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Toward an Analysis of Concepts and Solutions to Training Concepts

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What concepts are and how we learn them have been debated and studied across the world and throughout history. The evolution of concepts from the ancient Greeks to modern instructional technologies will be reviewed. Although an extensive history exists on concepts and how to teach them, scientists and educators have often proven ineffective at carrying out such a task. The current evidence suggests a revisit to the history and philosophy of concepts and concept formation. This paper will research the history of concepts and concept formation. A definition of concepts will be presented, following with a discussion on how to measure, teach, and test for concepts.

Keywords: animal cognition, behavior analysis, concepts, concept formation, Model of Hierarchical Complexity

This paper will discuss four things. First there will be the traditional Inhelder and Piagetian (1858) notions of concept. Second will be the history of the number of attempts to define and teach concepts to animals. These attempts have failed one after another. The attempt to train concepts in animals has been mixed and depends highly on what is used to represent concepts. Third, a behavioral developmental sequence of the development of concepts will be set forth. Fourth, in that sequence, the historical definitions will be shown where they fit.

The history of the number of attempts to define and teach concepts to animals is presented. These attempts have failed to produce an outcome that convinced the community that the animals were responding to concepts rather than responding by simple or compound discrimination. The attempt to train concepts in animals has been mixed at best. Responding is based on previously learned instances rather than true conceptual responding.

For example, in the case of oddity learning using a matching to sample paradigm, after training to one "odd" stimulus to match to, pigeons do not generalize to other new "odd" stimuli. They do not have the concept of odd. To say an organism has learned a concept, they must identify examples of the concept, and also must identify examples not presented during instruction or training (Bruner, Goodnow, & Austin, 1956; Clark, 1971; Merrill, Tennyson, & Posey, 1992; Sota, Leon, & Layng, 2011; Tiemann & Markel, 1990). Training to these criteria ensures that the desired responses are occurring under the conditions defined by the concept. Often, animals fail this second test of identifying what is not an example of the concept. So, even when animals appear to learn concepts, the concepts may not be that general, as will be shown further on. Here the distinction is training with criterion-related cues that shape to the test conditions versus training programs that depend on transfer on stimulus control.

The presence of self-awareness was determined by a mirror test, where subjects pointed to dots on their body after locating them with a mirror. Animals have demonstrated an ability to complete this task after they were taught how a mirror worked. After teaching this requisite skill for the mirror test, various animals were able to pass this test relatively easily. When it was demonstrated that pigeons and chimpanzees could pass the same self-awareness tests as people, psychologists then decided responding to open-ended concepts was not just a trait unique to humans. But self-awareness can be accomplished by paying attention to just a few features and not the entire set presented by an

Michael Lamport Commons discussed with the author and provided notes on which this paper is partially based.

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image shown in a mirror. The only reflection identified is that of the self. Can these animals match a reflection of many animals to their reflections? This is simply teaching occasion–behavior pairs, not even a discriminated sequence (chain or algorithm). This distinction between concept learning and basic conditional discriminations is important when evaluating concept formation (Layng, 2014).

There have been many attempts to teach open-ended concepts to animals (Hayes & Hayes, 1952; Pepperberg, Gardiner, & Luttrell, 1999; Premack, 1978; Thomas, 1980; Wasserman & Young, 2010). Some of these attempts are considered successful attempts, though they lack the rigorous controls necessary for one to be sure. An evaluation of a range of relevant literature suggests that scientists are having a hard time teaching animals concepts for multiple reasons. One reason is that experimenters tend to seemingly arbitrarily apply procedures hoping the target pattern emerges, rather than starting by assessing the behavioral repertoire of the animal. Often overlooked, or taken for granted, are the prerequisites necessary to perform particular complex tasks. The new must come from the old (Commons, 2007; Markle, 1969). This was demonstrated to be the case in the studies concerning self-awareness. The presence of self-awareness was determined by a mirror test, where subjects pointed to dots on their body after locating them with a mirror. Animals just could not seem to do it, at least not until they were taught how a mirror worked. After teaching this requisite skill for the mirror test, some animals were able to pass this test relatively easily.

It has been assumed that animals cannot learn concepts because of the failure to teach animals complex concepts. Although there has been some success in apparently teaching some animals complex concepts, including Skid-Boot the dog, Chaser the dog, Alex the parrot, and others, evidence suggests that animals can learn at least some kinds of concepts if the learning situation is set up correctly. A careful examination of these situations, however, shows that with the possible exception of Alex, they do not test the participants with never-before-seen exemplars.

The argument over the relative failure to teach animals true concepts can easily be extended to the failures documented in teaching humans as well. In schools, the current failures to teach certain academic concepts to all learners has led to the labeling of students as unintelligent or delayed. There are also other sources of blame and explanations about characteristics of the learner or their background. It may just as likely be attributable to how the teaching is done. This further suggests that improvements are needed in how teaching of concepts are addressed, rather than rely on explanations that the limitations of the learner in question.

In this paper, we will redefine the notion of what a concept is, and show implications of this new definition for how learning should proceed in order to be more effective in both nonhuman and human animals. To do so, we will introduce a behavior developmental theory. Such a theory is necessary because neither behavior analytic accounts, nor developmental accounts, by themselves, are adequate.

Behavior analytic accounts are useful in that they entail elegant and well operationalized experiments, demonstrating the effects of different environmental events on behavior. However, a major issue in behavior analysis is that most notions are treated as "flat." That is, if something is true in one species, such as a pigeon or a rat, it is then assumed to be generally true in other species, including humans. The possibility of something like a developmental sequence, or that phenomena might differ across species as a result of the different species' phylogenetic position, is not usually considered. Here, we address this issue with respect to behavior analytic studies of concepts and concept formation.

A developmental view of concepts will be invoked and detailed. Basically, Piaget's work was about concepts (e.g., Inhelder & Piaget, 1958), although in Piaget's theory these were called "schemas." Bruner, Goodnow, and Austin (1956) elaborated on this with respect to concept formation and defined concept attainment (or concept learning) as "the search for and listing of attributes that can be used to distinguish exemplars from nonexemplars of various categories." After the stages are introduced, they will be applied to the historical explanations, and accounts of concepts and their learning.

We propose that how concepts are defined differs across development. Specifically, as Commons and colleagues have shown (Commons & Pekker, 2008; Commons & Richards (1984), the hierarchical complexity of tasks that an animal can successfully solve differs across species. As a result, the type of concept learning that is relevant in one species is not necessarily the same type is relevant in another species. We will start by briefly reviewing information about the Model of Hierarchical Complexity, and then show how different models of concepts and concept learning that have been argued for in the past represent notions of concepts that are characteristics of only a single stage of development.

The Model of Hierarchical Complexity

The Model of Hierarchal Complexity or MHC (Commons, 2007; Commons & Pekker, 2008) is a nonmentalistic, neo-Piagetian and quantitative behavioral–developmental theory that can be used to analyze the difficulty or complexity of tasks. The model is based on the assumption that a large number of tasks and task sequences exist in the environments of all animals, whether humans or not. These sequences exist in different domains of behavior including problem solving, personal, social and others.

The difficulty of tasks is operationalized in terms of a measure called the Order of Hierarchical Complexity (OHC). Tasks at the lowest order can be solved with one simple hard-wired action. Tasks at each higher order above that result from the combination and coordination of at least two actions from the next lower order task. Figure 1 illustrates this property of the Model. The resulting 17 orders of complexity (0 to 16) are shown in Table 1. Although the Order of Hierarchical Complexity is a systematic description of the tasks to be completed, it is not a measure of performance. The performance of the organism, called stage, is defined by the highest order task that organism can successfully complete. The stage numbers are therefore the same as the order numbers of the tasks by stage. By applying the nature of the sequence one shows how new training comes from the old acquisition of next lower-adjacent stage are completed before the next, more complex tasks are trained.

The application of the model that is introduced here proposes that there is no one definition of a concept. Instead, concept-learning tasks at different orders of hierarchical complexity differ. Briefly, to teach a concept at a higher order of complexity, those responsible for the learning must insure that concepts at the necessary lower orders of complexity have been previously acquired. This idea is similar to one proposed by Bruner (1960) - the concept of the spiral curriculum. In the spiral curriculum, information is structured in a way that complex ideas can be taught at a simple level, and then escalated to more complex levels later. This ensures that students are taught at levels of increasing difficultly; the new coming from the old. This process allows learning to occur in an errorless fashion by minimizing errors through taking into account where the learner is currently successful and extending that success to novel situations.

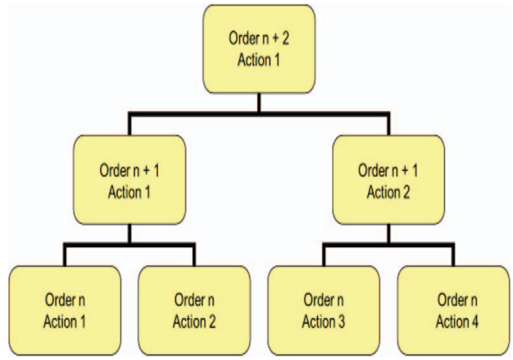

Figure 1. Task complexity. Each higher order is demonstrated by a combination of two (or more) tasks from the next lowest order in a nonarbitrary way. This figure demonstrates how an order $n + 2$ action is defined by the two actions from order $n + 1$, which are themselves defined by a nonarbitrary combination of two order n actions.

Stages of Concepts

The first four stages (0, 1, 2, 3) consist of completely preprogrammed responses (Calculatory, Stage 0), Automatic (Stage I) behavior (such as tropisms) and respondent responding without conditioning, Respondent conditioning (Sensory or Motor, Stage II), and operant conditioning (Circular Sensory–Motor, Stage III), as shown in Table 2.

Sensory–Motor Stage IV is the first stage at which any form of concept exists. In the case of Stage IV, the concepts are all perceptual classes. That means that each individual instance of a perceptual dimension has to be learned. So, in terms of the axioms, a concept is just the com-

Table 1
Orders of Hierarchical Complexity, Along With Examples at Each Order

Order name	Order #	Example
Calculatory	0	Follow a programmed set of instructions. Example: computer program.
Automatic	1	Unconditionable reflexes, sensitization, habituation, tropisms. Example: Paramecium moves away from light (Mingee, 2013).
Sensory or motor	2	Respondent conditioning. Example: On hearing mother's voice, infant turns head in that direction, begins rooting.
Circular sensory–motor	3	Operant conditioning. Example: When infant babbling is followed by vocalizing and smiling from adult, infant babbles more.
Sensory–motor	4	Forms concepts. Example: Animals from a variety of species learn discriminations of concepts, such as same/different.
Nominal	5	Relates two (or more) concepts, including relating a concept to its name. Example: can say the word, "same" or name other concepts, such as "boy."
Sentential	6	Combines names into short sequences or sentences. Example: A child says the names of a few numbers or letters, in order. Says short sentences.
Preoperational	7	Combines sentences into sequences. As a result, makes simple deductions, follows a list of sequential acts. Does not relate these to reality. Example: Tells a story of a few sentences.
Primary	8	Relates single actions to reality. Applies simple deduction and empirical rules. Recounts what has happened reasonably accurately. Understands their own perspective, or that of another person, but does not relate these two at the same time. Example: "I was sad because I lost my toy."
Concrete	9	Simple logical deduction and time sequences are used to describe actual instances. The instances are actual because they occur in past or present time. They are composed of specific things, incidents events, actions, actors and places. Coordinates own perspective with that of one other (at a time). Example: "When my grandmother was sick, I took care of her."
Abstract	10	True concepts appear. Classes with infinite number of members make true concepts possible.
Formal	11	True concepts may be applied both in a logical or empirical form. Both logical and empirical concepts are created.
Systematic	12	Multivariate concepts are introduced.
Metasystematic	13	Universal concepts are created. They are not content no context bound. They include properties of systems.

bination of either the specific examples the organism has seen or of some relatively easily extracted perceptual feature. There is a perceptual generalization gradient. Given our example of "blue," beyond some degree of dissimilarity, they will no longer say it is the same.

But perceptual concepts are not general. The specific features are not learned. The only generalization is the failure to discriminate differences between the values or intensities of these characteristics. For instance, a pigeon might peck at a blue lit key even if it varies in how much white has been added to the blue. But say that a color that the pigeon has never been trained on is presented to be matched to, for instance, a shiny brown. The pigeon, without further training, would most likely not match this to the sample. That does not mean that all perceptual concepts need to be about simple dimensions. As Herrnstein and Loveland (1964) have shown, pigeons can tell trees from nontrees with minimal training.

Note that at this stage organisms cannot tell benches from chairs. For humans, chairs have multiple characteristics so the comparison of them with benches is not straightforward. Benches are usually made out of a hard substance and do not have backs. Chairs may or may not be. Benches are usually thought of as holding at least two people. That is difficult to determine from an upholstered chair or loveseat which is not usually thought of as a bench.

In Stage 5 Nominal, the key characteristic is that names are given to perceptual concepts. The organism organizes a group of perceptual conceptual objects. The names may be vocalized, as in humans, or may be identified by a symbol understood as a spoken word as with a dog and in some other organisms. Dogs can fetch the red ball versus the yellow ball. They

Table 2
Types of Defined Concepts

Name	Definition	Examples	Stage
Perceptual concepts	Perceptual concepts are based on visual characteristics. They are not always descriptive even though the words used are.		Sensory–motor
Identities	Identities are concepts that only share a single critical defining feature.	Blue only has one critical feature, and that is the wavelength that creates "blue." Any deviation from this "blue" can be discriminated and no longer is truly "blue." The stimulus would then be considered dark-blue, blue-green, or topaz. This key feature is what makes blue an identity, and separates identities from other concepts like conjunctive concepts.	Sensory–motor
Conjunctive concepts	Conjunctive concepts, also called "and" concepts, share at least. two critical defining features. To belong to this class, the concept must have "feature A" and "feature B."	All chairs must have a place to put your bottom, and leave your feet touching the floor, with knees bent at ninety degrees. If we remove any of these critical features, we no longer would have a chair. It is the combination of these critical, must-have features that make the concept of the chair.	
Disjunctive concepts	Disjunctive concepts share only one of several possible features. These are "either-or-concepts." This either-or quality of disjunctive concepts often makes them difficult to learn.	In the game of baseball, a strike is either a swing and a miss, a pitch down the middle of the plate, or a foul ball.	

can drop the green ball versus the blue ball. So they learn arbitrary names for perceptual concepts. With short training, they can generalize to other shaped objects. This is typical of 18-month-old children. Humans with training on just two to three instances of objects, such as doors, do generalize (Gewirtz & Stingle, 1968).

At Sentential Stage 6, nominal representations are organized into sequences of such nominal stage actions. Concepts at this stage include the order in which stimuli are presented. An example is of a human child being told to pick up a ball and bite it, then drop it out. They understand these requests and perform them in the correct order, no matter which order they are given. Such sequentially has not been shown in dogs although it has been partially shown perhaps in one parrot, Alex (Pepperberg, Gardiner, & Luttrell, 1999). The concept of sequentially and rudimentary ideas about cause and effect are understood.

At the Preoperational Stage 7, sequences of representations may be organized into actions. Think of paragraphs organizing sentences. There are speculations that animals such as elephants may organize long trips to water and food by sequencing shorter "here to there" sequences. They are not just using smell or tropisms or other simple stimuli to guide their behavior such as occurs with migrations. They are taking sentential things and organizing them. Elephants and chimpanzees have a notion of the concept of death. When they come across the bones of a deceased animal they acknowledge it.

At the Primary Stage 8, paragraphs are organized into coherent stories. In humans, there is a logical order to the spoken paragraphs. The stores are known by the teller to be matching reality or fantasy. The notion of cardinal numbers is well understood. Children can relatively accurately count objects without over counting. The organize the preoperational saying of the number to the object they are counting and stop when they run out of objects. They can add and multiply. Chimpanzees have been shown to count object up to around 20. But the amount of training is large and there is no evidence yet that they can continue courting further. Humans can count and count without much of a limit. People can give reasoning between facts and fantasy in primary stage. Organisms at this stage take the perspective either of themselves or that of others but not both at the same time.

At the Concrete Stage 9, the actions from the primary stage are organized into new actions. Leader chimpanzees and almost all humans integrate the perspective of others with their own (de Waal, 1986). This allow for deal making and the formation of alliances based on political skills in perspective taking. Humans can also combine Primary Stage 8 addition, subtraction, and multiplication to form long multiplication and long division into long multiplication and long division.

At the Abstract Stage 10, only humans form symbolically named Abstract classes. Humans classify someone as being in-group or out-group instantly by their dress. For example, different headwear can identify different religious or cultural groups. Chimpanzees on the other hand can only recognize other chimps with which they have interacted versus those with which they have not. They do not immediately differentiate various out-groups from each other based on dress, hairdo, facial markings, and so forth. They can recognize everyone in their own group based on the fact that they greet each of them. So, they are only recognizing out-group because they are not members of their own group.

At the Formal Stage 11, as Inhelder and Piaget (1958) show, all quantitative concepts from the Abstract stage become relatable to one another just like the Nominal Stage 5 concepts become relatable at the Sentential Stage 6.

At the Systematic Sage 12, concepts that are multivariate in nature are introduced. They are formed by two or more organized Formal Stage 11 relationships. For example, the concept of expected utility is the product or risk and reward, both formal stage relationships.

At the Metasystematic stage, properties of systems and comparison of systems comes into play. System may have ordering of item with their variables that are transitive, that is, if $a > b$, and $b > c$, then $a > c$, the system may be complete in that there are no axioms used to describe the system that lie outside of the system. The system may be incomplete in that attempts to add axioms to complete the system lead to contradiction.

Different Historical Views of Concepts

Behavior analysts have in some sense adopted a Platonic view of concepts. In Plato's view (see Ross, 2009), concepts exist in nonmaterial and perfectly formed universal truths. He referred to the properties of these concepts as "universal truths," asserting that knowledge of these truths is inherited, residing somewhere in our souls. Descartes (Fraire et al., 2014) later elaborated on the Platonic assumptions suggesting that concepts were specific to humans. He proclaimed that animals can never form concepts like humans do. Human concepts that are complete, such as those found in simple Euclidian Geometry and in simple Predict Logic, meet Plato's ideal. Predicate logic has statements like, "if *A* and not *B*, then *A* does not imply *B*." What behavior analysts have attempted to contribute beyond this view are rough operationalizations for how to test for these concepts. For example, do humans actually test the implication that *A* implies *B* by using the counterexample *A* and not *B* to reject such implication? The problem is that these operationalizations or tests have become reified as representing the meaning of concepts. Do they show that in matching to sample the failure to generalize that any "odd" or nonmatching stimulus suffices as an "odd" stimulus?

It will be shown that the kinds of concepts that Plato (and nativists) are talking about exist only at the higher stages, specifically Metasystematic Stage 13. Such Metasystematic concepts only do exist in humans.

Plato's student Aristotle looked for another way of understanding. Aristotle asserted that individuals could only learn universal truths, or concepts, by empirically gathering information about particulars; more specifically, through knowing, doing, and making (Fraire et al., 2014). Aristotle was suggesting that the best way to learn a concept is by learning facts about it, applying those facts, and making something from the knowledge. In disagreeing with Plato's view, Aristotle introduced the experiential point-of-view of concepts and their formation. This is more consistent with a behavior analytic view. Also, because it is multivariate and empirical, this view is at the systematic stage.

At first glance, Plato and Aristotle appear to disagree. But when reviewed with careful consideration, it may be true that these philosophers, with different vantage points, were both correct. They both had definitions of a concept that were accurate. Together, they are adequate but alone each is incomplete. Plato describes an ideal that most likely only exists at the very high behavioral developmental stage 13, in which one compares systems and articulates the properties of systems. But the capacity to develop what is argued in this paper are true concepts is limited to humans. Aristotle is correct in that each person has to acquire each concept, but each was describing concepts at a different stage of development.

People are all born able to perceive differences in the environment. When learning to refer to blue, or in Mexico, *azul*, we are not introducing blue or *azul* to this person's reality. More precisely, what we are teaching is that saying blue will be reinforced in the presence of the spectral color (Skinner, 1957). Although they do not all call the exact same stimulus blue, almost every culture has one or more words for one or more stimuli in the "blue" portion of the spectrum. This fact may have been what Plato meant by having a universal truth already present inside ourselves. Aristotle never refuted the existence of universal truths, only that they did not exist inside our "universal soul." From this point of view both philosophers' positions warrant consideration. If a person detects their environment, then they may be making discriminations about the world around them.

The stimulus–response association theory of concept formation (Hull, 1920) suggests that we learn to associate a particular response with a variety of stimuli and that these stimuli come to define a concept. For instance, we associate the concept "dog" with all of the characteristics of dogs (four legs, fur, tail, and so on) and we are able to generalize the concept to unfamiliar dogs. Hull's account fails to explain why a conceptual response would occur on some occasions and not others. Further, it assumes a concept to be a thing demanding study itself. Trying to understand the concept in absence of the context in which it is used will lead to an incomplete understanding of what a concept is and how one would go about learning concepts. This view is at the Systematic Stage 12 of the MHC, because it is a three-variable contingency, made up of two relationships. The first relationship is between the stimulus and response and the second is between the response and the reinforcer. Animals that can form concepts in the Hullian sense are sensory motor. The exception is when the concept is a perceptual concept, which are already organized.

Keller and Schoenfeld (1950) defined a concept as a generalization of responding within classes of stimuli and discrimination between classes. What is added here is the discrimination part. That is already Metasystematic because it uses two properties of systems of concepts: generalization and discrimination. This new approach to defining a concept was a line of fracture from the typical definitions of the time that allowed room for mentalistic explanations, or explanations that would leave the controlling factors inside the stimulus. Keller and Schoenfeld also brought Skinner's functional analysis of verbal behavior into the question of concepts by asking the question; what makes us say the word concept in the first place? Keller and Schoenfeld effectively changed the definitional problem from "what is a concept?" To "what are the contingencies that determine when we should say the word 'concept?'" This is why behaviorism, despite popular belief, is adept at analyzing and explaining concepts and other forms of private events.

The History of How Various Behavioral Analyses Define Concepts

The meaning of terms such as concepts consists of a description of the conditions under which they are used (Skinner, 1957). Since 1957, a wide range of research has pretty clearly defined what scientists mean when they say "concept." Bourne et al. (1976) stated that to learn a concept you must focus on the relevant features and ignore those that are irrelevant. Perhaps a more current but wrong definition is given by Layng (2013), which defined a concept as "a set of shared features found in each example of the concept." From this point of view every concept shares certain "must-have" features with all other examples of that concept. These are the features that define the concept, and without these features would not be a member of the concept class. In the case of a chair we could note that a place to sit with feet still on the floor, and knees bent at roughly 90 degrees are critical "must-have" features. In addition to the "must-have" features, the examples have other "can-have" features, which the other examples of the concept may or may not have. The "can-have" features represent the various ways the concepts can differ from example to example. In the case of the chair, the material of the chair, color, or number of legs are all "can-have" features not shared across all instances of "chairs." A chair can come in many different colors, shapes, and with varying forms and numbers of legs and still be a chair. The clarification of what the can-have features are takes this approach one step closer than Bourne, who stated that the nondefining features are irrelevant, rather than another feature to be examined.

The problem is that only small subsets of the characteristics are shown. In some cases, like in natural concepts, no shared features are found between the stimuli. Yet animals distinguish between fish and nonfish for example. The second problem is that what the definition of concepts changes with stage. "What is a concept" depends on what stage you are at.

A wide range of literature exists on different types of concepts. Most of these only apply to Sensory–Motor Order tasks. These tasks require only Stage III performance. Table 1 is a partial list of such low-stage concepts and their definitions. The main distinction between the groupings is the number of shared features between each concept and other members in its class. This distinction between types of concepts can be helpful categorizations concerning the approach we might take to teach the concept in question.

However, sometimes one part of definition for a concept is one that takes into account the occasions under which the concept is generally used. This may consist of the critical features that are shared by all members of concept, and the nondefining "may-have" features that may or may not be shared with other members within the concept.

Learning and Failing to Learn Concepts From a Given Stage

Concept learning or formation is generally referred to as the process of classifying information into meaningful categories. At its most basic, concept formation involves experience with both positive and negative instances of the concept (for example, learning the difference between "dog" and "cat" categories). Forming rules at the Preoperational Stage 7 may be one way to acquire concepts, but it may not be the only approach. Rule learning is generally more efficient than learning by examples, but examples remain important until the Abstract Stage 10. In humans, it is unlikely that memorizing a set of rules would allow a novice music listener to accurately categorize punk, new wave, fusion, salsa, heavy metal, rock, and rap music.

To teach concepts, it is useful to know the stage and the particulars of the concept as well as the conditions under which the concept is used. To identify the conditions, consider two things: What are the critical features that are shared with the other instances of the concept, and what are the nondefining "may-have" features not shared by each instance. Too often when training concepts, behavior analysts rely too heavily on the shaping of small, successive, approximations and thereby may overlook other methods more suited to teaching concepts such as learning rules. This becomes a vital point when teaching concepts that are more complex, perhaps having very few must-have variables. Teaching abstract, disjunctive, or other complex concepts requires a procedural analysis as well as a task analysis to be able to measure, and teach the concept. Procedural analysis lays out what is presented as stimuli, what are the required responses, what are the reinforcers, and on what schedule. For example, correction versus no-correction, trial schedule, or wait of responding. A procedural analysis will provide the method of the training process from the bottom up, ensuring transfer of the critical controlling variables through criterion related cues. This same approach can be applied when teaching identities as well.

Vaughan and Greene (1984) showed pigeons an arbitrary set of pictures and divided them into two parts and trained the pigeons to respond quickly to one set and slowly to the other set. Then he reversed it and the pigeons switched. This shows that their understanding of concepts was arbitrary.

Learning Concepts in Animals

A true concept has infinite variations. For example, the concept of additivity does not depend on what numbers are to be added. Only humans understand this, and they only do so at the Abstract Stage 11 in which variables first occur. There has not been any evidence that any other animal species can reach that stage. Thus, although animal training of concepts can be improved, it is unlikely true concepts will ever be understood by nonhuman animals.

Learning Concepts in Humans

A lesson can be learned from the troubles documented from attempting to teach animals concepts. The lack of focus on a program that begins with the available skills of the learner and the prerequisites needed to accomplish the task are much the same problems in teaching concepts to humans.

Overlooking prerequisites in the developmental sequence, and beginning with a lack of control during initial training, permits the development of incorrect responses, established by errors, or the occasion permitting the error. This is an unintended consequence of providing occasions to respond where appropriate responses have not yet been established. Probably the most successful way of dealing with this problem is to avoid its occurrence by place the person in activities at the right place in the sequence. If established errors have occurred, a possible solution for this would be to teach the person not to use the wrong response by teaching them to avoid guessing when the right response is easy to learn. Without the rejection response there is no way for the learner to tell you that the stimulus is not present. This is not only important to the training steps, but to the analysis of the data as well.

Another question, still not yet answered, is what effect earlier errors have on the development of learning of concepts. No matter how good the training is, almost all learning involves making errors. On the surface this may not seem like a major problem, but these errors become part of the learner's repertoire. There is a difference in opinion as to how to address this question. If the initial control of the behavior is nontask criterion related, the intervention may benefit by relying on transfer procedures. Remember, transfer of control only works within a stage of the person's performance or on a lower stage. Hoping transfer will take place may prove problematic. Programming the transfer of control from one task success to another, may depend on careful attention to instructional and dimensional control. Sometimes the transfer of a control is a difficult task. The specification in the change in one controlling relation to the target relation needs to be made explicit. Developmental costs need to be assessed. It may be possible to hold steady the critical features that we know are controlling the desired response. From here we might introduce just one nondefining feature at a time, until we reach the point that only one critical feature is controlling the response against an array of nondefining features.

Analysis of Methods

Rarely when teaching a concept will distinctions between members of the concept class be easily distinguishable. Concluding that a learner understands a concept may be difficult. It may be hard to tell whether the learner is responding to the critical "must-have" features, or some shared combination of "can-have" features. For a series of concepts of increasing difficulty and behavioral developmental stage, one successful way it to use Rasch (1960) analysis. Without going into detail, Rasch analysis scales the difficulty of the items and how well a person scales the items. Both are estimated from maximum likelihood regression at the same time. A linear scale of the values of item score and person score is thereby generated.

The typical approach to analyzing data is to use a percent correct measure, which provides an aggregate picture of the total results. The problem with only taking the aggregate picture is that it ignores the acquisition of learning, and misses the specific stimulus–response topographies critical to the performance. For example, we might say that a basketball player is successful 65% of the time shooting from the three-point line. But what if we look at the data and notice he always makes three-pointers when left unguarded? That would mean he is 100% when unguarded, and lower than 65% when being covered. If we were to take into account the specific stimulus–response topographies and use a SDT analysis to analyze the data, we could identify the necessary stimulus–response topographies necessary to increase the player's performance. There is a common assumption that the controlling properties lie inside the stimulus. However, if this were true the same responses would occur to that stimulus every time. We know this is not true given that altering the consequences, the a priori probability, the decision rules, or giving prior instruction will all have an effect on the way the learner responds to the stimuli. From this, one can conclude that the controlling properties of the stimulus lie within the stimulus-response topographies, rather than in the stimulus alone.

Testing and explaining concepts has proven to be a difficult task because much of the behavior takes place on a private level. Research shows that scientists have been ineffective at teaching concepts. These results may be an outcome of overlooking the training of prerequisite skills necessary to carry out the task, or the learning program may not be up to par to carry out the learning objectives. An advantage to the use of SDT for the analysis is the ability to identify specific stimulus–response topographies that can assist in the direction of the training program, as well as provide a better representation of the performance than a simple percent correct measure.

Discussion

Concepts and concept learning, or formation, have held a place in education and the definition of intelligence. The capability to learn has always been considered reflective of intelligence. The current failure to teach certain academic concepts has led to the labeling of students as unintelligent. The position of this paper is that failure of teaching concepts is a result of various procedural implications with the program, rather than a reflection of the learning or the intelligence of the learner. Most learners typically show high levels of understanding in one area at a given behavioral stage but may perform poorly in other areas.

Currently, failures of the education system are blamed on the learners, their families, or the society. The children are often deemed extremely gifted or disadvantaged in some way. This approach leaves students unjustifiably labeled as unintelligent, incapable, or sometimes passed along with gaping holes in their education. The misunderstanding of how to define and teach concepts has led to significant deficiencies in approaches in programming for concept learning. The failures of past efforts should not be interpreted as a lack of capability or intelligence to carry out such task, rather than a sign that a different approach is required. For example, education can individualize learning by using computer-run education and the like. However, there is speculation regarding whether or not an increase in learning or performance is representative of an increase behavioral stage of development. This is a question that should be addressed by future research.

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