

From Mechanistic to Functional Behaviorism

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A shift from mechanistic behaviorism to functional behaviorism is presented against the background of two historical traditions, one with an emphasis on form, the other with an emphasis on function. Skinner's work, which made more contributions to a functional behaviorism than to a mechanistic behaviorism, exemplifies this shift. The two traditions and an account of Skinner's development of functional relations are presented in order to show Skinner's contributions to aligning modern behavior analysis with the functional tradition.

A widespread cultural concern with abstract forms can be seen earlier in this century—from taking mathematical logic as a foundation for philosophical and scientific analysis to the geometry and streamlining of Art Deco and the exemplification of abstractions in machines (cf. Barnes & Edge, 1982; Beard, 1928; Horsham, 1989; Suppe, 1977; Toulmin, 1977; Wilson, 1986). Later, various functional relations in concrete particulars received more attention. In philosophical heritage, a tradition that looked back to Parmenides and Plato gave way to one that looked back to Aristotle (Toulmin, 1977, pp. 144 & 160). Similar distinctions occurred in the study of behavior (cf. E. S. Russell, 1934a, 1934b). The mainstream of early behaviorism was awedly mechanistic, but modern behavior analysis is more appropriately characterized as a functional behaviorism (cf. Himeline, 1980; J. Moore, 1987; Moxley, 1984). This shift to functional behaviorism can be seen by comparing the formal tradition and mechanistic behaviorism with the functional tradition and B. F. Skinner's contributions to aligning behavior analysis with that tradition.

Mechanistic Behaviorism in the Formal Tradition

According to Broad (1925),

pure Mechanism is (a) a single kind of stuff, all of whose parts are exactly alike except for differences of position and motion; (b) a single fundamental kind of change, viz., change of position . . . (c) a single elementary causal law, according to which particles influence each other by pairs; and (d) a single and simple principle of composition, according to which the behaviour of any aggregate of particles . . . follows in a uniform way from the mutual influences of the constituent particles taken by pairs. (p. 45)

This explanation parallels Euclidean forms. Particles are like points. The fundamental relation is between two particles, like a line connecting two points. In addition, causal relations were necessary relations like the necessary relations in Euclidean proofs.

Some Historical Background for Mechanistic Explanations

As part of a broad formal tradition of necessary relations, mechanism shares features of Platonism, atomism, rationalism, and materialism (cf. Hacking, 1990, p. 154; Pepper, 1942/1970). In relating abstract forms and concrete experiences, the formal tradition gave priority to abstract rules (or theory) with necessary relations and deduced implications for concrete empirical events. For many who held such a view, observed discrepancies between rules and experiences would disappear if they knew all the rules.

Plato. Illustrating the primacy of theory, Plato's Socrates said, "I first lay down the theory which I judge to be soundest, and then whatever seems to agree with it . . . I assume to be true, and whatever does not I assume not to be true" (Plato, cited in Hamilton & Cairns, 1961, p. 81, *Phaedo*, 100a).

Atomism. The atoms of Democritus differed in shape and orientation and combined in different order in analogy to the letters of the alphabet (e.g., Aristotle, cited in J. Barnes, 1984, *Metaphysics*, 985b 12–18; Lucretius, 100–50 B.C./1977, pp. 20–22), but the only essential relation for Democritus (cited in Bailey, 1928) was necessity: "By necessity are foreordained all things that were and are and are to come" (p. 120). All experiences resulted from the constant motion of unchanging particles interacting by mechanical contact. Many features of atomism were later incorporated in mechanistic explanations (cf. Losee, 1972, pp. 27–28).

Cartesian rationalism. Descartes (1644/1991) deduced empirical events from first principles that met logical criteria: "The Principles themselves are very clear, and . . . all other things can be deduced from them; for only these two conditions are required of true Principles" (p. xxi). Although Descartes (1637 & 1641/1968, pp. 80–81) acknowledged that effects could be deduced in many different ways and that experimentation was needed to resolve the way the explanation lies, he held fast to many analogies and deductions that would be disproved by a little experimentation and even common experiences (see Losee, 1972, pp. 75–77). In analogy to mechanical automatons, Descartes saw the animal body as a machine of necessary connections that acted by stimulus and response "with the pale ghost of a mind hovering over its

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working, but not interfering" (E. S. Russell, 1934b, p. 87; also see Ryle, 1949).

Materialism. The materialists Julien Offray de la Mettrie, author of *Man a Machine* (1748/1912), and Paul D'Holbach extended Descartes' necessary connections. For D'Holbach (1770/1868), "Necessity is the constant and infallible connection of causes with their effects . . . in the universe every thing is connected; it is itself but an immense chain of causes and effects" (p. 31). The biologist Ernst Haeckel expressed a similarly pervasive necessity (Lenoir, 1982, p. 271), and the medical materialist Ludwig Buchner equated mechanics and logic (Gregory, 1977, p. 157). Opposing the relativism of Ernst Mach, British empiricists, and American pragmatists, the dialectical materialist V. I. Lenin (1908/1927) held, "The recognition of necessity in nature and the derivation from it of necessity in thought is materialism" (p. 167), and mastery of nature proved this necessity because the reflection for this mastery must have been based on "objective, absolute, and eternal truth" (p. 192).

Newton's mechanistic physics. Newton (1686/1962) identified early mechanics and geometry as sources for coupling a mechanistic account of empirical events with the underlying necessity of geometric demonstration:

The ancients considered mechanics in a twofold respect: as rational, which proceeds accurately by demonstration, and practical. To practical mechanics all the manual arts belong, from which mechanics took its name. But as artificers do not work with perfect accuracy, it comes to pass that mechanics is so distinguished from geometry that what is perfectly accurate is called geometrical; what is less so is called mechanical. However, the errors are not in the art, but in the artificers. He that works with less accuracy is an imperfect mechanic; and if any could work with perfect accuracy, he would be the most perfect mechanic of all; for the description of right lines and circles, upon which geometry is founded, belongs to mechanics. (p. xvii)

After practical efforts of induction, Newton sought perfect accuracy of the perfect mechanic with " 'Rules of Correspondence' for converting statements about absolute spatial and temporal intervals into statements about measured spatial and temporal intervals" (Losee, 1972, p. 88). Newton subscribed to atomism (Thayer, 1953, pp. 175-176), required action by contact like other mechanists (Newton, 1686/1962, p. 634), and wished all natural phenomena could be derived "by the same kind of reasoning from mechanical principles" (Thayer, 1953, p. 10).

Mechanistic associationism. John Locke (1690/1964, p. 370), who advanced an empiricism of atomlike sensations, expressed substantial admiration for Newton; David Hartley, acknowledging the influence of Newton and Locke, applied the principles of atomism and mechanism to a physiological model of experience (cf. Walls, 1982). For Hartley (1749/1801), repeatedly impressed sensations from the impact of particles on the body left "certain Vestiges, Types, or Images, of themselves, which may be called, Simple Ideas of Sensation" (p. 56). These "Ideas" were associated when the impressions were made "precisely at the same instant of time, or in the contiguous successive instants" (p. 65).

Mechanistic physiology. In 1847, Carl Ludwig, Hermann von Helmholtz, Ernst von Brucke, and Emil Du Bois-Reymond made a concerted effort to establish physiology on mechanistic principles. Ludwig (cited in Cranefield, 1957) stated their goal: "We four imagined that we should constitute physiology on a chemico-physical foundation, and give it equal scientific rank with Physics" (p. 407). Du Bois-Reymond (cited in Cranefield, 1959) stated the line-between-two-points reduction for initiating an analytical mechanics of organic processes: "All changes in the material world . . . reduce to motions. . . . all motions may ultimately be divided into such as result in one direction or the other along the straight line connecting two hypothetical particles" (p. 423). Affirming "natural science is the resolution of natural processes into the mechanics of atoms," the "propositions of mechanics are mathematically presentable," and the propositions of mechanics "have the same apodictic certainty as the propositions of mathematics," Du Bois-Reymond (1872/1874) posited: "the whole process of the universe might be represented by one mathematical formula . . . which should give the location, the direction of movement, and the velocity, of each atom in the universe at each instant" (pp. 17-18).

This formula echoed Pierre Simon Laplace (1814/1951), who imagined a supernatural mind embracing "in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes" (p. 4). The phrase "nothing would be uncertain" implied that every physical event is predictable and retrodictable with any desired degree of precision because even a minute difference in measurement may be claimed to distinguish between different events (see Popper, 1979, p. 221, 1982, p. 6). For Henri Bergson (1911/1983), this absolute determinism was implicit in mechanistic explanation:

The essence of mechanical explanation in fact is to regard the future and the past as calculable functions of the present, and thus to claim that all is given. On this hypothesis, past, present and future would be open at a glance to a super-human intellect capable of making the calculation. Indeed, the scientists who have believed in the universality and perfect objectivity of mechanical explanation have, consciously or unconsciously, acted on a hypothesis of this kind. (pp. 37-38)

This view of reality advanced into the 20th century (e.g., Poincare, 1913/1963, pp. 2, 13-14, whose works on scientific method were read by Skinner, 1978b, p. 117).

Although Adolph Fick (cited in Cranefield, 1957)—one of Ludwig's students—found "the absolute dominance of the mechanistic-mathematical orientation in physiology has proven to be an Icarus flight" (p. 414), Jacques Loeb—one of Fick's pupils—pursued the mechanistic ideal in physiology. Attracted to philosophy before turning to biology, Loeb read Haeckel and Buchner as a student (Pauly, 1987, p. 12) and held many of the assumptions of materialist philosophers, most notably D'Holbach (Robertson, 1926). Loeb emigrated to the United States in 1891 and taught at the University of

Chicago, where John Watson, a student of his, did research in physiological psychology (Boakes, 1984, p. 145). According to Fleming (1964), Loeb engaged in a "Weltanschauung of materialism in philosophy, mechanism in science, and radicalism in politics" (p. xix), became a hero of the American intelligentsia, and was the model for Max Gottleib in Sinclair Lewis's *Arrowsmith*.

"In my own work," said Loeb (1912/1964), "I have aimed to trace the complex reactions of animals back to simpler reactions like those of plants and finally to physico-chemical laws" (p. 58). For Loeb and other mechanistic physiologists, the fundamental relation in underlying laws was necessity. Ivan Pavlov (1927/1960), for example, asserted the "scientific" requirement for necessity in the reflex: "Our starting point has been Descartes' idea of the nervous reflex. This is a genuine scientific conception, since it implies necessity" (p. 7).

Stimulus-Response Behaviorism

Adopting similar assumptions, Watson (1914/1967) said, "That the organism is a machine is taken for granted in our work," that the complete set of physico-chemical changes would ultimately be traced "from the moment of incidence of the stimulus to the end of the movement in the muscle," and that the end of behavior analysis would be "the reduction of complex congenital (instinct) and acquired (habit) forms of response to simple reflexes" (pp. 52-53). A. P. Weiss (1924, p. 39) and Z. Y. Kuo (1928) made similar statements. Kuo said:

Behaviorism . . . cannot be anything more than a science of mechanics dealing with the mechanical movements of [organisms]. The S-R formula of behaviorism is directly derived from the basic principles of physics. . . . The basic principles that . . . explain the behavior of a stone should be sufficient to explain human behavior. (pp. 416-417)

Prescriptive rhetoric like this placed early behaviorism in the mechanistic tradition.

These first principles for a science of behavior, however, led to problems that were evident in the work of Clark Hull (1943), whose readiness to invent underlying rules for behavior was in line with later cognitive psychologists (see Dreyfus, 1988, and Gardner, 1987, for how cognitive psychology continues the Platonic-rationalist-mechanist tradition). Hull looked to the physical sciences—especially Newton's *Principia*—for the principles of behavioral science; saw machines, theories, and organisms as parallel entities; and, like Loeb (1915), advocated the construction of machines as models for understanding behavior (see Smith, 1986, pp. 158-162, 178, and 243). One problem for mechanistic behaviorism was to transform purposive accounts into mechanistic explanations without suggesting reactions to nonexistent events (e.g., Hull, 1930, p. 514) or backward causation (e.g., Thorndike, 1940/1969, p. 10).

An alternative was to regard purposive explanation as a different kind of acceptable explanation. However, only mechanistic explanations were reputable in the Mechanistic World View. Nevertheless, the behaviorist Edwin R. Guthrie (1924, 1960, p. 292), a pupil of Edgar

A. Singer (see Singer, 1924, 1946, on teleology), saw a place for purposive or teleological explanations in science. Guthrie (1960) distinguished a focus on purposive acts, such as Skinner's, from a focus on mechanistic movements: "Acts are defined by consequences but executed by movements" (p. 196), and Skinner "selects as his response in a basic experiment not movements of skeletal muscle but the accomplishment of a change in the environment" (p. 252). Skinner was taking a direction that would lead away from the Mechanistic World View.

Functional Behaviorism in the Functional Tradition

In a descriptive functional account, rules are verbal behavior resulting from the relations in contingencies (verbal and nonverbal events) that gave rise to the rules. Some discrepancy between rules and concrete experiences is understandable because the rules approximate experiences. The particular forms for rules in human discourse (oral or written, public or private) survive because they are useful.

All three senses of function considered here (cf. Ruckmich, 1913; Simpson & Weiner, 1989) occur in a fully functional approach to experiences. First, in a contextual sense, we speak of functions in a surrounding environment (e.g., the function of the heart in the body or the function of a word in a text), and we may or may not detail the relations with specific parts of the environment. In saying that the meaning of a word is its function in a text we do not necessarily distinguish which parts of the text affected, or were affected by, the word. This sense of function is useful in considering the context and its relations as a whole.

Second, in a consequence sense, some functions are directed to a specific part or activity of their environment (e.g., the pumping of the heart to circulate blood through the arteries and veins). These functions commonly entail other functions, and one function may be directed to another in an indefinite sequence (e.g., the function of the heart in circulating the blood and the function of circulation in distributing oxygen). In addition to ongoing functions, some directed functions occur less regularly (e.g., the function of a knife to cut bread). This consequence sense of function is useful in understanding and arranging for regulation and change.

Third, in an "if . . . then" sense, function may be a relation between two events. In common mathematical formulas, functional relations are reciprocal and necessary; but functional relations between events may also be considered as one-way or as a probabilistic correlation. In current usage, statements of functional relations commonly assume some degree of probability for empirical events. Such statements are often preferred to statements about cause and effect, whose usage has been problematic in that the effects implied by causes have often been taken as a defined certainty for both the verbal relations and the empirical relations referred to.

When verbal behavior has been manipulated into a general formula having internal relations that are logically

certain and when these relations approximate external empirical relations, it has often been tempting to consider this approximation as an exact conformity. According to Henri Poincaré (1905/1952, p. 214), "most enlightened Frenchmen" were predisposed by their education to "think" this way: "The only true matter in its [such a thinker's] opinion . . . will no longer have anything but purely geometrical qualities . . . the atoms of which will be mathematical points subject to the laws of dynamics alone." This underlying reality is identical to geometrical expressions. In contrast to such geometrical contemplation, however, what scientists empirically do is produce or observe functional relations of (at best) a high degree of order even when their accounts are rendered in mechanistic causal-chain language (cf. Hanson, 1955, 1958; Rymer, 1988; Schiller, 1917/1955). Mathematical formulas can be useful in science, and the relations may be acceptably certain within the mathematics, but the exact continual conformity of nature to a formula is less than certain, and even mathematical certainty may need qualification (see Kline, 1980). Similarly, the "hard facts" of science may be presented as certain, atomic, unchanging building blocks of reality (see Gregory, 1977, pp. 152–153), but the expression of a fact may change and change the fact (cf. Hanson, 1958, on theory-laden facts; Skinner, 1986, pp. 120–121, on the evolution of facts).

Some Historical Background for Functional Accounts

Aristotle. Unlike Socrates, Aristotle (J. Barnes, 1984)—whose treatment of functional relations is clearer, perhaps, in his later writing (see Graham, 1987)—gave a continuing role to experience in accounting for theory:

Such appears to be the truth about the generation of bees, judging from theory and from what are believed to be the facts about them; the facts, however, have not been sufficiently grasped; if ever they are, then credit must be given rather to observation than to theories, and to theories only if what they affirm agrees with the observed facts. (*Generation of Animals*, III, 760b29–33)

Aristotle also criticized those who held fast to principles without empirical justification:

In the confidence that the principles are true they are ready to accept any consequence of their application. As though some principles did not require to be judged from their results, and particularly from their final issue! And that issue . . . in the knowledge of nature is the phenomena always and properly given by perception. (*On the Heavens*, III, 306a13–18)

This emphasis on results would later be pursued by pragmatists.

Aristotle used four different senses of cause—material, formal (or formula of the essence), efficient (or source of change), and final (or end) cause (also called the good or the apparent good, *Metaphysics*, V, 1013b27). All of these causes could be involved in a single human action, suggesting the root metaphor of an artisan shaping material into a product (Graham, 1987, pp. 177–182), and it has been suggested that the everyday usage of cause continues to have a root metaphor in human manipu-

lations for producing effects (Cook & Campbell, 1979, pp. 25–31; Gasking, 1955; also see Skinner, 1971, p. 5).

Illustrating common usage of "The end, i.e., that for the sake of which a thing is," Aristotle presented health as the end of walking: "For why does one walk? We say 'in order that one may be healthy', and in speaking thus we think we have given the cause" (*Metaphysics*, V, 1013a32–36). Aristotle also described actions with (*Eudemian Ethics*, II, 1227a6–30) and without (*Physics* II, 199a20–29) deliberation in terms of ends as well as the functions of objects and parts of a whole: "Every instrument and every bodily member is for the sake of something, viz., some action" (*Posterior Analytics*, II, 645b15–16).

Although William Harvey's physiology was indebted to Aristotle's theory of final causes (Pagel, 1967; Plochman, 1963), teleoformal or teleomechanistic combinations of final causes like the argument from design were often seen as a hindrance to science (cf. Lenoir, 1982; Ospovat, 1981). For Francis Bacon (1620/1960), "The final cause rather corrupts than advances the sciences, except such as have to do with human action" (p. 121). The fruits or outcomes of human actions, however, were central to Bacon's views:

Of all signs there is none more certain or more noble than that taken from fruits. For fruits and works are as it were sponsors and sureties for the truth of philosophies Where, as in religion we are warned to show our faith by works, so in philosophy of the same rule the system should be judged of by its fruits, and pronounced frivolous if it be barren. (pp. 113–114)

Accordingly, Bacon saw truth as utilitarian or pragmatic: "Truth, therefore, and utility are here the very same things" (p. 114). Put another way, "What in operation is most useful, that in knowledge is most true" (p. 124). The inductive-deductive method that Bacon advanced for science, however, assumed "eternal and immutable" forms or laws (p. 129, also see pp. 122 and 152), which his induction could not establish.

Darwin. A major advance in teleological explanation came with Charles Darwin's natural selection. W. Charlton (1970) noted, "Many remarks could be taken from *The Origin of Species* which have an Aristotelian ring" (p. 122), and the high regard Darwin (1888/1959, p. 427) later expressed for Aristotle may be understandable on that basis. In addressing Darwin's teleology, Asa Gray (1874) wrote: "In many, no doubt, Evolutionary Teleology comes in such a questionable shape, as to seem shorn of all its goodness; but . . . In its working applications it has proved to be a new power, eminently practical and fruitful" (p. 81). Darwin (1892/1958b) accepted Gray's characterization: "What you say about Teleology pleases me especially. . . . I have always said you were the man to hit the nail on the head" (p. 308). The key terms of Darwin's account, however, were different from those that had been used in traditional teleological explanations. Claiming that he "worked on true Baconian principles, and without any theory collected facts on a wholesale scale," Darwin (1892/1958b) was led to an early

focus on selection: "I soon perceived that selection was the keystone of man's success in making useful races of animals and plants" (p. 42). With the help of two more key terms, *the conditions of life and variations*, Darwin (1859/1958a) subsequently explained the forms and functions of living things through an accumulation of changes over time. Darwin (1872/1965) accounted for the behavioral expression of emotions in man and animals in a similar way. In this respect, the modern scientific study of behavior—particularly in ethology—may be traced to Darwin (cf. Jones, 1972, p. 39; Lorenz, 1965, p. ix).

Pragmatism. The pragmatists Charles Peirce, William James, John Dewey, and George Mead—whose work supports modern behavior analysis (see Day, 1980; Hayes, Hayes, & Reese, 1988; Lamal, 1983; Morris, 1988)—were influenced by Darwin's theory of natural selection and extended similar accounts to other phenomena (cf. Wiener, 1949).

Acknowledged by James as the founder of pragmatism, Peirce (cited in Cadwallader, 1974) said he "read and thought more about Aristotle than any other man" (p. 291). Peirce (Hartshorne & Weiss, 1931–1963) saw the discovery of laws of nature, the improvement of inventions, and natural selection as similar processes:

We here proceed by experimentation. . . . What if we were to vary our procedure a little? Would the result be the same? We try it. If we are on the wrong track, an emphatic negative soon gets put upon the guess, and so our conceptions gradually get nearer and nearer right. The improvements of our inventions are made in the same manner. The theory of natural selection is that nature proceeds by similar experimentation to adapt a stock of animals or plants precisely to its environment, and to keep it in adaptation to the slowly changing environment. (2.86)

In continuing this explication, Peirce distinguished between a two-term relation in mechanistic accounts and a three-term relation in selection accounts:

Just as a real pairedness consists in a fact being true of A which would be nonsense if B were not there, so we now meet with a Rational Threeness which consists in A and B being really paired by virtue of a third object, C. (2.86)

Applied to natural selection, the relation between (A) the environment and (B) the stock of animals adapted to it exists because of (C) the consequences that occurred for previous AB (environment–animal) relations. Applied to behavior, the relation between (A) the environment and (B) the behavior exists because of (C) the consequences that occurred for previous AB (environment–behavior) relations. These AB-because-of-C relations occur in Skinner's three-term contingency (see Moxley, 1987).

James (1890/1983) said "that both mental and social evolution are to be conceived after the Darwinian fashion and that the function of the environment properly so called is much more that of selecting forms . . . than producing of such forms" (p. 1232). For James, "Consciousness is at all times a selecting agency" (p. 142) which "with its own ends present to it, and knowing also well which possibilities lead thereto and which away, will, if

endowed with causal efficacy, reinforce the favorable possibilities and repress the unfavorable or indifferent ones" (p. 144). James's views were advanced in functional psychology, early sources of which James R. Angell (1907) traced to Aristotle, Spencer, and Darwin.

Dewey (1896) saw the mechanistic reflex arc theory as a dualism in which "the idea (or central process) is purely psychical and the act (or movement) purely physical" (p. 365). Instead, stimulus and response were functions: "Stimulus and response are not distinctions of existence, but teleological distinctions, that is, distinctions of functions, or part played, with reference to reaching or maintaining an end" (Dewey, 1896, p. 365). Dewey also identified fundamental problems with mechanistic views (1929/1988, pp. 160–177) and emphasized the pervasive role of consequences in human experience (e.g., 1916/1966, pp. 139–140) and learning (e.g., 1936/1965, p. 477), even from infancy (e.g., 1939, pp. 8–9).

Mead (1936) distinguished the contexts for mechanical explanations from the contexts for functional explanations in which the function "would be called, in terms of an Aristotelian science, a 'final cause'" (p. 268). For Mead (1934/1962), contextual considerations extended to "inner" self-conscious behavior as well as "outer" social behavior:

Social psychology is behavioristic in the sense of starting off with an observable activity. . . . But it is not [Watsonian] behavioristic in the sense of ignoring the inner experience of the individual. . . . It simply works from the outside to the inside, so to speak, in its endeavor to determine how such experience does arise. . . . [Our point of approach] is behavioristic, but unlike Watsonian behaviorism it recognizes the parts of the act which do not come to external observation, and it emphasizes the act of the human individual in its natural social situation. (pp. 7–8)

Mead's views are in conflict with Watson but not Skinner (1988a), who identified circumstances where private events "may be called causes" (p. 486; also see Skinner, 1945/1972b).

Development of Functional Behaviorism

As pragmatic considerations spread, Bertrand Russell (1928) noted, "Science is . . . developing a philosophy which substitutes for the old conception of knowledge the new conception of successful behavior" (p. 65). In behaviorism, Edward Tolman (1932/1951) asked, "We are asserting, are we not, a pragmatism?" (p. 430), and Stephen Pepper (1934) replied, "You are, but with certain curious inheritances still holding over from the traditional mechanistic psychology of the past" (p. 108). Pepper (1942/1970) described pragmatists as contextualists and portrayed Tolman as a contextualist using too much of the language of mechanism. J. R. Kantor (1959, pp. 14–17; 1981, pp. 254–255), a more consistent contextualist and Skinner's colleague at the University of Indiana, addressed extensive functional relations in setting events with his behavior segment or interbehavioral field unit. Not using a separate contextual unit, Skinner moved away from early mechanistic influences and toward a fully

functional behaviorism in the three senses of function previously described.

An early conflict. Although apparently unnoticed by Skinner, a fundamental conflict existed between two of the sources he relied on in his early work. A source for mechanistic views was Loeb, whom Skinner (1989a, p. 122) credited for his theoretical position in *The Behavior of Organisms* (1938/1966a) along with crediting his work in the biological laboratories of W. J. Crozier, his dissertation supervisor and "Loeb's major disciple." Loeb and Crozier provided a base and point of departure for Skinner (cf. Coleman, 1984, 1987; Day, 1980; Herrnstein, 1972; Pauly, 1987, p. 188; Skinner, 1979, pp. 44-47; Smith, 1986, pp. 276-277). A source for functionalism was Ernst Mach, whom Skinner (1989a, p. 122) also credited for his theoretical position in *The Behavior of Organisms*. However, a fundamental conflict existed between Loeb and Mach that raises the question of how Skinner reconciled their views. Loeb thought Mach's descriptive emphasis went too far in opposing mechanistic explanations (see Loeb, 1915; Pauly, 1987). Although Mach's phenomenalism and its elements of sensation appear as a "psychological atomism" (Capek, 1968, p. 171), Mach (1960) said, "Purely mechanical phenomena do not exist. . . . The mechanical theory of nature [may] for a time, have been of much value. But, upon the whole, it is an artificial conception" (p. 597). Mach faulted mechanistic cause and effect (pp. 580-581) and regarded Laplace's determinism as "a *mechanical mythology* in contrast to the *animistic* of the old religions. Both views contain undue and fantastical exaggerations of an incomplete perception" (p. 559).

Skinner's pursuit of Machian functionalism was somewhat at odds then with a mechanistic reflexology. In stating his early position, however, Skinner showed no awareness of a conflict. On the one hand, Skinner (1931/1972a) advocated functional description:

We may now take that more humble view of explanation and causation which seems to have been first suggested by Mach and is now a common characteristic of scientific thought, wherein . . . explanation is reduced to description and the notion of function substituted for that of causation. (p. 449)

On the other hand, after thus obviating a need for necessity, Skinner (1931/1972a) said, "The reflex is important in the description of behavior because it is by definition a statement of the necessity of this relation [between behavior and its stimulus]" (p. 449). How can this view of S-R necessity be reconciled with Skinner's statement on functional relations? Scharff (1982) answered, "The only thing which could have prompted this opinion is an underlying and deeply entrenched ontological assumption, viz., that any science, even a descriptive one, is dealing with a world of necessarily collected phenomena" (p. 48).

Curiously, the deterministic predestination in the Calvinism of Jonathan Edwards may have contributed to this assumption: "Much of my scientific position seems to have begun as Presbyterian theology, not too far re-

moved from the Congregational of Jonathan Edwards" (Skinner, 1983, p. 403; also see Skinner, 1979, p. 29). Skinner's (1983) characterization of himself as "thoroughly Baconian" (p. 406) also suggests a contribution to this assumption from his early reading of Bacon, whose deterministic metaphysics was also supported by a Calvinistic background (Anderson, 1960; Bacon, 1620/1960, pp. 121-129, and 151-152; Hill, 1965). In addition, scientific determinism was a widely received view. Physical or scientific determinism "was held by physicists, practically without exception, until 1927, and by Einstein, it seems, almost until his death in 1955" (Popper, 1982, p. 2).

However, the necessary relations that scientific determinism traditionally implied—for example, as accepted by Laplace (1814/1951) and rejected by Peirce (Hartshorne & Weiss, 1931-1963, pp. 6.35-6.65)—exceeded empirical evidence. Logical necessity cannot be induced from empirical events. Nor does an accumulation of knowledge in one area or level of investigation prevent an increasing awareness of lack of knowledge elsewhere. Scientific answers are invariably followed by new questions and revisions of earlier answers. A continuing reduction of uncertainty (or increase in determination) rather than a complete reduction of uncertainty (or complete determination) is a more reasonable induction and more consistent with modern physics (cf. Capra, 1982; Feynman, 1985; Gigerenzer et al., 1989; Hawking, 1988). In addition, world-formula determinism implied contingent relations are ultimately derived from rules rather than rules being ultimately derived from contingent relations. If rules are verbal behavior, whose unobserved verbal behavior would this be? The anthropomorphism here is a problematic ghost in the machine of world-formula determinism. A cognitive psychologist might say the underlying rules are actually nonverbal (Reese, 1989, p. 29), but the concept of a nonverbal rule is self-contradictory in Skinner's (1969) account of rules as verbal behavior.

Nevertheless, Skinner (1932; also see 1953, p. 112) seems to have initially accepted the mechanistic assumption that if functional relations appear inconsistent with necessity it is only because the true relations are obscured by other relations:

The inevitability of any reflex, the necessity of the relationships of any stimulus and response, rests ultimately upon observation: a response is observed to follow the administration of a stimulus and to be absent otherwise. But no reflex shows an absolute necessity of this sort. For example, the necessity is lacking during the absolute refractory phase and after complete fatigue. Necessity, moreover, implies a constant ratio of the values of stimulus and response, which is, nevertheless, seldom observed. No one will be likely to urge these exceptions against the validity of a reflex, for the conditions under which they are observed are almost always induced experimentally, with the result that the experimenter is provided with some means of accounting for an effect even before he has observed it. But such an appeal to a third variable (to a condition of the experiment, for example) will be fully satisfying only if the effect can be shown to be an exact function of the variable, and we ordinarily attempt to

secure this satisfaction by demonstrating the nature of the function—for example, by discovering the “curve” for the refractory phase or for reflex fatigue. (p. 32)

When the observed relation of the third variable fails to show an exact function, this is presumably accounted for by further obscuring variables, and so on indefinitely.

Those who hold such assumptions may be tempted to invent intervening variables to support necessary relations and to confine the search for truth to areas where the subject matter already appears to approximate strict “if . . . then” order (e.g., the regularities of planetary movements, the reflex action of a severed or constrained animal, or the heliotropic movements of an organism). However, Skinner’s use of description rather than invention in laboratory studies of intact, unrestrained organisms under a variety of conditions (although relatively decontextualized) led him away from necessary relations.

New directions. Even though Skinner occasionally invoked an ontology of necessary relations, what he *did* was to pursue functional relations of one kind or another. Skinner commented on the changes in his views, especially to emphasize that they no longer represent an S–R psychology. Skinner said that he should have abandoned the “reflex” (1978b, pp. 119–120) and “reflex reserve” (1989a, p. 131) sooner than he did and that he had not been an S–R psychologist for more than 50 years (1988a, p. 460). Several studies have noted changes in Skinner’s work (e.g., Coleman, 1981, 1984, 1987; Hine-line, 1990; Killeen, 1988; Timberlake, 1988; Verplanck, 1954). Timberlake (1988) concluded,

He [Skinner] drew his formal framework from work on the reflex, . . . expanded it to account for all purposive behavior, . . . avoided or abandoned most high-level theoretical concepts, . . . [and] strongly encouraged the establishment of functional relations between variables, although the results were not included in a formal way in his system once he abandoned the reflex reserve concept. (p. 315)

Over time, functional features of Skinner’s work were expanded in new directions while formal and mechanistic features were abandoned.

In moving away from a mechanistic reflexology derived from Descartes (Skinner, 1931/1972a), Skinner (1938/1966a) defined the operant as a functional class: “The number of distinguishable acts on the part of the rat that will give the required movement of the lever is indefinite and very large. They constitute a class, which is sufficiently well-defined by the phrase ‘pressing the lever’” (p. 37). In contrast to structural classes that contain features common to the topographies of behavior, Skinner’s functional class was determined solely by the resulting consequences. Whatever the topography of the behavior, it counts as a member of the class if it results in a “lever press” (cf. 1938/1966a, p. 40).

Using two different senses of function, Skinner (1938/1966a) distinguished operant behavior from respondent behavior. A respondent involved function in the sense of an observed correlation between stimulus and response (Skinner, 1938/1966a, pp. 9–20). An operant involved function in the sense of consequence in

a three-term relation for reinforcement: a prior discriminative stimulus, a response, and the (consequent) reinforcing stimulus (Skinner, 1938/1966a, pp. 20–22 and 178).

Probability relations. Although at one point Skinner (1938/1966a) referred to the three-term relations as “the mechanical necessities of reinforcement” (p. 178), he was clearly making a case that “a stimulus may have more than one kind of relation to a response” (p. 241). Later, Skinner (e.g., 1969) described the three-term relations as “the contingencies of reinforcement” (p. 23). The shift from “necessities” to “contingencies” is revealing in that a certain and invariable “necessity” has historically been contrasted with a less-than-certain “contingency” (cf. Edwards, 1754/1982, pp. 15–23; Priestly, 1777, pp. 7–19; Spinoza, 1677/1982, p. 51).

Later, Skinner (1966b) distinguished the experimental analysis of behavior from S–R psychologies:

The task of an experimental analysis is to discover all the variables of which probability of response is a function. . . . The position of an experimental analysis differs from that of traditional stimulus–response psychologies or conditioned reflex formulations in which the stimulus retains the character of an inexorable force. (p. 214)

An “inexorable force” reflected a necessity that Skinner was replacing with probability (also see Skinner, 1973, pp. 258–259, on control as “probability” rather than “forcible coercion”).

A probability relation—expressed as rate or frequency of occurrence of a response—was prominent in the operant and unlike the “determined” relation in the reflex:

Rate of responding . . . could be said to show the probability that a response would be made at a given time. Nothing of the sort could be said of a reflex, where the stimulus determined whether or not a response was made. Probability simply did not fit the stimulus-response pattern. (Skinner, 1989a, p. 124)

Later, Skinner referred to “probability of action” (1989b, p. 83), which further distanced the operant from an S–R formulation.

Consequences. Skinner’s concept of the operant was consistent with his developing pragmatic epistemology, which gave more importance to effective consequences than to agreement:

The ultimate criterion for the goodness of a concept is not whether two people are brought into agreement but whether the scientist who uses the concept can operate successfully upon his material—all by himself if need be. . . . this does not make agreement the key to workability. On the contrary, it is the other way round. (1945/1972b, p. 383)

Skinner continued to emphasize the priority of establishing effects rather than truth: “So far as I am concerned, science does not establish truth or falsity; it seeks the most effective way of dealing with subject matters” (Skinner, 1988a, p. 241).

Consistent with the pragmatic tradition, Skinner (e.g., 1981, 1984, 1986) looked more and more to biology

and evolution, rather than physics and chemistry, as sources for explanatory accounts of behavior and presented a tradition for selection by consequences that replaced the causation of classical mechanics:

Selection by consequences is a causal mode found only in living things, or in machines made by living things. It was first recognized in natural selection, but it also accounts for the shaping and maintenance of the behavior of the individual and the evolution of cultures. In all three of these fields, it replaces explanations based on the causal modes of classical mechanics. (1981, p. 501)

The consequence relations in machines constructed with feedback were of course not sources for the accounts of classical mechanics.

Using the language of teleology to explicate selection by consequences, Skinner (1974) said, "Operant behavior is the very field of purpose and intention. . . . It is directed toward the future: a person acts *in order that* something will happen, and the order is temporal" (p. 55; see Skinner, 1953, pp. 87–90, for similar comments and a caution against a defective meaning of final cause; also see Skinner, 1973, p. 264, on how "living things have circumvented the rule against final causes"). For Skinner (1953), purposive behavior occurs "because of the consequences which have followed similar behavior in the past" (p. 87), and his account is consistent with modern senses of teleology (cf. Kitchener, 1977; Moore & Lewis, 1953; Ringen, 1976; Staddon, 1983, pp. 79–80).

Skinner also modified his mechanistic requirement of contiguity for the operant—between behavior and a reinforcing consequence—which he had long maintained despite a dubious need to do so (cf. Baum, 1973; Lattal & Gleeson, 1990; Moxley, 1984). Skinner (1978a) had said, "Reinforcement must overlap behavior if we are not to suppose that something which has not yet occurred can have an effect" (p. 20; also see 1984, p. 220). Later, Skinner (1988b) said, "Verbal behavior is defined as behavior reinforced by the actions of listeners (or viewers), and the reinforcement is always slightly delayed" (p. 467). From a mechanistic perspective, the shift from an unqualified "must overlap" to "always slightly delayed" (for verbal behavior) is considerable and opens up a wider consideration of consequences.

Contexts. In addition, Skinner expanded the role of functional contexts for which his early formulation of the operant had limited room: "Three terms must therefore be considered: a prior discriminative stimulus (S^D), the response (R^0), and the reinforcing stimulus (S^I)" (Skinner, 1938/1966a, p. 178). Subsequently, Skinner (1987, p. 201; 1988a) expressed dissatisfaction with *discrimination*: "The choice was unfortunate. The issue is not discriminability but how stimuli acquire control of behavior from their role in contingencies of reinforcement" (1988a, p. 471). In place of *discrimination*, Skinner used *occasion* (e.g., 1969, p. 7; 1973, p. 257) and *setting* (e.g., 1973, p. 257, 1988a, p. 215; also see 1988a, p. 265, 1989a, p. 126; 1989c, p. 10; and 1989d, pp. 62–63). In particular, *setting* indicates contextual relations such as

Kantor addressed in his (Kantor's) use of the term. In granting a role to various contextual relations—including personal histories as well as genetic and cultural influences—Skinner's expansion of contexts for the operant is at odds with S–R reduction.

These changes in terms may appear less drastic if the initiating antecedent stimulus (A)—an "attention-getting" or "just presented stimulus" (Timberlake, 1988, pp. 312–313)—is considered as part of a fuller account of the occasion provided by the setting (S): giving AB-because-of-C-in-S. This formulation may be regarded as including (a) the stimulus-response unit as AB, (b) the three-term operant unit as AB-because-of-C, and (c) the setting event unit as S. These units can be considered separately as representing one of the three senses of functional relations or together as representing all three senses of functional relations.

Mechanistic vestiges. Although Skinner's central analysis of contingencies shows a persistent development toward a fully functional behaviorism, mechanistic vestiges appear in peripheral areas. For example—although he never addressed ontological determinism in detail and it was not essential for his functional behaviorism—Skinner (1971) retained allusions to it: "Personal exemption from a complete determinism is revoked as a scientific analysis progresses" (p. 18) and "We cannot prove, of course, that human behavior as a whole is fully determined, but the proposition becomes more plausible as facts accumulate" (Skinner, 1974, p. 189). Skinner (1988a) also suggested instances when "selection as a causal mode has done its work and a mechanical model may suffice" (p. 25). Interestingly, Skinner (1983) indicated how some of his deterministic statements may be problematic:

When [Percy Bridgman] saw the manuscript of *Science and Human Behavior*, he caught me up on two subtle points. He wrote: "I think it would be better in discussing the principle of indeterminacy to say that relevant information does not exist than to say we cannot put ourselves in possession of it. And I would not like to say, as seems implied, that science has to assume that the universe is lawful and determined, but rather that science proceeds by exploiting those lawfulnesses that it can discover. Anything smacking of faith I think we can get along without." (p. 60)

In addition, Skinner made claims that appear to be deductions from deterministic assumptions, such as his claims that technology follows or can be deduced from science (see Moxley, 1989, on problems with this).

One curious variety of deterministic claims occurs in some of Skinner's criticisms of word usage in which he appears to assume fixed meanings for words regardless of their contexts. As a result, some of his attributed meanings are questionable (cf. Harzem & Miles, 1978, pp. 57–59; Midgley, 1978, pp. 109–112; Wright, 1976, pp. 87–90). At times, these criticisms seem to depend, at least in part, on rhetorical contingencies for making points at an opponent's expense. For instance, Skinner (1988a) said of a critic's statement about rules extracted from contingencies of reinforcement: "It is a mistake to say

'extracted from' since the rules are not in the contingencies. They are descriptions of contingencies" (p. 265). Yet, Skinner (1969) himself said, "Rules can be extracted from the reinforcing contingencies" (p. 124; also see 1980, pp. 85 and 275; 1987, p. 107). Although Skinner presumably considered his own usage of "extracted from" a reasonable metaphorical extension, he attributed an erroneous literal meaning to his critic without any evident analysis of what the relevant contingencies were—and hence what the meaning was—for his critic's use. Showing some awareness that his interpretations of other people's use of words could be problematic, Skinner (1980) conceded that "*Beyond Freedom and Dignity* was a misleading title" (p. 5).

The importance of the contexts for verbal behavior was emphasized by Ludwig Wittgenstein (1960) as well as by the pragmatist F. C. S. Schiller (1917/1955), who is "part of the line leading from Peirce and James to Ramsey and Wittgenstein" (Thayer, 1981, p. 308). According to Wittgenstein (1960), "We don't use language according to strict rules" (p. 25). Rather, words should be viewed as instruments characterized by their use: "Think of the use of a hammer, the use of a chisel. . . . It is the particular use of a word only which gives a word its meaning. . . . The use of the word *in practice* is its meaning" (pp. 67–69).

Illustrating how some of his comments on terms were peripheral to his functional behaviorism, Skinner's (1945/1972b) fundamental view of the contingencies of verbal behavior is compatible with Wittgenstein and pragmatism:

[The psychologist] cannot, unfortunately, join the logician in defining a definition, for example, as a "rule for the use of a term" (Feigl); he must turn instead to the contingencies of reinforcement which account for the functional relation between a term, as a verbal response, and a given stimulus. This is the "operational basis" for his use of terms; and it is not logic but science. (p. 380)

Skinner (1980, p. 114) later restated this position in pointing out the problem of investing the topographical form of a word with meaning. The meaning of a word, or phrase can be given only on the basis of the contingencies for its use. Such examinations show that a word commonly has a different meaning in different uses because different contingencies are commonly relevant in those different uses. It is not form but function that gives the meaning of a word and verbal expressions composed of words.

Conclusion

The significance of Skinner's work lies in its changing development over time—its contributions to functional behaviorism. In making these contributions, Skinner turned away from necessary relations, such as those in the mechanistic S–R tradition, and pursued a wide range of functional relations in the probability between events, in consequences, and in contexts. As a result, his behaviorism became aligned with a functional rather than a

mechanistic tradition. All traces of an early mechanistic orientation, however, did not disappear from his later writing. An approving use of *mechanical* or a deterministic relation still appeared, but these references were peripheral to the core of his functional analysis of behavior. Perhaps of some significance, contemporary behaviorists who have retained mechanistic terms often do not use them in the sense of classical mechanism. *Mechanistic* may mean functional relations to a high degree of order, and *determinism* may mean a similar high probability for functional relations. The retention of terms from a previous paradigm—but accompanied by a change in the meaning of the terms or concepts to accommodate the new paradigm—is not unusual when a paradigm shift occurs (cf. Elkana, 1984, p. xxiii).

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