On the Revolutionary Nature of the Operant as a Unit of Behavioral Selection

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The term operant *is used in many different but related ways. Implicit in most uses is the concept of the operant as a behavioral unit. Historical origins of the operant unit are traced in Skinner's early work on the relational character of behavior as a subject matter in its own right. An operant unit in an individual's repertoire is compared with a species as an evolutionary unit or taxon. It is suggested that usage of the term* class *in the definition of operants leads to confusion regarding the operant as category versus the operant as taxon.*

The term *operant* is used in many different but related ways. We speak of operant *conditioning* when we focus on the effects of behavioral consequences. To use a familiar example, adults can condition whining in a child by giving the child a lollipop each time he or she whines. We speak of operant *behavior* when we focus on behavior that becomes either more frequent or less frequent as a result of consequences contingent on earlier occurrences. The child's whining is operant behavior because it becomes more frequent after lollipops are contingent on whining. We speak of operant *discrimination* when operant behavior occurs under some conditions but not under others. If the child whines only when one parent is present but not when the other is present, whining is a discriminated operant. If we have been told of such a history of operant conditioning and then we hear the child whining, we call the whining we are hearing an operant *response*. Implicit in all of these uses of the term *operant* is the concept of the operant as a behavioral unit. It is that concept that is revolutionary. An appropriate unit of analysis enables a natural science to progress rapidly. For example, biology flourished when the *cell* was isolated as the fundamental building block for all organisms, however complex. Zeiler (1986, p. 1) compared the cell as the "smallest [unit] having the complex of properties that define life" with its behavioral counterpart. "The fundamental [behavioral] units . . . are the smallest entities that display the full characteristics of adaptive behavior" (Zeiler, 1986, pp. 4–5). In this respect, the cell is an apt analogy for basic behavioral units that become integrated in increasingly complex repertoires of particular persons. Zeiler's analogy between the cell and the behavioral unit is based on their common *function* in the scientific accounts of two subject matters.

An operant unit as an individual entity, however, is very different from a cell, especially with regard to its distribution over space and time. An individual cell is located at a particular point in space and time. From the perspective of the scientist, a cell appears, extends continuously through time at a particular place, and then ceases to exist. An operant, on the other hand, is distributed across time and has temporal and spatial gaps between its instances or parts: The child whines off and on throughout the week. In this respect, an operant is more like a *species* of cell than like a cell. A species is a *population* of organisms with a common origin. Ghiselin (1974) argued that species are biological individuals, and increasing numbers of biologists recognize the usefulness of such a view (Ghiselin, 1980). Ghiselin's (1974) clarification of the species concept makes the analogy between operant and species easier to understand. A population of organisms having a common origin constitutes a particular species (e.g., *E. coli*). Similarly, an operant unit is a *population* of behavioral instances having a common origin (e.g., the child's whining). Each member of the population—each organism in the species and each occurrence of an operant response—exists at particular points in space and time; but species and operants, as units, are distributed across space and time. Furthermore, each population owes its existence to a selection process: *natural selection* in the evolution of species and *reinforcement* (or *behavioral selection*) in the evolution of operants.

Although many scientists have contributed to the development of the operant concept, that concept as here understood is most closely associated with the work of B. F. Skinner and his associates. In the following sections we suggest the revolutionary characteristics of the operant concept, as we trace the development of Skinner's concept of behavioral units and of the operant as a unit owing its existence to a selection process occurring during the lifetime of a behaving organism. Following that, we examine the parallels between the *operant* and *species* concepts and suggest reevaluation of some terminology typically used with respect to operant units.

Nature of Behavioral Units

From the outset, Skinner was interested in clarifying the nature of behavior as an object of experimental enquiry.

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At the time Skinner became interested in behavior, it was not considered a scientific subject matter in its own right despite the efforts of Watson (e.g., 1924) and other early behaviorists.

Psychology had originated in philosophy as the study of mind, as its name suggests. Behavior as a subject matter in and of itself was not of primary import to most philosophers. Behavior for philosophers was generally of interest for the clues it provided regarding the structure and function of mind. Descartes, the philosopher generally held responsible for the mind–body dichotomy that is now common sense, considered "human actions and experiences [to be] spontaneous outcomes of reasoning" (Toulmin, 1990, p. 108), thus unamenable to a scientific account. Animal behavior, however, was part of the "natural world of physical phenomena" (Toulmin, 1990, p. 107); and Descartes, who also weighed in as a scientist, explained animal behavior in terms of mechanical principles.

Philosophers following in Descartes's philosophical footsteps pursued their interest in mind, and physiologists following in Descartes's scientific footsteps sought to elucidate the mechanism between a stimulating (goading) world and specific animal movements. Important to note is that a scientific account meant a mechanistic account at that time. For reflex physiology, behavior was, appropriately enough, the spatiotemporal end point of physiological events initiated by a stimulus.

The interests of philosophers and physiologists became intertwined when the "advance of the physiology of the nervous system" (Boring, 1950, p. 157) resulted in some answers to questions previously raised by philosophers. By the 1920s "the new 'scientific psychology' was nothing other than a fusion of these two psychologies [experimental physiology and philosophy]" (Boring, 1950, pp. 157–158). For psychologists working in this tradition, behavior is still of interest as the spatiotemporal end point of neurochemical events initiated either (a) by a stimulus or (b) in the brain. Sometimes the functions of the brain are summarized by mental or cognitive constructs. This approach to a scientific understanding of behavior defines behavior in terms of movement.

Skinner's alternative would lead to an entirely different kind of formulation—one in which behavior would be understood not as the movement of an organism but as a relation between that movement and other events (see Lee, 1988). Neurological activity is considered part of the organismic functioning that enters into behavioral units, not as the explanation for those movements. Thus, both organismic activity and properties of the environment entered into Skinner's definition of behavioral units.

Reflex as a Relational Unit

Skinner was interested in giving a scientific account of all behavior, including that which Descartes had set aside as "willed" and outside the reach of science. Following Pavlov and Watson, Skinner first attempted a preemptive sweep of all behavioral phenomena into the domain covered by the concept of the reflex. "The description of behavior . . . is adequately embraced by the principle of the reflex" (Skinner, 1931/1972a, p. 457). Paradoxically, his definition of the reflex was the first step in a different kind of formulation.

To Skinner, the locus of a reflex was in the "observed correlation of two events, a stimulus and a response" (1931/1972a, p. 448). This formulation had two critical elements. First, a reflex entailed a relation between two events; behavior was not defined in terms of the second event by itself (the movement of an organism's parts). Second, the relation could not be observed to exist as a singular occurrence. Two events (a stimulus and a response) had to be observed to be temporally related repeatedly in order to detect the correlation. Once the existence of such a correlation was established, the business of a science of behavior was to determine the effects of various manipulations on the characteristics of the observed correlation. The requirement that a relation between a stimulus and a response had to be reproducible if it were to be amenable to experimental investigation (Skinner, 1931/1972a, p. 453) raised another issue: What counted as a reproduction? "It is very difficult to find a stimulus and response which maintain precisely the same properties upon two successive occasions" (Skinner, 1935/1972b, p. 458). Skinner's solution to this dilemma would have profound implications.

The stimulus in a reflex unit was to be identified empirically as that class of environmental properties found to reliably correlate with a class of movement properties ("the response"; Skinner, 1935/1972b, p. 466). Both stimulus and response could vary in the values of their relevant properties, but the correlational unit had to be defined "at a level of restriction marked by the orderliness of changes in the correlation" (Skinner, 1935/1972b, p. 477). The unit of analysis, then, was not a relation between a singular response event and a singular stimulus event but an observed correlation between a class of stimulus properties and a class of response properties.

That Skinner's formulation of the reflex was a radical departure from the views of his contemporaries and his academic mentors was evident from E. G. Boring's written response to Skinner's dissertation:

> You have given a very broad, strange, almost bizarre meaning to the word *reflex*. You have taken it away from the constrained anatomical reflex-arc meaning, and you have equated it to the concept of the psychological fact-as-relational-correlation which already has terms for itself. (Skinner, 1979, p. 73)

Reflexes of Ontogenic Origin

The correlations Skinner used to derive a definition of behavior were those observed in unconditioned reflexes, the dimensions of which are specified by natural selection during the evolution of species. Skinner was soon concerned, however, with behavioral units "said to be *conditioned* [emphasis added] in the sense of being dependent for [their] *existence* [emphasis added] or state upon the occurrence of a certain kind of event, having to do with the presentation of a reinforcing stimulus" (Skinner, 1935/1972c, p. 479). Thus, Skinner's focus from the very beginning of his career was on the origins of behavior acquired during an organism's lifetime. It was this interest in acquired behavioral units that eventually led him to the *operant* concept.

Pavlov's investigation of the conditioned reflex provided for Skinner an example of how new behavioral units could be established during the lifetime of individual organisms rather than during the history of the species to which the organism belongs. This is not to say that the history of the species is irrelevant to the existence of a conditioned reflex—only that the properties of specific relational units are specified ontogenically. A conditioned reflex was a behavioral unit of ontogenic origin—brought into existence by a contingency. The necessary contingency involved the repeated presentation of a stimulus (one with no specified eliciting function) along with or just preceding occurrences of reflex relations. The ontogenic unit was a new correlation between stimuli and responses.

The genesis of a conditioned reflex (later called *respondent*) during the lifetime of an individual requires an existing (phylogenic or unconditioned) behavioral unit as a prerequisite. Although a conditioned reflex has its origin in the history of the individual, the characteristics of the derived (ontogenic) unit are constrained on both the response side and the stimulus side of the unit. The dimensions that define the response class in a conditioned reflex have been roughly specified during the history of the species. Following Pavlov, Skinner's view was that respondent conditioning involves "the substitution of one stimulus for another" [in the reflex unit] (Skinner, 1935/1972b, p. 487). The function of the conditioning process in the economy of the organism is to "*prepare* the organism by obtaining the elicitation of a response before the original stimulus has begun to act, and it does this by letting any stimulus which has *incidently* [*sic*] accompanied or anticipated the original stimulus act in its stead" (Skinner, 1935/1972c, p. 487).

A conditioned reflex, then, is a behavioral unit in the repertoire of an organism. It is observed as a correlation between stimuli and responses having specified properties. And it is built by establishing a contingency between a neutral stimulus and a reflex relation preestablished by natural selection.

Origin of Operant Units

An operant unit differs from a conditioned reflex in several ways. It is not built by establishing a contingency between a neutral stimulus and a reflex relation preestablished by natural selection. It is built by establishing a contingency between responses having particular functions and contingent consequences. In the prototypical experiment, food is made contingent on any and all movements having the effect of downward excursion of a lever to a criterion level. The contingency necessary in the origin of an operant unit is one between (a) movements having a particular effect and (b) a consequent stimulus change. The resulting behavioral unit is a relation between movements having certain properties and the functional effects of the movement. An example of such a unit would be the barpresses (of a particular animal) that occur as a function of a contingency between barpressing and consequent food delivery.

Outside the laboratory, and particularly in the repertoires of humans, there may be few examples of such simple operant units as the standard barpress. Most operant units enter into more complex relations, a topic we shall turn to shortly. Before that, however, we consider some of the conceptual issues that are raised by the operant concept as so far discussed.

As in the case of a reflex, conditioned or not, the existence of an operant unit cannot be ascertained by observing a single instance of movement–effect, even if that relation is followed by a stimulus change likely to function as a reinforcer. An operant is a *population* of such instances, and the population is distributed across time. The characteristics of an operant can be ascertained, then, only by observing the behavioral unit as it occurs over time. Instances of the operant vary among themselves across time, and, in fact, it is that variation that allows the operant to evolve (i.e., allows its characteristics to change over time). Such variation is also characteristic of the relatively undifferentiated activity that serves as the raw material on which reinforcement operates, selecting the characteristics of future operant instances. Variation among instances may be reduced by stricter selection criteria; or variation can be increased by reinforcing variability itself, as has been experimentally demonstrated by Page and Neuringer (1985). Variation, however, is an important property of an operant unit and can affect the way independent variables function with respect to the unit (Joyce & Chase, 1990).

The function of behavioral consequences in an evolutionary process different from that of biological evolution was implicitly recognized by Skinner very soon after his experimental work commenced. In 1937, he reported "elaborate and peculiar forms of response may be generated from undifferentiated operant behavior through successive approximation to a final form" (Skinner, 1937/1972d, p. 495). The form is only final, of course, if selection (reinforcement) contingencies remain constant. Changes in the dimensions of behavior may be accomplished by gradually changing the response dimensions on which reinforcer presentations are made contingent. The result is an evolving behavioral unit, a unit composed of a population of movements or effects, maintained in existence by a reinforcement contingency.

By the time Skinner wrote *Science and Human Behavior*, he was explicit in his view of reinforcement as a kind of selection process that accounted for the origin and evolution of behavioral units. "We have seen that . . . operant reinforcement resembles the natural selection of evolutionary theory. . . . Just as genetic characteristics which arise as mutations are selected or discarded by their consequences, so novel forms of behavior are selected or discarded through reinforcement" (1953, p. 430). Operant units evolve.

Discriminated Operants

The contingency between an operant unit and the reinforcers that select and maintain the unit is often called the *two-term contingency*. We have been discussing operants without regard to the role of environmental events *preceding* occurrences of the operant. Skinner was investigating the role of antecedent stimulation in the control of barpressing even before he had formally designated barpressing as operant behavior. He found that the rate of barpressing could be alternately increased and decreased by presenting and removing a light in the experimental setting. Such stimulus control over the operant unit was instigated by limiting presentation of the contingent consequence to occasions on which a light was present when barpressing occurred. This led Skinner to the concept of the *discriminative stimulus*, a stimulus in the presence of which instances of an operant unit are likely to result in (or be correlated with) contingent stimulation. And this, in turn, led to the concept of the discriminated operant—a behavioral unit consisting of the relation between properties of a class of stimulus events and an operant that occurs in their presence.

When instances of an operant unit are correlated with a reinforcing consequence only in the presence of certain stimulus properties, those stimulus properties acquire an evocative function with respect to instances of that operant (see Michael, 1983). The reinforcing stimulus, then, has a selection function not only with respect to activity having certain environmental effects but also with respect to the environmental events that evoke (or occasion or control) instances of the operant unit. The discriminated operant has its origin in a *three-term contingency*, which is considered the basic unit of analysis in the analysis of operant behavior. "An adequate formulation of the interaction between an organism and its environment must always specify three things: (1) the occasion upon which a response occurs, (2) the response itself, and (3) the reinforcing consequences" (Skinner, 1969, p. 7). This formulation involves two contingencies and three terms. The first contingency is between operant instances (first term) and reinforcing consequences (second term); the second contingency is between properties of the environment present when the operant occurs (third term) and the first contingency. The discriminated operant is instantiated intermittently over time and consists of a population of instances.

The discriminated operant as a behavioral unit may have offered possibilities for complex behavior that parallel the nucleated cell's potential for the evolution of complex organisms. The discriminated operant is a behavioral unit in which the activity element in the unit is highly integrated and coordinated with the environment. The extent of this coordination and the subtleties of behavioral relations built on the discriminated operant were summarized by Sidman (1986).

With the formulation of the discriminated operant, operant units could be understood as behavioral units freed from preestablished characteristics. The only formal limit to the dimensions of the elements in operant relations were those imposed by the anatomy of the behaving organism. We do not mean to imply that there are no biological constraints on ontogenic behavioral units of individual organisms or of species. In the human case, however, the range of possibilities may be infinite, especially because the products of operant behavior have become increasingly complex in the context of evolving cultural practices. For example, anatomical constraints prevented operant flying from emerging in a human repertoire only until airplanes were constructed as behavioral products. Natural selection's leash has been greatly relaxed in the ontogeny of operant units: Any properties of the environment capable of affecting a receptor can potentially become correlated in some behavioral unit, and a wide range of organismic activity can become correlated with some properties of the environment.

> The principle of operant conditioning may be seen everywhere in the multifarious activities of human beings from birth until death. . . . It is present in our most delicate discriminations and our subtlest skills; in our earliest crude habits and the highest refinements of creative thought. (Keller & Schoenfeld, 1950, p. 64)

Summary

Skinner's formulation was revolutionary in several respects. First, behavioral phenomena are not located in organisms or defined in terms of the movements of organisms; behavioral phenomena involve relations between movements and other events, most (but not all) of which occur outside the organism that moves. The relational character of behavior is recognized in everyday life, as Lee (1988) pointed out. For example, the behavior of walking downstairs refers to a relation between certain bodily motions and a change in location. It is an example of "having commerce with the outside world" (Skinner, 1938, p. 6).

Second, singular behavioral events cannot be the focus of an experimental analysis and do not constitute behavioral units. An operant is a behavioral unit that consists of repeated instances of movements (e.g., walking) having common properties across instances and correlated environmental changes (e.g., change in location) across instances. It is necessary to look beyond a particular instance of a correlated response and its environmental effect in order to understand operant phenomena.

Third, the operant relation between activity and environmental change is established and maintained as a unit by a contingency between instances of this operant and some subsequent event. When reinforcing consequences always fail to follow instances of the unit, the conditions maintaining the integrity of the unit are absent, and the operant disappears from the repertoire of the organism. Thus, reinforcement functions with respect to operants in a manner parallel to the function of natural selection with respect to species.

Fourth, two correlated contingencies are required to endow stimuli with evocative control over operant instances. The formulation of the three-term-contingency and discriminated operants provides the foundation for understanding more complex behavioral relations.

Species and Operants

In 1969, Skinner again pointed out conceptual parallels between evolutionary biology and behavior analysis. "The relation between a species as a class and contingencies of survival resembles the relation between an operant as a class and contingencies of reinforcement" (1969, p. 132). Skinner's use of the word *class* in this context is consistent with his designation of "an operant [as] a class, of which a response is an instance or member" (1969, p. 131) and, indeed, consistent with his earliest designation of *stimulus* and *response* as class concepts. We suggest that usage fails to distinguish between two ways in which the *operant* concept is used in behavior analysis. The confusion parallels similar confusion in biology regarding the *species* concept. Recent clarification of the species concept may help behavior analysts to sort out the ways the operant concept is used. We turn, then, to some issues pertaining to the species concept in evolutionary biology as they parallel issues pertaining to the operant concept.

Class Versus Population

Pre-Darwinian biological theory was essentialist in that organisms were classified into groups on the basis of common properties that constituted the unchanging essence of their species (Mayr, 1982). The essentialist view of species was very similar to the logical concept of *classes*. Objects (or events) constituting a class are similar in terms of their common properties. They are grouped together, as members of a single class, on the basis of their similarity to one another. For example, chairs belong to a class of objects that have certain properties in common and that are not common to nonchairs. Variations among class members are generally considered deviations from the true nature, or underlying essence, of the class.

Natural selection requires variability among organisms in order to operate, so differences among individual organisms are crucial to evolutionary theory. Variability cannot be "error"; it is a necessary condition for evolution to occur. Once the interplay of variability and natural selection in the origin of species was understood, it appears that the species concept was problematic for evolutionists. Resolving the puzzling status of the species concept required "a conscious rejection of the essentialist concept" (Mayr, 1982, p. 271). Eventually a species was recognized as a "reproductive community . . . that occupies a specific niche in nature" (Mayr, 1982, p. 273). The reproductive community is sometimes referred to as a *natural population* and the biological concept of species as *population thinking*. Important to note is that the populations that constitute species are fundamentally different from the "populations" from whom data are obtained in much psychological research. The members of a population (or community of populations) that constitute a species have a common origin; although the population is distributed across space and time, the members have a common ancestral origin. Current members are reproductively interchangeable, and the selection of some members over others accounts for the characteristics of later members of the species. In contrast, the populations comprising the experimental and control groups in psychological research are not natural populations. Members within each group do not have a common origin; they do not occupy a specific niche in nature. In fact, the grouping of these individuals is done on the basis of common properties (administering of the independent variable or not, the presence or absence of a clinical feature, etc.). This meaning of *population* is closer to essentialism than to evolutionism.

The population thinking underlying the biological concept of species does have its counterpart in operant behavior, however. Like a species, an operant comprises a natural population—all those responses having a common origin or owing their existence to a common history of reinforcement. Variability among the instances provides a basis for selection and modification of characteristics of the population.

Class Versus Individual

Another evolutionary theorist, Michael Ghiselin, has sought to clarify the species concept by contrasting the species-as-class concept with his concept of a species as an individual (Ghiselin, 1974). Although Mayr (1988) suggested that the term *individual* applied to a species is confusing because a species comprises individual organisms, individuals frequently are composed of other individuals. For example, an individual organism comprises many individual organs; and organs are composed of individual cells.

Ghiselin provides a number of cogent reasons for considering a species to be an individual, an evolutionary *unit*. Ghiselin argues that organisms are parts of the species unit. The unit is distributed in time and space; its existence extends beyond the lifetime of each of its parts, as an organism's existence extends beyond the lifetime of each of its cells. Each member of the unit exists at a particular time and in a particular place. The operation of selection on the members of the unit results in changes in the characteristics of the unit. Organisms are selected and species evolve. Species may change over time if contingencies of natural selection change. And species "can speciate (split into two), they can hybridize (fuse) and they can become extinct. No class can ever become extinct" (Mayr, 1988, pp. 347–348).

In the ontological sense, an operant is likewise an entity—a unit, an extant individual. It exists as part of the repertoire of a living organism. It is composed of a population of behavioral occurrences that are distributed over time, each occurrence having a unique spatiotemporal location. The operant unit can evolve (as only operants and species can but organisms and responses cannot). It may have subpopulations that can split off, eventually to evolve into separate entities. It may become fused with another operant in a repertoire, and it can be extinguished while other operants remain intact in a repertoire.

Operants: Classes or Individual Populations

Because all of these characteristics of operants were recognized by Skinner, one might wonder why he persisted in defining an operant as a *class* of responses. By insisting on recognizing the natural lines of fracture between behavior and environment, he clearly suggested that he viewed an operant as a natural population. By identifying operants as the units of analysis, Skinner clearly recognized operants as individuals. Mayr has suggested that "the 'classes' of the biologist often are not equivalent to the 'classes' of the logician" (1982, p. 57). We might surmise, likewise, that the classes of the behaviorist often are not equivalent to the classes of the logician. Even so, behaviorists, like biologists, may find it useful to clarify their most fundamental concept.

Taxon Versus Category

The discussion above, regarding a species as an entity (or individual) with an origin, is about species as taxa. "A taxon is a concrete zoological or botanical object. Groups of individuals like wolves, bluebirds, or houseflies are species taxa" (Mayr, 1982, p. 253). By saying that humans belong to the species *homo sapiens*, we are using the term *species* to label a specific taxonomic entity. As an entity, a species is a particular population having internal (genetic) cohesion and historical continuity. Its members are distributed in time and space and have a common origin.

The term *species* is also used in another sense. It is a particular category in a hierarchical organization, as are *genus, family,* and *order* (Mayr, 1984). One may speak of all winged species or all species of bacteria without implying any biohistorical relationship among these species. A similar distinction may be made in the case of the term *operant,* and it seems to engender similar confusion.

An operant existing as a behavioral unit in the repertoire of an individual organism is comparable to the species taxon. Take, as an example, Person A's can-opening operant. It is an entity with all the characteristics enumerated above. However, an operant having similar characteristics may exist in the repertoire of another organism. That is, a can-opening operant also may exist in Person B's repertoire. Are they the same operant?

If we mean by *same* that they belong to the same historical entity, they are not the same. The two can-opening operants are not members of the same population. Person A's can-opening operant is composed of a population of acts all having their origin in contingencies specific (in space and time) to *his or her* activity. The origin of *Person B's* can-opening operant is in events that occurred at altogether different times and places. But if we mean by *same* that they are similar to one another in their characteristics, they are the same. They involve similar kinds of movement and similar effects on the environment (opened cans) and are very likely maintained by similar reinforcement (e.g., food). Both responses may be members of a *class,* in the same sense that chairs are members of a class. It is also the sense in which the wings of birds and the wings of insects are in a class. The birds and insects are not members of the same species taxon for the same reason that the can-opening behaviors of two different people are not members of the same operant unit. Different origins account for their existence.

Operant as Individual and Operant as Class

In operant theory, as in evolutionary theory, this distinction between two usages of the same term has not been clearly understood. Yet it is fundamental to operant analysis. Indeed, the existence of operant taxa as the individuals (units of analysis) whose origins are accounted for suggests the absolute necessity of the single-subject methodology characteristic of operant experimental work. The origin of any operant as an existing entity is specific to a specific organism and can never be otherwise. Selection by consequences accounts for the existence of species and operants as entities.

We believe Skinner's designation of an operant as a class fails to distinguish the operant as category and operant as taxa. Yet he implicitly distinguished them by calling an identifiable unit "set up . . . through conditioning . . . an *operant*" and "the behavior in general [the kind or type] operant behavior" (1937/1972d, pp. 491–492). An *entity* brought into *existence* by conditioning was *an* operant. The noun form plus the individuating adjective suggests its status as an individual. But the term *operant* also identified a type of unit, and its use as an adjective to modify *behavior* suggests this different meaning.

Historical Origins

Mayr (1988) suggested that the confusion regarding the species concept had its source in concepts that antedated the theory of natural selection and that Darwin himself did not appreciate the ramifications of his theory for the species concept. The historical origins of the operant concept might, similarly, account for the melding of an operant as a unit of behavioral selection and operant as a category term.

Despite Skinner's implicit distinction between *operant* as an individual and *operant* as type, he defined the operant taxon in terms of a category term: *class.* We consider below some possible reasons for this by returning to Skinner's original formulation of a reflex.

Skinner defined a reflex as a correlation between stimuli having certain properties in common and responses having certain properties in common. Because the properties of reflexes were the products of natural selection, the correlated stimuli and responses were similar across organisms belonging to the same species (and often across species). So any particular reflex (taxon) that could be identified as a behavioral unit in the repertoire of an experimental subject had dimensions similar to that "same" (category) reflex in the repertoire of other intact organisms: If the stimulus was meat powder, salivation was predictable; if the stimulus was a light directed at the eye, pupillary constriction was predictable.

Conditioned reflexes presented an altogether different situation. Conditioned salivation in three different experimental subjects could involve stimuli of entirely different dimensions. Salivation might enter into a reflex relation with a tone in one case, an object in a second, and pressure in a third. Furthermore, three such differing conditioned reflexes could exist in the repertoire of one experimental subject. They would be different reflexes (by definition) if a conditioned reflex were defined as a correlation between a class of stimuli of specified properties and a class of responses of specified properties.

Skinner's interest in conditioning guaranteed he would be concerned with ontological issues. "A conditioned reflex is said to be conditioned in the sense of being dependent for its *existence* [italics added] or state upon the occurrence of a certain kind of event" (Skinner, 1935/1972c, p. 479). Even in the case of the unconditioned reflex, however, it was necessary to "take into account . . . the natural lines of fracture along which behavior and environment actually break" (Skinner, 1935/1972b, p. 458). The fact that the natural lines of fracture in unconditioned reflexes were similar from one organism to another, plus the fact that the reflex provided the historical context for establishing behavioral phenomena, per se, as a scientific subject matter, may have resulted in a kind of overlapping or merging of the concept of a reflex as a behavioral *unit* in the repertoire of an organism and a *kind* of behavioral unit.

Experimenter Behavior and Subject Behavior

Skinner's designation of the operant as a class of responses may be understood also if we recognize the term *class* as what the various responses in the unit are to the experimenter. It is, after all, through experimental analysis that existing behavioral units are produced and studied, presumably as representatives of the kinds of phenomena existing outside the laboratory. In specifying the properties of acts to be selected (reinforced), the experimenter designates the selection criteria, thus specifying a *descriptive operant* (Catania, 1973). For example, the criterion for a lever press is downward movement to *x* extent, requiring *y* force. The contingency established by the experimenter produces a behavioral unit comprising a range of activity and a range of environmental changes resulting from that activity. Such an entity has been called the *functional operant* (Catania, 1973). For example the positioning of the organism with respect to the lever results in various motions, and the force differs from instance to instance. A press may fail to meet the criterion, or it may exceed that criterion by differing degrees. In addition, the conditioned unit has a number of properties that are not specified by the contingency, yet that consistently can be classified by the experimenter (Mechner, 1992).

In order to identify an extant operant, as in the repertoire of an individual seeking help for a "behavior problem," an observer must identify environmental events hypothesized to be elements in ongoing contingencies. The observer in this situation is not in a position to create the operant unit to be studied but must detect the natural lines of fracture in order to intervene systematically. The operative contingencies that are maintaining a behavioral unit can be ascertained only by observing repeated instances of activity with respect to the environment. The environmental events entering into the contingencies may be exceedingly subtle and complex—abstract, relational, and multiple (see Hineline & Wanchisen, 1989).

Summary

Conceptual clarity requires a distinction between two usages of the term *operant*. An operant is an individual behavioral unit, comprising temporally distributed instances of activity with respect to the environment, that exists as part of the behavioral repertoire of a living organism. An operant in this sense of the term must be specific to a particular organism. It parallels the usage of *species* as a taxon.

Conclusion

We have tried to set forth some of the reasons we consider the operant as a behavioral unit to be a revolutionary concept. By focusing here on the *operant* concept, we do not mean to imply that different mechanisms necessarily underlie operant and respondent behavior. Although Skinner found it useful to distinguish between operant and respondent behavior on procedural grounds, others (e.g., Donahoe, 1991) have argued cogently for a reexamination of this issue. However the issue is eventually decided, Skinner's distinction between operant and respondent behavior has had heuristic value in the development of both operant theory and operant methodology.

Revolutionary concepts are not easy to understand. They are, by their nature, at odds with previous approaches to a subject matter. In the case of the operant, its revolutionary aspects have been foreshadowed by parallel concepts in evolutionary theory. One reason that biological and behavioral evolutionary concepts are difficult to understand may be that selection is a different kind of cause from the causes characteristic of earlier scientific formulations (Skinner, 1981/1986).

The fact is that even after 135 years, biologists are still working to clarify key concepts in the explanatory structure of evolutionary theory. So we should not be unduly troubled if those psychologists and other scientists most interested in operant behavior have not sorted out all of the subtleties and nuances of a concept that is still evolving. We should be even less surprised to find that other scientists and laypeople alike find the operant concept difficult to incorporate into their conceptual repertoires.

After a long period in which the operant concept was, for the most part, simply taken for granted, the concept is now undergoing reexamination and extension. Sidman (1986) has developed a conceptual scheme in which discriminated operants are viewed as subcomponents of higher order operant units. Lubinski and Thompson (1986) suggest ways in which basic units (operant and respondent) become integrated in repertoires so that traits are apparent. Glenn (1988, 1991) has taken steps toward specifying the role of operant units in cultural evolution.

If Zeiler is correct that operants and respondents are fundamental behavioral units and can serve the same function that the cell has served in biology, then there exists an unparalleled opportunity to integrate the collection of disparate areas of psychology. Considering the prominence of the operant unit in the complex repertoires we consider most human, Skinner's work in developing the operant concept may well prove to be of revolutionary import in the history of science.

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