Respondents, Operants, and *Emergents*: Toward an Integrated Perspective on Behavior

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A triarchic organization of behavior, building on Skinner's description of respondents and operants, is proposed by introducing a third class of behavior called "emergents." Emergents are new responses, never specifically reinforced, that require operations more complex than association. Some of these operations occur naturally only in animals above a minimum level of brain complexity, and are developed in an interaction between treatment and organismic variables. (Here *complexity* is defined in terms of relative levels of hierarchical integration made possible both by the *amount* of brain, afforded both by brain-body allometric relationships and by encephalization, and, also, the elaboration of dendritic and synaptic connections within the cortex and connections between various parts/regions of the brain.) Examples of emergents are discussed to advance this triarchic view of behavior—the prime example is language. This triarchic view reflects both the common goals and the cumulative nature of psychological science.

Scientific psychology has been accused of failure to grow theoretically.   Its critics claim that we do not integrate prior findings and explanations into contemporary perspectives (see, for example, the discussion and rebuttal by Posner, 1982). A goal of good science is progress, whether reflected in cumulative theoretical development, or through Kuhn's (1962) paradigmatic revolutions, cyclic and dramatic changes that are likely to exclude many central tenets of the previous theoretical regime in favor of "more enlightened" or "more accurate" approaches.

Science may have moved beyond the phase Kuhn described, in which paradigmatic development and rejection were the primary modes of change. Kuhn's unflattering claim that exponents of different paradigms could not communicate may have been a self–subverting law; scientists who knew about it may have tried harder to eliminate their intellectual provincialism. Technological advances like the "information highway" have countered most of the contribution that geographical distance made to intellectual distance.   In any case, the present article is an attempt to circumvent revolution to achieve cumulative progress.

Psychology was (R. I. Watson, 1967), and perhaps still is, in a preparadigmatic stage characterized by a failure to agree sufficiently on the fundamentals to qualify for a Kuhnian paradigm. If we are right about the progressive substitution of cumulative science for paradigmatic revolutions, psychology may move smoothly from pre–paradigmatic to post–paradigmatic status without ever clearly having a Kuhnian paradigm.

Whether or not it is philosophically justifiable, it is trendy to discuss the "cognitive revolution" kindled in the 1950's and 1960's and evident in the current popularity of cognitive science. Behaviorism may not have been a true paradigm, but in any event cognitivists tended to challenge, discount, or ignore five decades of research in the behaviorist tradition. Conditioning, schedules of reinforcement, and similar topics once esteemed by behaviorists are rarely discussed in treatments of human cognition; rather, they receive limited attention in introductory and animal learning texts.

Ironically, if behaviorism did have a kingly paradigmatic head that cognitivism has chopped off, its crown of objective methodology remains firmly in place.

It is true that behaviorism's metatheoretical commitment to associationism (Marx & Hillix, 1987) has been challenged by the camp of cognitivists most closely related to traditional computer science and artificial intelligence.   However, the parallel distributed processing camp, technologically advanced and sophisticated though it is, relies on a connectionism that is fundamentally the same as that of Edward Thorndike (1898) or John B. Watson (1919). (Connectionists frequently do try to identify within hidden layers the rule-like patterns that mediate stimulus-response associations--patterns that are consistent with the thesis advanced here.) The historical roots of the connectionistic movement are often overlooked: even the very direct ancestors of parallel distributed processing (Selfridge, 1955, 1959; Rosenblatt 1958, 1962) are seldom cited.

Although there is thus a recidivistic/modern side of cognitive psychology, the present thesis is that the rise of cognitive psychology represents substantial progress—not just change. As one way of recognizing this progress, we suggest a trichotomous classification of behavior that recognizes and adds to Skinner's (1938) distinction between respondent and operant conditioning, while continuing to acknowledge the importance of antecedents, behavior, and consequences in psychological research. At the same time, we assert that there exist complex processes and determinants of behavior that go beyond those involved in operant or respondent behaviors. These emergent processes should not be confused with species–typical behaviors (instincts) that are fundamentally unlearned adaptations, such as imprinting, taste aversion (i.e., bait shyness), and courtship and migration patterns (see Alcock, 1979).

Consequently, we propose that a third category of behavior, *emergents*, be defined to extend the domain of inquiry for those who espouse an experimental analysis of behavior.   The recognition of emergents will provide a unifying link connecting

the several camps (e.g., behaviorist and cognitivist) that try to understand behavior through empirical, systematic research that identifies the antecedents and consequences responsible for the appearance, morphology, and disappearance of responses. This "new" class of behaviors is particularly likely to appear in organisms possessing cerebral complexity (see earlier definition) and encephalization (i.e., the extraordinary elaboration of the cortex relative to the rest of the brain; see Stephan, Bauchot, & Andy, 1970), as within the order Primates.

Emergents include alterations in the nature of the learning process (e.g., in the ability to learn relationally as well as associatively, to form both natural and arbitrary concepts, to recognize equivalence relations between stimuli that are not specifically trained/reinforced, and to develop the ability to solve novel problems in a single trial). Emergent abilities also enable an organism to learn to use symbols as representations of things and events not necessarily present, to comprehend and to use language, to speak and sing, to be able to learn vicariously from secondary records (e.g., written materials and other records), and to reflect upon past experiences and events projected in the future—to mention a few of the salient ones.

From a behavioral perspective, these alterations can be properly viewed as *emergent response modes*; from a cognitive perspective, they can be viewed as *cognitive operations and structures*. Either way, however, these alterations have properties that reflect the neuroarchitecture, neurophysiology, and neuropsychology of specific organisms as affected by specific experiences, treatments, or rearing conditions.

Precedents in the history of thought have led the present authors to label this third category of learning "emergent." In the 19th century, John Stuart Mill postulated a "mental chemistry" that coalesced simple ideas into complex ideas (see Heidbreder, 1933). Emergent complex ideas had their own distinguishing structures and properties and, hence, were more than just a composite of the simpler ideas on which they were based. In the 20th century, Nissen's (1954) discussions of possibly new and qualitatively different processes emerging as products of quantitative elaborations of the primate brain directed the senior author of the present report into research regarding their etiologies.

An interesting question that arises in this connection is whether phylogeny to some extent recapitulates the ontogeny of human development with respect to emergent behaviors. These behaviors, like all behaviors, depend on an interaction of organismic and experiential factors; thus, the full complement of emergents is available only to normal adult humans. It may be that some animals never get beyond the first stage of human development-- according to Piaget, the sensory-motor stage. Higher stages may emerge in more complex animals. An argument can be made that linguistically trained chimpanzees, orangutans, and gorillas have manifested in rare cases some properties of Piaget's highest stage, the formal operational stage. Some aspects of the intermediate stages are almost certainly seen in nonhuman primates.

Another fascinating question is how precisely the fundamental elements of behavior should be described. It is well accepted that the formation of associations is one basic mental capacity. This involves one type of memory. The ability to compare stimuli with respect to various properties--size, color, shape, and desirability, for example--seems to be an emergent capacity. Several researchers, from Krechevsky (1932) to Levine (1971) have presented evidence that animals from rats to humans are able to generate and test hypotheses about the relationships between stimuli and reinforcers. These are only two of many possible emergent capabilities that might be suggested.

Before distinguishing emergents from Skinner's respondents and operants, consider their important dimensions of commonality. First, they are all forms of behavior. Second, the behaviors are observable and measurable. Third, all three are taxonomic groups of behaviors. As such, they categorize behaviors so that they can be better understood and studied with tactics appropriate to their defining features. It is important to note, however, that, as categories of adaptive behaviors, they are not to be confused with scientific explanations. Fourth, each category has antecedents and consequences that must be defined as parameters of behavior if valid scientific descriptions and explanations of the form and continuance of behavior are to be obtained. Fifth, none of the three categories can be accounted for satisfactorily by, or reduced to, the operations of any two of the other categories. Generally, respondents and operants provide the foundation for emergents: stimulus equivalence relationships, or expectancies (Tolman, 1959) may also be considered part of this foundation; alternatively, means-end readinesses and the expectancies on which they are based can themselves be regarded as emergents.

Brief definitions of each category of the behavioral trichotomy are as follows:

I. Respondents

Respondents are responses that are elicited, without prior training, by the presentation of specific stimuli, called "unconditional stimuli" (UCS) or their conditional associates. It is reasonable to view respondents as being basically unlearned, reflexive responses elicited by specific stimuli that organisms encounter in the natural world. All other things being equal, one can predict with considerable confidence the form and continuance of a respondent upon its initial elicitation given the identity of the subject's species, its state and context, and the specifics of the UCS. For a given species, set of circumstances, and UCS, a respondent is very likely to recur time after time in the same form. Generally, a respondent requires only the impact of the UCS upon a given specimen, not upon that specimen's history of reinforcement with the UCS. Pavlovian conditioning involves respondents; the reinforcer is a stimulus, the UCS, that is correlated with an initially neutral stimulus, the conditional stimulus (CS). The UCS both elicits the respondent to be conditioned and serves as the reinforcer. After repeated presentations of the CS–UCS pair, the CS will tend to elicit a response similar to, though not in detail identical to, the response elicited initially by the UCS.

II. Operants

In contrast to respondents, operants are responses that are emitted by the organism and that are modified by their consequences. There is no readily definable UCS that elicits the operant to be conditioned. Rather, the response is initially emitted with apparent spontaneity by the subject and is not directly produced by specific operations of the experimenter. The operant can come to be occasioned by an initially neutral stimulus—a discriminative stimulus (S^D)—that functions somewhat analogously to the CS in respondent conditioning. Operants function by operating upon the environment and are selected by the reinforcing properties of the environment (e.g., the locations of nourishment, contrasted with sources of pain and trauma). Reinforcers for operants can be any external stimuli that increase the probability that the operant will be emitted. Consequently, by contrast to respondent conditioning, where the reinforcer is a rather specific UCS, in operant conditioning any of a number of consequences (e.g., things and events) might sustain the acquisition and continuance of an operant.

In the case of both respondent and operant conditioning, the presentation of the antecedent stimulus may provide a necessary context for the conditioned response to be manifested (i.e, for a discriminated operant, or for a respondent). Their learning entails reinforcers as consequences. There are several different types of procedures for both respondent and operant conditioning, and for schedule–of–reinforcement effects, that are beyond the scope and purpose of this paper.

III. Emergents

Emergents are *new competencies and/or new patterns of responding* that were never specifically reinforced by operations of the experimenter. They are not relatively simple, unitary responses (e.g., salivating, eye blinking, jumping over a hurdle, pecking a target, pressing a bar, or even chains of such behaviors) as in the case of respondents and operants. Several good examples of what we call emergents are presented by Sidman (1994; see Rumbaugh, 1995, for a review) stimulus–equivalence paradigm, in which as a result of a few specifically reinforced responses to relationships between specific stimuli, a substantially larger number of unreinforced relations can be obtained that, in turn, demonstrate "stimulus equivalence," defined by the properties of reflexivity, symmetry, and transitivity. These associations have been described by Sidman as having "emerged"; hence, their classification here as emergents is congruent with Sidman's view of them.

Emergents occur in a variety of contexts, in addition to that of Sidman's stimulus equivalence paradigm. These examples of emergents will be discussed subsequently, but each of them has in common the following attributes: (1) All emergents are forms of *silent learning*—by which it is meant that learning or acquisition of new response patterns or the cultivation of new competencies (i.e., the emergents) might progress with no obvious manifestation. (In reference to various aspects of inhibition, excitation, second order

conditioning, and so on, Flaherty, 1985, pages 126–127, uses the term "silent" in his discussions of kinds of learning that go unnoticed unless special tests are instituted.) Emergent behaviors/competencies may go unmeasured, if not anticipated, unless the subject is tested in unique/altered contexts for transfer of learning and novel patterns of behavioral adaptation. However, subjects may spontaneously manifest emergents if, during training, they markedly alter their responses in a way that is both novel and extraordinarily adaptive. (2) The emergent behaviors/skills were never intentionally or systematically reinforced as part of the experimenter's treatment procedures. (3) The emergent behaviors/skills are established through induction, so it would appear, by the organism. Again it should be noted that emergents sometimes surprise the observer when they first appear—a consequence of the fact that they were not specifically reinforced or trained by the experimenter. (4) Emergents are noted for their apparent appropriateness to new situations. Emergents can make their appearance in new contexts which only in principle are similar to those in which they formed. *They generalize between contexts not on the basis of the of specific stimulus dimension, as in stimulus generalization, but rather on the basis of relationships between stimuli and/or rules.* The relationships and/or rules referenced here can be between any kind or number of elements (stimuli, responses, reinforcers, etc.) that are shared by two or more contexts.

Interim Summary. Although emergents, like operants and respondents, provide for adaptation and generally gain in strength with time and experience, only emergents are characterized by their complexity (e.g., heirarchical integration and creativity) and by their adaptive value in highly novel contexts. These contexts must be novel enough that, as posited above, generalization on traditional stimulus and response dimensions cannot provide a sufficient account for the response. Additionally, whereas operants, respondents, and emergents all depend on antecedents and consequences, and are sensitive to contingencies, emergents are not as readily accessible to the experimenter for specific shaping by consequences as are operants. Hence, emergents are distinguished from respondents and operants in that they can appear in novel, unanticipated forms that frequently appear to be clever, creative, and, indeed, smart.

Emergents differ from respondents and operants in still other important characteristics: Whereas both respondents and operants are relatively specific responses that can become conditioned to initially neutral stimuli, emergents are modes of responding or solving problems that are not "forced" by specific antecedents/stimuli, such as a UCS or S^D. Also, the overt motoric response entailed in the conditioning of respondents and operants is fundamentally the same as the resultant conditioned response, whereas an emergent response might be strikingly different from the behavior manifested by the subject during the training experiences that generated the emergent response. Whereas overt motor responses are generally required by the subject for the conditioning of respondents and operants (sensory preconditioning is a notable exception), *emergent responses can be learned silently by an apparent passive subject through observation.* Finally, the

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learning of respondents or operants can be easily charted, for example by a cumulative recorder, whereas the formation of emergent response modes may not be discernible, because neither their formation nor their probability of later emission necessarily are indexed by concomitant behaviors.

Table 1.

Parameter	Respondents	Operants	Emergents
A. well-defined CS or antecedent	yes	yes	no
B. acquisition depends upon experience with specific and limited antecedents and consequences	yes	yes	no
C. overt response required and recordable during acquisition	yes*	yes	No—their formation may be SILENT
D. conditionable to CS/S^D	yes	yes	no
E. based on histories that emphasize generalized classes of experiences	no	no	yes
F. repetition of trials or events important	yes	yes	yes?
G. new response modes form and provide for novel adaptations	no	no?	yes
H. appears in novel contexts/problems and transfer tests	no	no	yes
I. entails syntheses of individually acquired responses	no	no	yes
J. particularly sensitive to Early Rearing variables	no	no	yes
K. interactive products of Task X Organismic variables (e.g., brain complexity as per maturation and species)	no	no	yes

* sensory preconditioning is a notable exception

These distinctions between respondents, operants, and emergents are summarized above in Table 1. Most important, however, is that emergents are much more likely to be revealed in *treatment X organismic interactions*, where "organismic" refers to both between- and within-species variables, than are either respondents or operants. Some species are able to benefit from treatment conditions that hinder others, or to which the latter species are oblivious. For example, although stimulus equivalence training can generate reflexive, symmetric, and transitive relations in normal 4-year- old children, it did not in rhesus macaques *(Macaca mulatta;* Sidman, Rauzin, Lazar, & Cunningham, 1982)—though that is not to conclude that macaques are incapable

of stimulus–equivalence relations. After appropriate training on other pairs of numerals, Rhesus macaques can choose the larger of two numerals, never before encountered as a pair, and, thereby, obtain the greater number of reinforcers (Washburn & Rumbaugh, 1991, p. 191; see details below). This behavioral skill, like the acquisition of symmetric relationships, requires an advanced brain, but not one so advanced as that of the human child.

Similarly, individuals within a given species benefit differently from treatment conditions because of parameters such as age, level of maturation, state of health, and so on. Emergents can be particularly sensitive to differences in early rearing conditions. Examples of emergents from areas of psychology in which *treatment X organism* interactions are more likely to be sought and defined—such as comparative, developmental, and stimulus–equivalence research—will be discussed to help distinguish emergents from respondents and operants. The examples listed in Table 2 do not exhaust those available from the literature, and future research will surely define additional ones.

Examples of emergents

Learning set, defined by Harlow in his classic paper of 1949, operationalized procedures which resulted in the transformation of rhesus subjects from trial–and–error associative learners to one–trial, seemingly insightful, problem solvers. Complexity of the brain across species and integrity of the brain within species, along with levels of maturation, were demonstrated to be powerful *organismic* variables which, in interaction with the *treatment* of learning–set training, affected the probability that one–trial learning capabilities would emerge. The ability to choose the correct (reinforced) one of a pair of novel stimuli at nearly the 100% level after a single "testing" trial was the terminal point of learning set formation. From the cognitivist perspective, the organisms capable of learning set formation had learned an emergent strategy, "win– stay, lose–shift," that they applied to each new pair of stimuli. From a connectionist perspective, they had learned to strengthen or reduce associative strength to stimulus cues enough in a single trial so that they could choose the stronger association at near 100% levels after that trial. Part of the reason for that might be that all increments or decrements in associative strength were attached to the cues offered by the discriminanda rather than to other "error factor" cues like right vs left position.

Transfer of learning research has a long and rich history. Transfer of learning is quantified on a continuum that extends from strongly negative (e.g., transfer slows learning), through null (e.g., no transfer), to strongly positive (e.g., transfer facilitates new learning). Brain complexity, as represented within the array of species that comprise the order, Primates, is also a continuum that extends across several levels. When one examines transfer–of–training effects in reversal learning as a function of amount learned prior to the test for transfer, one finds a remarkable effect—transfer for prosimians with their relatively

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Table 2. Research Areas that Produce

Emergent	Investigators	Characteristics
Learning set	Harlow, 1949; see Schrier, Harlow, & Stollitz, 1965, for a review	Primates and children's learning changed from trial and error to 1-trial learning as a function of number of problems.
Transfer Index	Rumbaugh & Pate, 1984	As an interaction between increased brain complexity across taxa and increased learning prior to test, primates' transfer of learning changed from negative to positive
Mediational learning	Rumbaugh & Pate, 1984	In association with increased brain complexity across taxa, learning shifted from associative to mediational or relational
Ape-language research	Savage-Rumbaugh, 1986, Savage-Rumbaugh & Lewin,1994; Savage-Rumbaugh, Murphy, Sevcik, Brakke, Williams, & Rumbaugh, 1993.	Chimpanzees learned to use arbitrary symbols to represent items, to categorize them symbolically, and to communicate about them in their absence. Also, learned symbols by observation and came to comprehend syntax of human speech.
Stimulus equivalence	Sidman, 1994	Reinforced choices of specific stimuli in discrimination learning generated many other relations between stimuli.
Latent learning	Blodgett, 1929; Tolman, 1948	Subsequent to exploration of mazes, rats demonstrated learning had taken place and to obtain incentives in accordance with privation states.
Mapping	Menzel, 1978	Chimpanzees, carried and shown locations of foods in an open field, subsequently obtained them by travelling a route that required minimal effort.
Recognition of self in mirror	Gallup, 1983	Chimpanzees, if reared in social groups, come to recognize their images in mirrors, but do not do so if reared alone.
Counting by a chimpanzee	Rumbaugh, Hopkins, Washburn & Savage-Rumbaugh, 1989	Lana, chimpanzee, learned to count in that she could remove 1, 2, or 3 boxes from a video screen in accordance with the value of each trial's target number, 1, 2, or 3, with only her memory of intra-trial events to guide her choice.
Ordinal judgments of numerals by macaques	Washburn and Rumbaugh, 1991	In transfer tests, rhesus monkeys were able to choose the larger of two numerals, never before paired, as a consequence of learning the relative pellet-values of experience with other pairs of numerals, 0-9, during training. They had acquired a matrix of relationships between all numerals.
Integration of temporally-separated explorations of maze segments	Ellen, Sotores, & Wages, 1984	Rats learned a three-table "reasoning-type" problem via unreinforced exploration of separate segments on separate days.

smooth, small brains becomes increasingly negative as pre-test learning increases, whereas the more encephalized, large-brained primates' transfer can become increasingly positive. The interactive effect between *treatment* (i.e., amount learned prior to transfer) and the *organismic* variable of brain complexity qualitatively alters the essence of the transfer effect (Rumbaugh & Pate, 1984). This phenomenon may be related to, and certainly confirms, the connection between brain complexity and the ability to form learning sets. In both cases, organisms with more complex brains are better able to "escape the bonds" formed by previous learning in order to form new associations quickly. Cognitively speaking, more complex organisms learn to identify "relevant" and discount "irrelevant" cues better than less complex organisms.

Learning processes also vary in relation to levels of brain complexity within the order, Primates. Primates with relatively smaller and simpler brains learn in accordance with the traditional stimulus–response associative models that apply best to the establishment of habits of responding to reinforced stimulus choices and of not responding to unreinforced stimulus choices in a multiple-problem, two-choice, discrimination-learning situation. Whereas some primates with relatively larger brains and cortical elaborations apparently learn as stimulus–response learners, others can learn in accordance with a mediational or relational model which enables the subject to take, for example, discrimination–reversal test trials seemingly as a continuance of the initial discrimination task (Rumbaugh and Pate, 1984). In other words, they discount the fact that the cue values of the discriminanda have been exchanged and continue to improve in the execution of choices. These emergent response modes alter transfer–of–learning effects, and the essence of the discrimination learning process itself. They are not a consequence of procedures used by the experimenter to establish such modes. Rather, they emerge as a consequence of how brains of greater and lesser degrees of complexity respond to the same treatments (e.g., the discrimination tasks and tests for transfer).

Of course, organisms that learn relationally do not cease to learn associatively. In fact, it seems likely that, for species with the capacity for relational learning, the propensity for relational versus associative learning improves both with phylogeny and ontogeny. Thus, rhesus monkeys have demonstrated the capacity for relational learning, but have also failed to extract rule-like relations from other tasks, responding stubbornly (but generally successfully) according to stimulus-response associations (Filion, Washburn, & Fragaszy, 1995).

Stimulus–equivalence training experiences result in differential outcomes depending upon the species (humans are markedly superior to nonhuman primates that, at best, have less ability to manifest equivalence, symmetry, and transitive relations) and, within humans, upon whether or not language is operative (Sidman, 1994).

Concept learning for both natural and arbitrary things and events varies markedly as a function of species and age level,

when treatment variables (e.g., tasks) are held constant. Emergent behaviors may include generalized identity matching-to-sample, symbolic matching, and sameness-difference concepts.

The representational use of symbols, as an ability, is strongly controlled by brain complexity and the age at which such training/learning experiences are given to the subject. Chimpanzees are clearly capable of using symbols to represent things not present, as indicated by their ability to classify symbols into appropriate categories (for example, whether the symbol represents a tool or food; see Savage–Rumbaugh, 1986, for a review of relevant research).

Speech comprehension and the invention of proto–grammar appear to be strongly related both to the variables of brain complexity (e.g., monkeys, chimpanzees, and children) and rearing (i.e., treatment) conditions for the subject. Kanzi, a bonobo (*Pan paniscus*) has manifested the ability to understand novel requests, conveyed to him via sentences spoken by humans, at a level that compares favorably with a child whose mental age was 2½ years. He also has employed what would be termed grammar, if he were a human of 1-1/2 years, in the productive combinations of gestures and symbols that he uses to communicate complex messages/requests to his caretakers (for details see Savage–Rumbaugh, Murphy, Sevcik, Brakke, Williams, & Rumbaugh, 1993; Savage-Rumbaugh & Lewin, 1994; Greenfield and Savage–Rumbaugh, 1991). It is also significant that Kanzi did not develop his language skills as a result of specific, discrete–trial, reinforced training. Rather, his skills were acquired quite indirectly—through observation of efforts to teach his mother, Matata, to learn the appropriate use of word– lexigrams (i.e., geometric symbols) and use a "talking" lexigram board. Matata, who was then more than 15 years old, failed to learn any language skills, quite possibly because she was a feral animal until the age of about 6 years. For her, the years for the optimal learning of language had long passed. For Kanzi, however, they had not, for he played about in the context within which Matata received her scheduled language training from soon after birth to the age of 2½ years. Here we have, then, a prime example of the organismic variable of age (Matata was too old to learn language skills, while Kanzi was precisely the right age, as it turned out) interacting with the treatment condition that consisted not of language training, but, rather, of *exposure* to language usage.

Numerical cognition by nonhuman animals provides an additional example of emergents. As mentioned earlier, Washburn and Rumbaugh (1991) reported that rhesus monkeys learn substantially more than which of two numerals is the one that pays off the most in food pellets. Two monkeys were trained with all but seven combinations of pairs of numerals 0 through 9; seven pairs were chosen to be used later as novel test pairs to determine whether, during training, the monkeys had learned only to pick one of each specific pair of numerals, or whether they learned something about the "value" of each numeral. If, for example, on a given training trial they were

presented with a 5 paired with a 3, the selection of the 3 would result in the automatic delivery of 3 food pellets, whereas the selection of the 5 would result in the delivery of 5 pellets. During test trials on the seven new pairs in which the numerals 6, 7, and 9 were each used twice (i.e., 6:4, 6:5, 7:5, 7:6, 8:5, 9:7, and 9:8), one monkey made no errors on their first presentation, and the other made only two errors. If they had learned only which numeral to choose in the context of each training pair, they would not have been able to perform above chance on the novel pairings. Thus the monkeys performed significantly above chance—they may have learned something like a matrix of relative values.

Alternatively, the animals could have learned a comparison strategy: they could have attached a value to each numeral as a result of the original training, and learned that they profited most by comparing each pair of numerals and choosing the one with the larger value. In Hull's theory, these "values" for each stimulus would be called "reaction potential." In contemporary cognitive terms, these would be representations of quantities corresponding to the meaning of the numerals. In either case, this type of comparison is a different process from immediately responding to any stimulus that has been reinforced, or even to the stimulus that had the greatest habit strength.

Such an altered response mode was not specifically trained— nor could it have been demanded. It may, however, have been prepared through evolutionary selection for animals that try to obtain better nutrients, rather than selecting whatever food is available. Notwithstanding, the training, in interaction with the brain/learning capacity of the rhesus subjects, allowed the ability to execute ordinal judgments accurately to emerge, as reflected in their choice of the larger numeral in novel pairings presented for test.

Other examples of phenomena from the history of psychology that exemplify emergent response modes include *latent learning* (Blodgett, 1929; Tolman, 1948) and the effects of *early rearing environments* (Riesen, 1982; Bryan & Riesen, 1989; Stell & Riesen, 1987) upon patterns of brain development and complex learning skills, and still others that are listed in Table 2. In these experiments, treatment effects interacted with developmental, hence organismic, variables to determine whether or not learning was manifested subsequent to explorations of mazes without specific reinforcement, or whether learning, language, and speech were compromised as a consequence of deprivation of appropriate stimulation or of the opportunity to learn at appropriate levels of maturation.

Even Epstein's (Epstein, 1985; Epstein, Kirshnit, Lanza, & Rubin, 1984) simulation of "insight" in the pigeon illustrates what we call an emergent response mode in this paper. Epstein's pigeon, in a final test, moved a box into position, then stood on it in order to access a target that was otherwise out of reach. His account detailed the antecedents, but it was the pigeon's brain that processed the prior training and blended it to allow for a chimpanzee-like solution to a classic problem (Ellen & Pate, 1986). The importance of experiences relevant to task demands has been recognized by researchers with chimpanzees from the days of Köhler's (1925) classic studies.

Notwithstanding, it is the subject, be it pigeon or chimpanzee, whose brain operations generate a new response mode, an emergent, that allows for problem solution. That individual and specific prior conditioning of operants is part of the subject's training history is certainly relevant, indeed critical, to the emergent response mode; but it is the subject's brain's processes, contingent as they are upon the organization and complexity of the brain, that generate the new, emergent, response modes. The most salient attribute of those modes is that, in novel tests/contexts, they provide for adaptive novel behaviors that are substantially extended in form and organization beyond those manifested during "training."

Summary

Do operants and respondents operate in the manifestation of emergents? Most certainly they do, but it is the novel blending of them, their varied orchestration and patterning, their immediate manifestation, that reveals the emergents present in the brain's operations; it is not specific reflections of antecedents and contingencies provided by the environment or the experimenter.

Are emergents reducible to either operants or respondents? It is the argument of this paper that they are not, though, as stated above, operants and respondents surely are the behavioral elements and indicants of emergents. Indeed it is through behaviors that by tradition might be termed <u>respondent</u> or *operant* that emergents are manifested. Notwithstanding, it is precisely the non-respondent, non-operant nature that makes certain behavior an *emergent*. Emergents make their appearance as novel patterns of responding or choosing between alternatives, and they do so with some element of surprise to the observer. By contrast, both respondents and operants make their appearance as improved forms of what they were at the very beginning of training or conditioning. Their basic forms are not altered. Again, and by contrast, emergents do not have specific training histories. There is no reason to assert that they were there in some miniscule form that either became stronger or was shaped across time, as is the case of operants. This is not to contradict the argument, however, that emergents have their etiology in the experiences whereby organisms, particularly those with complex brains, acquired respondents and operants. Emergents are new competencies, new patterns of behavior, based in experience, that are produced by novel generative operations of the subject's brain—a brain whose operations depend on age, absence of trauma, experience, tasks, and species.

The category "emergents" encourages the behavioral researcher to use time-tested tactics that emphasize antecedents and consequences to study behaviors that are new patterns and demonstrate competence for adapting. Alternatively, one may study the same behavioral modes using a cognitivist point of

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view, but that is neither necessary nor necessarily advantageous compared to use of the framework herein advanced.

Science moves with the times and new findings. We here argue that it is timely for behaviorally oriented psychologists to evaluate the merits of extending Skinner's "respondent and operant" dichotomy to a trichotomy that includes the new category of *emergent*. The category "emergent" can facilitate the integration of large corpuses of comparative. developmental, and brain research into the behavioral framework, and thereby substantively enhance the science generated by the rich tradition of psychological research.

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