumed prerequisite (first) behavior. Performing such manipulations in a multiple baseline across subjects or across complex behaviors would provide strong evidence for the sufficiency (or insufficiency) of first behavior for producing second behavior.

Research Needed on Cumulative-Hierarchical Learning

By carefully manipulating the learning conditions and the sequences in which skills are taught, the behavioral cusps for complex behavior could be identified. In the case of nonhuman research, the efforts at teaching language to apes has this potential, but has not been realized because the researchers have not adequately specified the learning conditions and the behavioral principles involved (Hixson, 1998). Nor have the researchers identified the repertoires that were basic to the acquisition of other repertoires, but certainly such changes in research methods are possible. Horne and Lowe's name relation, which offers a behavioral explanation of relational responding and transfer among language repertoires, could be studied by training apes in the various repertoires that comprise the name relation (Horne & Lowe, 1996). Similarly, Lowenkron's concept of "joint control" (Lowenkron, 1998), which offers a more detailed behavioral explanation for relational responding, could be studied with nonhumans using the same basic methods as those he used with the children with mental retardation (1988). If the teaching of the repertoires and stimulus control in naming and joint control result in successful nonhuman performance on tests of relational responding, then this would suggest that similar repertoires and forms of stimulus control may be involved in human performance. Much of the research on stimulus equivalence and relational responding has been conducted with humans who have complex learning histories that are unknown (Galizio, 2003). Research specifically manipulating the repertoires and learning histories is needed in this area (e.g., Lowe, Horne, Harris, & Randle, 2002).

The manipulation of learning conditions and the sequences in which skills are taught should also be done to study various performances in humans. For example, research on transfer between the receptive language repertoire and the tact repertoire (i.e., productive language) has found inconsistent results across subjects (e.g., Guess, 1969; Guess & Baer, 1973; Smeets & Striefel, 1976, Wynn, 1996), but none have identified behavioral explanations for this inconsistency. This has left only vague explanations for differences in transfer across subjects, such as that it may be due to differences in children's "language ages," as measured by a standard language scale (Wynn, 1996). Alternatively, perhaps such transfer depends, at least to an extent, on a strong echoic repertoire. A strong echoic repertoire might result in the accidental reinforcement of tact responses during receptive language training, when the therapist says the name of the object to be indicated. This hypothesis specifies the prerequisite repertoire, which then allows the hypothesis to be tested experimentally.

The basic approach to studying cumulative-hierarchical learning with humans will likely involve assessing the current repertoire of the participants and manipulating various learning conditions and repertoires to determine the effects of such manipulations on the behavior of interest.

For example, a number of repertoires have been identified as important in learning to read (e.g., the size and complexity of the verbal repertoire, phonemic awareness skills, letter-sound correspondences, letter naming, sight-word reading, reading fluency, etc.). But many of the studies in this area are correlational (Simmons & Kameenui, 1998). More studies that involve assessing and experimentally manipulating learning conditions and repertoires need to be conducted in the area of reading. Such research may help explain the differences in learning to read among children. Although these research methods will only prove the sufficiency and not the necessity of the learning conditions and first behaviors, the increasing knowledge of behavioral cusps may go a long way in developing a behavior analytic developmental psychology based on known principles of learning.

A possible criticism of studying cumulative-hierarchical learning is that it is inconsistent with the methodology of behavior analysis. Behavior analysts study environment-behavior relations, not behavior-behavior relations (Chase, 1996; Stromer, 1996; Zettle & Hayes, 1986). Not only must behavioral cusps be identified, but also the method by which the cusps are learned. The term "behavior-behavior relations" is not quite right. An established *environment-behavior* relation can affect the further development of environment-behavior relations given particular environmental contingencies. The reading repertoire of most children, for example, typically does greatly affect the further development of other repertoires because of the great number of contingencies that such a repertoire accesses. But knowledge of the repertoire or behavioral cusp alone is insufficient—one must understand both the repertoire/cusp and the current environmental contingencies. For instance, an antisocial repertoire may not lead to school failure given a school environment that sets up appropriate contingencies for learning.

An important issue in behavior analysis (from both an experimental and applied perspective) is the interpretation of complex behavior. A complete behavior analysis would identify all of the learning conditions that produced the current complex behavior. But knowing that history is impossible in many cases. The evolutionary biologist is faced with similar difficulties because the selection histories for most organisms are inaccessible. Instead, biologists look for proximate causes, which are found in the DNA of the species, but the ultimate cause is the history of natural selection for that species (Alessi, 1992). Behavior analysts can study the effects of learning histories (although this is not often done), but for behavior analysts too the learning histories of many organisms are out of reach. Therefore, the identification of the organism's current repertoire may be all that is available to understand the complex behavior of a particular organism. Even when not specifically studying cumulative-hierarchical learning, there is a need for behavioral researchers to specify the learning histories and repertoires of the subjects. The rare inclusion of this information in applied and experimental research limits the generality of the findings (Fuqua & Bachman, 1986). The repertoire can be assessed through reinforcer assessments, functional analyses, and skill assessments. The continued development of assessments from a behavior analytic perspective with emphasis on identifying specific environment-behavior relations will be critical for assessing a person's current repertoire. Traditional assessment instruments that measure such vague constructs as IQ and personality will be less useful.[2]

In summary, it is hoped that the present paper will stimulate theory and research on cumulative-hierarchical learning. An appreciation of this process may shed greater light on the development of a wide range of human behaviors in such diverse areas as abnormal behavior, child development, personality, intelligence, social behavior, creativity, athleticism, and so on. There are, however, a number of methodological problems that need to be addressed in such research, but we may still proceed in identifying behavioral cusps sufficient, if not necessary, for the development of further complex behavior. D. C. Palmer (1999, personal communication) succinctly described cumulative-hierarchical learning and its importance from a learning perspective:

> Behavior analysis is in competition with other paradigms to find the Holy Grail of psychology: a plausible interpretation of complex human behavior. Our interpretations tend to be parsimonious, but many people outside our field find them unconvincing. One of the reasons for this skepticism is that the path from a set of atomic contingencies distributed over time to a fluent novel, complex behavior is a long and torturous one. It is tempting to invent explanatory way stations that seem to stand for a history of reinforcement. These shortcuts are objectionable when, like schemas, representations, and icons, their existence is inferred from the data to be explained. But a subject's repertoire is also a kind of way station, and it is not objectionable. That a subject can read letters of the alphabet "represents" a long history of atomic contingencies distributed over time, and knowing the repertoire lets us infer the history and helps us to predict how the subject will perform in a beginning reading task. Ultimately it is the atomic contingencies that explain the behavior, but often they are out of reach, while the repertoire can be evaluated directly. Moreover, there are inflection points in the development of any selection history that are particularly important for understanding subsequent development. Just as the evolution of the lung enabled animals to exploit a range of environments previously out of reach, so learning to walk, learning to tact, and learning to count open new worlds of contingencies for the individual.

[2]For an example of a detailed behavioral assessment that measures specific environment-behavior relations, see Partington and Sundberg (1998).

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