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The Prediction and Control of Behavior: Watson, Skinner, and Beyond[1]

La predicción y control de la conducta: Watson, Skinner y más allá

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Abstract

This paper seeks to clarify and expand on the meaning of "prediction and control" as the goals of behaviorism. Historically, these were the goals of the natural sciences. When John B. Watson declared psychology to be a natural science, they became the goals of classical behaviorism, too, as they would later for B. F. Skinner's radical behaviorism. These goals are controversial, however, because what Watson and Skinner meant by them has been subject to misinterpretation. Over Watson's career, the significance of prediction and control changed, from a means for studying behavior to a means of social engineering. Unfortunately, the latter suggests that "demonstrating control" is the only goal of behaviorism, whereas the goal expands into "discovering functional relations." For Skinner, prediction and control were significant, not as *the* goals of behaviorism, but as the basis for specialized goals in basic and applied research and conceptual analysis (e.g., theory construction). As such, prediction and

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control are also the pragmatic arbiters for judging success in attaining these goals. Prediction and control need to be expanded beyond this, however, by applying them not only to behavior as a subject matter, but also to the behavior of scientists (e.g., resolving puzzlement), thereby revealing the role they play in thinking. Discovering functional relations and thinking converge on ordinary-language meanings of understanding —understanding as the goal of behavior analysis.

Key words: Behaviorism, "demonstrating control", ordinary language.

Resumen

Este artículo busca aclarar y ampliar el significado de la "predicción y control" como metas del conductismo. Históricamente, estas fueron las metas de la ciencia natural. Cuando John B. Watson declaro que la psicología era una ciencia natural, también se volvieron metas del conductismo clásico, como lo fueron después para el conductismo radical de B.F. Skinner. Sin embargo, estas metas son controversiales porque lo que Watson y Skinner quisieron decir acerca de ellas ha sido malinterpretado. A lo largo de la carrera de Watson, cambió la significación de la predicción y el control, de un medio para estudiar la conducta a un medio de ingeniería social. Desafortunadamente, lo último sugiere que "demostrar control" es la única meta del conductismo, mientras que la meta se amplia a "descubrir relaciones funcionales". Para Skinner, la predicción y el control no fueron significativas como *las* metas del conductismo, sino como la base de metas especializadas en la investigación básica y aplicada y el análisis conceptual (v.g., la construcción teórica). Como tales, la predicción y el control son también árbitros pragmáticos para juzgar el éxito en la obtención de estas metas. Sin embargo, la predicción y el control deben expandirse más allá de esto no solo aplicándolas a la conducta como objeto de estudio, sino también a la conducta de los científicos (v.g., resolviendo problemas), revelando por consiguiente el papel que juegan en el pensamiento. Descubrir relaciones funcionales y pensar convergen en los significados del lenguaje ordinario respecto de la compresión-la comprensión como la meta del análisis de la conducta.

Palabras clave: conductismo, "demostrar control", lenguaje ordinario.

In 1892, William James (1842-1910) wrote that the aim of the natural sciences was "practical prediction and control" (James, 1892, p. 148). For psychology to become a natural science, James (1892) argued that these must be its goals too — and they became so. Prediction and control became the goals of a psychology that achieved its independence as a discipline separate from philosophy. They became the goals of a psychology that gained a place and a standing in the culture of the United States through university and foundation support, and from support of the culture at large (see O'Donnell, 1985). They became the goals of behaviorism, reasonably adopted from 19th century natural science. They became goals more on principle, however, than through self-conscious consideration, perhaps less a problem then than now. In what follows, we examine prediction and control as the goals of behaviorism, both then and now, and consider how they might be more usefully construed in these postmodern, postpositivist times.

This paper is not the first one to examine prediction and control as the goals of behaviorism. There are others. Hugh Lacey (1979) has described how prediction and control need not be the goals of psychology at all, but only the goals of a psychology that shares certain ontological assumptions with radical behaviorism (e.g., determinism). Steve Hayes and Aaron Brownstein (1986, 1987) have discussed how the goals of prediction and control render mentalism counterproductive in a natural science of behavior. And Laurence Smith (1992) has reflected on how the technological ideal of prediction and control is today challenged by other ways of knowing in postpositivist science, such that behaviorism, too, is challenged.

The purposes of our paper are different than these, however, and perhaps foundational to them. Our first purpose is to examine just what prediction and control meant for the founders of classical and radical behaviorism — John B. Watson (1878-1958) and B. F. Skinner (1904-1990), respectively. What Watson and Skinner meant by prediction and control was not always simple and straightforward. What they meant was often subtle and complex, and it sometimes changed as a function of context and purpose. Any analysis of prediction and control as the goals of behaviorism should first consider this.

Our second purpose is to suggest that behavior analysis should expand on what Watson and Skinner meant by prediction and control. This, we think, may yield two useful consequences. First, the expansion may clarify and extend the meanings of prediction and control in ways that contribute to more effective

basic and applied research, and conceptual analysis. Second, by clarifying and extending these meanings, we may allay criticisms that behavior analysis is shallow and narrow in its goals, for instance, criticism that Skinner's "techniques of behavior modification are powerful tools for manipulating behavior, but singularly devoid of understanding that behavior" (Barash, 1979, p. 202fn; see also Evans, 1975; Garcia, in press).

In sum, we seek to describe some deeper and broader meanings of prediction and control so as encompass more of what is meant by ordinary-language terms such as "knowing," "understanding," and "explaining." The success and vitality of behavior analysis as a discipline and a profession may require that it clarify and expand on —and perhaps even evolve beyond— the meanings of prediction and control as they originated in Watson and Skinner. We begin by examining the historical background behind Watson's and Skinner's assumptions that prediction and control should be the goals of a science of behavior.

Historical Background

In his 1913 "behaviorist manifesto," John B. Watson (1913a, p. 158) declared that "psychology as the behaviorist views it" was an "objective natural science" and that, as such, the "theoretical goal" of psychology was the prediction and control of behavior (see also Watson, 1914). This goal did not appear to concern many of Watson's colleagues, poised as they were for a science of psychology independent of philosophy, set as they were in the context of a socially progressive culture (Buckley, 1989). Psychologists who were subsequently raised on logical positivism and hypothetical-deductive research methodology, however, have often suggested that prediction and control are overly shallow and narrow goals for science, especially as later articulated by B. F. Skinner (1938) (see, e.g., Barash, 1979; Chomsky, 1959; Minsky, 1986). For them, the goals of psychology were expressed in formal and linguistic terms such as "knowledge," "understanding," and "explanation."

Watson and Skinner, however, were not necessarily (or perhaps ever) being dogmatic or arbitrary in their views, given their historical contexts —contexts that supported rational and empirical bases for adopting prediction and control as the goals of behaviorism. Watson and Skinner were simply expressing rather conventional positions for their times, given their orientation that the quality of science was defined largely by its ability to predict and control its subject matter —an orientation shared with scientists and scholars as different

as William James (1892) and Jacques Loeb (1916). To understand this, we comment briefly on the history of science and technology.

In the Middle Ages (500-1300), prior to Renaissance in Europe (1300-1600), science in its modern form was largely unknown. Prediction, of course, was a well-accepted activity, but practiced with equal credibility by astronomers and astrologers alike, and by magicians, witches, and other occult practitioners. Shakespeare, for example, took the widespread acceptance of astronomical and astrological prediction equally for granted. In his play, *Julius Caesar* (ca. 1599), Caesar's observations about the constancy of the northern star, for instance, were expressed with the same conviction as the predictions of the witches in the opening act of *Macbeth* (ca. 1606).

Control, similarly, often had supernatural overtones. Technological innovations had not yet established the view that people could have dominion over nature (if we do). Witches might cast spells and curses, and prayer might bring results, but reliable, practical control over anything but the limited and mundane aspects of daily living was not to be expected. Indeed, control was feared —feared for being the province of the supernatural. Even today, to have what appears to be excessive control in the natural sciences is to "play God" (Burke, 1985). The driving force behind the Scientific Revolution (1600-1700) that eventually came to Europe was the development and widespread dissemination of technology. The moldboard plow and horse collar, for example took control of the food supply away from nature —that is, away from God's will expressed through the weather— and gave it to the possessors of plows and horses. Surpluses of food and other commodities allowed people to devote time to activities other than producing those commodities, such as developing and refining technologies needed for other pursuits (Burke, 1985). The need for precision in navigation, for instance, created a need for precision in astronomy and the mathematics that went with it. By adopting an empirical, rather than a scholastic or rationalist approach, even medicine eventually became less dangerous than the diseases to which it was applied (Thompson, 1984). Many important scientific advances, then, were the result of attempts to solve practical problems rather than to advance or refine a scientific law or develop theories. Although exceptions to this orientation existed, technological advances helped convince Westerners that the goal of science was to control nature. Prayers and spells became increasingly notable for their relative unreliability; science, in contrast, was beginning to display its mastery over many aspects of the universe, including life itself. An observation by Mary Shelly

(1831/1969) in her book, *Frankenstein*, aptly illustrates the popular view that the ultimate achievement of science was control over nature:

> The ancient teachers [of alchemy] ...promised impossibilities and performed nothing. The modern masters promise very little; they know that metals cannot be transmuted and that the elixir of life is a chimera. But these philosophers, whose hands seem only made to dabble in dirt, and their eyes to pore over the microscope or crucible, have indeed performed miracles. They penetrate into the recesses of nature and show how she works in her hiding-places. They ascend into the heavens; they have discovered how the blood circulates, and the nature of the air we breathe. They have acquired new and almost unlimited powers; they can command the thunders of heaven, mimic the earthquake, and even mock the invisible world with its own shadows. (pp. 47-48)

Shelly's (1831/1969) passage is especially notable in that the scientists she described neither "understood" nor "explained" —nor did they have theories. Their activities did not conform to today's philosophy-of-science or textbook descriptions of "the" scientific method (see Skinner, 1956a). In other words, not only was a practical, pragmatic science acceptable as "science," it was what the public readily identified as science. Such science would eventually make the philosophy of pragmatism necessary because "truth" became increasingly ephemeral as each new discovery revealed the limitations of prior knowledge. Indeed, each answer seemed to raise dozens of new questions, leaving the universe proportionally *less well* understood than it was before. As practical prediction and control over the universe advanced, effective action provided a reasonably useful criterion for what was "true," at least provisionally (Peirce, 1905) .

This, then, is some of the historical context for Watson's and Skinner's claims that prediction and control were the goals of a natural science of psychology. The lineage of these views in the philosophy of science extends from Francis Bacon (15611626) and Ernst Mach (1838-1936) (see Smith, 1986, 1992); in biology, the lineage extends from Claude Bernard's (1859-1924) work in experimental medicine (Thompson, 1984). More focally, Watson was influenced by Jacques Loeb (1859-1924) at the University of Chicago (Pauly, 1987), and Skinner by his mentor at Harvard University, the general physiologist, W. J. Crozier (1892-1955) (Skinner, 1979), who himself was influenced by Loeb (see Pauly, 1987) . Although a closer, historical analysis of these lineages might profitably be pursued, our present purpose is to focus more on what

Watson, and then Skinner, actually said about prediction and control. We begin with Watson.

John B. Watson and Classical Behaviorism

Watson's commitment to prediction and control as the goals of psychology has been emphasized by the historian, Franz Samelson (1981), and has become central to many subsequent analyses of Watson's work (see, e.g., Buckley, 1989; Logue, in press; Todd, in press; Todd & Morris, 1986; cf. Samelson, in press). Samelson's analysis is especially important because he was one of the first Watson scholars to state clearly that Watson's message was not only about the applicability of prediction and control to basic, laboratory research, but also to social engineering in the culture at large (see Buckley, 1989).

Equating basic, laboratory research (and theory) with practical application via prediction and control was the essence of Watson's progressive, pragmatic viewpoint and an important early character of the goals of prediction and control. For Watson, psychology was to provide a means for predicting and controlling behavior in any domain —basic or applied. Lacking such goals, psychology would be incomplete as a science. Exactly what prediction and control meant for Watson, however, seemed to evolve over the course of his career, as we describe in what follows.

Psychology as the Behaviorist Views It

In "Psychology as the Behaviorist Views It," Watson (1913a) provided clear evidence for his view that science and practice were equivalent or at least inseparable, foretelling his later shift in emphasis toward the latter — toward practice. One of Watson's (1913a) major criticisms of Edward Titchener's (18671927) structuralism (see Titchener, 1896, 1929) was that it could do little else than produce "proficiency in mental gymnastics" (p. 168). Behaviorism, in contrast, was superior because it had immediate practical benefits. In Watson's (1913a) words:

> If psychology would follow the plan I suggest, the educator, the physician, the jurist and the business man could utilize our data in a practical way, as soon as we are able, experimentally, to obtain them. (p. 168)

Watson (1913a) continued by noting that his dissatisfaction with psychology was based on its lack of practical application:

> One of the earliest conditions which made me dissatisfied with psychology was the feeling that there was no realm of application for the principles which were being worked out in content terms. (p. 169)

This comment was followed by a strong defense of applied psychology which, according to Watson, was *also* scientific psychology. After mentioning "experimental pedagogy," "the psychology of advertising," "legal psychology," and other fields, Watson (1913a) complained:

> These are sometimes wrongly called "practical" or "applied" psychology. Surely there was never a worse misnomer....At present these fields are truly scientific and are in search of broad generalizations which will lead to the control of human behavior. (p. 169)

Watson's Early Research

In Watson's pre-1913 writings, he did not comment as frequently about the prediction and control of behavior, perhaps because his concerns then were those of a basic, laboratory researcher, not yet those of a social engineer. This did not mean he was unconcerned with prediction and control, for he was: He was concerned with them for what they could tell him about the nature of his subject matter — behavior.

Experimental research. In Watson's early experimental research, for instance, his concern with prediction and control was expressed as a means to an end, not as an end in itself. His 1903 dissertation on the developmental psychobiology of rats (Watson, 1903), for example, was entitled *Animal Education*, presumably to emphasize changes in the rats' behavior as a function of experience. This research stands in contrast to the work of other comparative psychologists, such as Romanes, who studied the intelligence of animals (Romanes, 1884), but where intelligence was not controllable, but innate and nonmanipulable. Likewise, Edward Thorndike's 1911 book, *Animal Intelligence* (Thorndike, 1911), pointed to the comparative aspects of his own puzzle box investigations, not to the possibilities for behavioral control offered by the law of effect.

Watson continued this emphasis on prediction and control in research subsequent to *Animal Education*. Indeed, his entire approach could be considered Baconian, although he did not characterize it as such. Virtually all his statements were descriptive, and his experimental manipulations were designed to answer specific questions about variables related to the behavior of interest (see Todd & Morris, 1986). In addition, some of his works — indeed, the entirety of *Animal Education* and his later studies of the spectral sensitivity of birds (Watson, 1908) —were designed to demonstrate the weaknesses of certain theories of behavior, as well as to provide new knowledge.

Ethological research. Many of Watson's early investigations were, of course, ethological in nature (see Pauly, 1987; Todd & Morris, 1986). Here, Watson did not attempt to make his subjects do anything in particular, that is, to control their behavior in any specific way. Rather, he observed and controlled environmental conditions and recorded the results. Again, though, what was important was the lawful and orderly relations between behavior and these conditions (see Watson, 1908). Behavior was controlled, then, in the process of, not as a goal, of Watson's research.

In summary, Watson's pre-1913 experimental and ethological research was primarily concerned with the demonstration of orderly relationships among variables — nothing else was necessary. His emphasis was on prediction and control in the laboratory and in the field, not on attempts to produce specific effects.

Watson's Books

After 1913, however, Watson became increasingly the promoter of behaviorism and a social visionary, and less and less the basic, laboratory researcher. He also became the author of books and textbooks, the contents of which allow us to observe changes in his views.

Behavior: An Introduction to Comparative Psychology (1914). At the time Watson published his 1914 textbook, *Behavior: An Introduction to Comparative Psychology* (Watson, 1914), he was aware of Ivan Pavlov's (1849-1936) research on the conditioned reflex (see Pavlov, 1927). Incorporating Pavlov's work into his behaviorism would seemingly have helped make prediction and control a central concern of his book. This was apparently unnecessary, however, because the book contained little about Pavlov, yet much about prediction and control —perhaps because Watson believed then that Pavlov's techniques

could not easily be adapted to animals other than dogs (see Watson, 1914, pp. 65-67).

As for Watson's subsequent emphasis on social engineering, Samelson (in press) has suggested that Watson's emphasis on control may be related to his later adoption of Pavlov's conditioned reflex as a behavioral mechanism (see Watson, 1916). Once Watson had a mechanism, then his statements about prediction and control could have practical, not just theoretical, import. Even then, however, the credibility of Watson's statements was more theoretical than practical. Watson and Rayner's 1920 "Conditioned Emotional Reactions" (Watson & Rayner, 1920), for instance, was his only major later study in which the production of a specific response was a practical goal.

Returning to Watson's 1914 text, its first chapter consisted of Watson's 1913 manifesto and another 1913 article, "Image and Affection in Behavior" (Watson, 1913b), both revised and combined to create an introduction to the conceptual foundations of behaviorism. The modern reader might be surprised by how infrequently terms such as "understanding" and "explanation" appear among these foundations — indeed, in all of Watson's works. At the end of the second chapter, Watson (1914) alludes to Loeb's research, and then tells us that the science of behavior consists of (a) analysis, that is, the reduction of "reactions to their simplest terms" (p. 53), and (b) synthesis. Of the latter, Watson (1914) wrote: "The building up of habits from simple reflexes for practical and theoretical (and ethical) purposes is as important as tearing them down" (pp. 53-54). Here, we are shifting toward control as a goal of a science of behavior.

Even when Watson described research on perception and consciousness (e.g., Titchener, 1896), he described it not as the analysis of mental sensations, but in terms of the control of behavior by certain classes of events. Indeed, for Watson, the important benefit derived from research on perception was our increased ability to exercise control over behavior. In other words, the analysis of perception was not a means for demonstrating some sensory or mental characteristic, but a means for discovering what classes of stimuli would cause an organism to react in certain ways. Watson (1914) even went so far as to offer a pragmatic justification for investigating the limits of E. H. Weber's (1795-1878) "Weber's Law" (Weber, 1846/1905):

> Our interest is not psychophysical here but methodological. We need to know for subsequent control of behavior, what difference in intensity one has to maintain between two reds of the same wave-length in order to afford a basis for a difference in response. (p. 35)

Psychology from the Standpoint of A Behaviorist (1919. 1924a 1929). As for Loeb, his influence becomes clearer in Watson's other post-manifesto writings. Loeb, for instance, approached science as a form of engineering, and Watson's writings became increasingly notable for the ease with which they combined descriptions of experimental findings with practical examples of behavioral engineering (see Keller, in press). This is especially clear in the three editions of Watson's *Psychology from the Standpoint of a Behaviorist* (Watson, 1919, 1924a, 1929), his first book for the general public. For example, within the first few pages of the 1924 edition of the book, Watson (1924a) introduced real-life examples such as being late for a bus and the liberalized divorce laws in Scandinavia. If this did not clarify the importance of control in science, Watson also declared that synthesis —which he took to be synonymous with both creation and control— was the "sine qua non of modern science" (p. 2). A few pages later, this message was explicitly reinforced:

> Every scientist feels that he makes progress in his field just to the extent to which he can gain control over the material with which he works —as examples: the harnessing of the tide, protection from lightning by lightning rods, the experimental production of lightning and rain, dissipation of fog. (Watson, 1924a, p. 7).

This reminds us of Mary Shelly and *Frankenstein* (Shelly, 1831/1969). Watson (1924a) continued:

> The psychologist likewise, having chosen human behavior as his material, feels that he makes progress only as he can manipulate or control it. (p. 7)

Watson was also not neglecting prediction. The discovery of procedures that enabled scientists to predict behavior were described as helping solve the two immediate problems facing psychology:

> [a] predicting the probable causal situation or stimulus giving rise to the response; [b] the other, given the situation, of predicting the probable response. (Watson, 1924a, p. 5)

With such knowledge, Watson (1924a) noted, a person could accurately account for behavior such as that of a neighbor who runs to his bus, stops

suddenly, and returns home. Watson defended such ordinary examples on the grounds that psychology must be able to answer questions about everyday behavior. By the mid-1920s, then, psychological research was, for Watson, a means to the end of accounting for behavior in general. For him, psychology made no sense apart from that end:

> Behavioristic psychology attempts to formulate, through systematic observation and experimentation, the generalizations, laws and principles which underlie man's behavior. (Watson, 1924a, p. 5; see also Logue, 1978).

Behaviorism (1924b, 1930). Watson continued to emphasize prediction and control in the 1924 and 1930 editions of his next book, *Behaviorism* (1924b, 1930). Here, he continued to make clear the importance of prediction and control for basic research, as in his comment on some thought experiments:

> In both of these examples I began to manipulate stimuli —*objects* in the environment of my subjects— to find out how I could make them [my subjects] *behave* in a certain way. (Watson, 1930, p. 21)

Overall, however, Watson treated control in a more practical, less conceptual manner than before. His style suggested, for instance, that a great number of everyday problems had been or could be solved, and virtually all of his examples involved analyzing or solving social problems. His descriptions included, for instance, brief analyses of the shortcomings of Prohibition and the new Soviet Government, both as failures to understand how to control behavior (Watson, 1930, p. 42).

Even Watson's (1930, p. 104) infamous "dozen healthy infants" statement in *Behaviorism* was a statement about control.

Here, Watson did not proclaim the superiority of behaviorism In terms of its conceptual strength or the formal elegance of its theoretical statements. Rather, he said that he could take normal, healthy children and teach them to become any kind of professional his audience might select. Although Watson may not have meant this literally, prediction and control were nevertheless fundamental to his point. Relatedly, his statement was a call for critical science. The context in which it appeared was a critique of the non-experimental, rationalistic approach embraced by so many other psychologists (see Todd, in press).

Conclusion

For Watson, the goals of prediction and control shifted somewhat over time, as Watson's interests shifted. In the beginning, prediction and control were a means for understanding behavior as a subject matter; later, they were more a means for social engineering. Watson's interests changed because his career changed and, with this, his audience changed. It changed in the early 1920s from a university and a scientific community to a business community and the culture at large — audiences that sustain quite different contingencies and promote quite different repertoires.

These changes in Watson's emphasis notwithstanding, he maintained an ongoing commitment to prediction and control as the goals of classical behaviorism. Although these goals were not explicitly stated until 1913, they were implicit in Watson's early research, as part of what it was to understand a subject matter in the natural sciences. After 1913, prediction and control melded into his progressive pragmatism, as though the latter were science itself. In either case, the goals of prediction and control were useful in promoting a science of psychology — in promoting it among other scientists and in the public at large, albeit with respectively different emphases. Psychology was not yet dominated by its formalism to come, and the public did not make a clear distinction between science and technology, so a strongly pragmatic viewpoint could be readily embraced whenever and where ever.

Indeed, the critics of classical behaviorism did not much question its goals of prediction and control. They complained, instead, about behaviorism's perceived narrowness of scope —especially its rejection of consciousness — *and* they warned of the possibility that behaviorism might actually succeed. By the time B. F. Skinner identified prediction and control as the goals of his science of behavior, the critics would question all of this — the scope, the success, and the goals of behaviorism. Before turning to Skinner, however, we expand upon the meaning of prediction and control as the goals of behaviorism so as to answer some of the critics. In particular, we clarify where these goals are shallow and deep, and suggest that where behaviorism emphasizes the latter, it approaches something closer to an ordinary-language meaning of "understanding" as the goal of behavior analysis.

Prediction and Control: Toward a Deeper Understanding

The unfortunate legacy of the post-1913 John B. Watson —Watson the social engineer — was that behaviorism's goal of control was seen as only shallow and manipulative. Kerry Buckley's (1989) biography of Watson, *Mechanical Man*, for instance, reflects just this view — the view that behaviorists think behaviorism will be successful only to the degree that behavior can be controlled in the context of social engineering (see Morris, 1991a).

With control so construed, no wonder the critics of behaviorism found (and find) it superficial and frightening (e.g., Black, 1973). But control can serve a broader, deeper, more thoughtful end: It can serve epistemology and then, perhaps later, application. The epistemological sense of control emerges in answers to such questions as: What are the conditions under which we say we "understand" something, for instance, about physics, biology, or behavior? One answer: Often when we can predict it, but better when we can demonstrate experimental control over it through the variables of which it is a function. That is, we understand behavior to the extent to which we know how it works, where knowledge of how it works is derived from its experimental analysis, either basic or applied. This deep sense of understanding is at the heart of the experimental analysis of behavior (see Skinner, 1966). This is not shallow or arbitrary control.

In applied behavior analysis, the distinction between the shallow and deep senses of understanding becomes a distinction between (a) *demonstrating* the effectiveness of behavioral technology in modifying socially important behavior and (b) *discovering* the functions (or causes) of that behavior, followed by changing the variables of which it is a function in order to prevent or remediate it (see Morris, 1991b). Applied behavior analysis tends toward shallow understanding (but sometimes necessary treatment) when it demonstrates and analyzes the effects of behavioral interventions at the expense of analyzing and discovering (and then demonstrating) actual controlling relations.

More generally, the discovery of controlling variables —not mere demonstrations of control— may be necessary for the continued evolution of behavior analysis: The analysis of controlling variables allows the possibility of discovering new facts about behavior (e.g., principles of behavior), as well as variables that generate and maintain behavior of interest to practitioners. Behavior analysis should not overlook this deeper, more fundamental contribution that control can make to how and what we understand about behavior —to our epistemology. In a different way, we elaborate on this point further after our discussion of what Skinner meant by prediction and control, to which we now turn.

B. F. Skinner and Radical Behaviorism

John B. Watson established prediction and control as the goals of classical behaviorism and, as a behaviorist, B. F. Skinner adopted them. At least as early as 1938, Skinner (1938) discussed prediction and control as "one of the objectives of science" (pp. 428-429). Since then, they have become the most commonly stated goals of behavior analysis (Holland & Skinner, 1961, pp. 276-280; Skinner, 1953, pp. 31-36; see Delprato & Midgley, 1992; Hayes & Brownstein, 1986, 1987; Lacey, 1979; Morris, 1992; Reese, 1986; Smith, 1992), some of the others being "description" (e.g., Morris, 1992), "explanation" (e.g., Hayes & Brownstein, 1986), and "interpretation" (e.g., Hayes & Brownstein, 1986; Holland, 1992).

In what follows, we describe Skinner's characterization of prediction and control as the goals of behavior analysis, and in so doing reveal some subtleties and complexities. We attempt to clarify these by explaining how control relates to specialized activities in the three branches of behavior analysis —in basic and applied research and conceptual analysis— and why Skinner emphasized control. We begin with a discussion of prediction.

Prediction

The significance of prediction in behavior analysis may be related to three points emphasized by Skinner (1938, 1966): (a) operant behavior is emitted, not elicited, (b) response probability is the dependent variable in a science of behavior, and (c) response probability and response frequency are related (cf. Espinoza, 1992; Johnson & Morris, 1987). Because operant behavior is not elicited by antecedent stimuli, but emitted, it requires an appropriate metric —something other than those derived from the static laws of respondent behavior (e.g., response latency, response magnitude; see Skinner, 1938, pp. 12-14). In Skinner's (1950) words:

> This solution of the problem of a basic datum is based upon the view that operant behavior is essentially an emissive phenomenon. Latency and magnitude of

> response fail as measures because they do not take this into account. They are concepts appropriate to the field of the reflex, where the all but invariable control exercised by the eliciting stimulus makes the notion of probability of response trivial. (p. 198)

The appropriate metric for operant behavior, then, is response probability which, for "practical" purposes, translates into response frequency (Skinner, 1956, pp. 78-79; 1957a, p. 344). As Skinner (1950) noted:

> It is no accident that rate of responding is successful as a datum, because it is particularly appropriate to the fundamental task of a science of behavior. If we are to predict behavior (and possibly to control it), we must deal with *probability of response*. The business of a science of behavior is to evaluate this probability and explore the conditions that determine it....Rate of responding is not a "measure" of probability but it is the only appropriate datum in a formulation in these terms. (p. 198; emphasis in original).

Given that probability of responding was the dependent variable of interest to Skinner, it is not surprising that he would emphasize prediction —probability and prediction are intimately related (see Johnson & Morris, 1987). Inasmuch as predictions of behavior are derived from or expressed as functional relations (Hayes & Brownstein, 1986, 1987), accurate predictions may have been seen by Skinner as a natural consequence of the experimental analysis of behavior (see, e.g., Skinner, 1938, p. 8).

As for the relation of prediction to control, Skinner said little. We would note, however, that prediction and control are alike in being probabilistic. That is, just as our predictions of behavior are probabilistic, so too are our attempts to control it. As for differences, control —but not prediction— is possible only when the variables of which behavior is a function are manipulable (e.g., Skinner, 1953, pp. 6, 23; 1956b, p. 82; see Hayes & Brownstein, 1986). When they are, control is the preferred alternative. Perhaps for these reasons, Skinner discussed control in considerably more detail (e.g., Skinner, 1947; see Lacey, 1979). We do likewise.

Control

For Skinner, the term "control" was used in two interdependent ways (cf. Lacey, 1979). First, it described a basic assumption about the nature of the

subject matter of behavior analysis. Second, it characterized certain activities in the three branches of behavior analysis. We begin with the subject matter of behavior analysis.

The subject matter. The most rudimentary use of "control" in Skinner's work pertains to the subject matter of behavior analysis —functional relations between response classes and stimulus classes. Here, "control" is not a goal of the science of behavior. Rather, it refers to the function of variables of which behavior, itself, is a function (see Skinner, 1953, p. 31), that is, to variables that control behavior. As Skinner (1983) put it, he used the term control just "as an astronomer might do in speaking of the control exercised by one planet upon another" (p. 338). The significance of this use of "control" is that it emphasized a fundamental assumption about the nature of behavior — that it was lawful and orderly (Skinner, 1959, p. 369). If control, as such, were not a characteristic of behavior, then for Skinner, a science thereof would not be possible.

Skinner (1947) described the relation among this assumption, the science of behavior, and behavior as a subject matter in the following words:

> To have a science of psychology at all, we must adopt the fundamental postulate that human behavior is a lawful datum, ...in other words, that it is completely determined. The genetic constitution of the individual and his personal history to date play a part in this determination. Beyond that, the control rests with the environment. (p. 23; cf. Delprato & Midgley, 1992).

The science: Basic research. Skinner's second use of the term "control" pertained, as we mentioned, not to the variables of which behavior is a function, but to certain activities in the science of behavior — basic and applied research and conceptual analysis. As for basic research (i.e., "the experimental analysis of behavior," see Skinner, 1966), Skinner (1953) noted: Implicit in a functional analysis is the notion of control. When we discover an independent variable which can be controlled, we discover a means of controlling the behavior which is a function of it. This fact is important for theoretical purposes. Proving the validity of a functional relation by an actual demonstration of the effect of one variable upon another is the heart of experimental science. (p. 227) The role played by "control" in basic research, then, is in discovering of abstract functional relations and proving their validity through experimental control and replication. The latter supports the reliability of the functional relations (see Perone, 1991; Sidman, 1960).

The science: Conceptual analysis. As for the place of control in the concep-

tual analysis of behavior — specifically, in theory construction — Skinner (1947) commented:

> A final distinction [between basic and applied research] can now be made. It concerns the use to which the control is put. What the experimental psychologist is up to when he is being essentially experimental is distinguished from other fields of psychology by the fact that he has a special goal. We need not blush to express this in rather general terms. The experimental psychologist is fundamentally interested in *accounting for* behavior, or *explaining* behavior, or in a very broad sense *understanding* behavior [emphasis in original]. (p. 26)

By "accounting for," "explaining," and "understanding behavior," Skinner did not simply mean "the cataloguing of functional relationships" (Skinner 1947, p. 27). If so, then we need not go beyond the use of "control" in basic research — control as the discovery of functional relations and proof of their validity (Skinner, 1953, p. 227). To the contrary, Skinner (1947) argued:

> Behavior can only be satisfactorily understood by going beyond the facts [i.e., functional relations] themselves. What is needed is a theory of behavior. (p. 27)

By "a theory of behavior," Skinner did not, of course, mean a theory based on physiological (or neural), mental (or psychic), or conceptual constructs (Skinner, 1950, 1953, pp. 27-31), but a theory based on units, relations, and abstractions at the level of behavior and environment in interaction (Skinner, 1938, 1947; see Delprato & Midgley, 1992; Schlinger, 1992).

To summarize to this point, the aforementioned uses of the term "control" are all largely interdependent. First, the subject matter of behavior analysis consists of functional relations — relations of control — between response classes and stimulus classes. Second, behavior analysts experimentally discover functional relations and prove their validity by, themselves, controlling the variables of which behavior is a function. And third, the validated functional relations enter into the construction of an inductively-derived theory of behavior.

The science: Applied research. As for the use of the term "control" in applied research (i.e., "applied behavior analysis," see Baer, Wolf, & Risley, 1968), Skinner (1972) pointed out that:

> It is not always easy to maintain a distinction between basic and applied research,...but an important difference lies in the reasons why research is undertaken and supported. The applied researcher is under the influence of a special kind of consequence. He carries on, in part, because he will make someone healthier or wealthier rather than simply wiser. (p. 279)

As in basic research, "control" here refers to the control of behavior by controlling the variables of which behavior is a function. In contrast, applied research is not concerned with abstract functional relations per se, but with preventing and remediating behavior that is of relatively immediate social importance (see Baer et al., 1968, on the "applied" dimension of applied behavior analysis). Although Skinner, himself, was not an applied behavior analyst, the significance of this use of "control" may be gleaned from such books as *Walden Two* (Skinner, 1948), *The Technology of Teaching* (Skinner, 1968), *Beyond Freedom and Dignity* (Skinner, 1971), and *Enjoy Old age* (Skinner & Vaughan, 1983).

Conclusion. This completes our sketch (and some interpretation) of Skinner's comments on prediction and control. It suggests the overly simple conclusion that they are *the* goals of behavior analysis, period. As we mentioned earlier, however, Skinner's views were more subtle and complex than this, which we examine in what follows by considering (a) how control, in particular, is interrelated with work in the three branches of behavior analysis and (b) why control might be identified as a goal of behavior analysis in the first place. We begin by describing how Skinner interrelated control with the three branches of behavior analysis.

General and Specialized Goals of Behavior Analysis

We earlier discussed control in the context of basic and applied research and conceptual analysis. Although never explicitly stated, control could have been construed, in each case, not as an end unto itself, but as a means to an end.

In basic research, for example, control serves the end of discovering and proving the validity of abstract functional relations. In conceptual analysis, it serves the end of constructing a theory of behavior. In applied research, it serves the end of preventing and remediating behavior problems. As Skinner put it: (a) "Proving the validity of a functional relation...is the heart of experimental science" (Skinner, 1953, p. 227), (b) constructing a theory of behavior was "a special goal" of conceptual analysis (Skinner, 1947, p. 26), and (c) preventing and remediating behavior problems was "a special kind of consequence" of applied research (Skinner, 1972, p. 279).

These ends, then, seemingly depict goals of behavior analysis other than prediction and control per se. If so, what then are the goals of behavior analysis: These other goals or prediction and control? One answer lies, we think, in considering control as a *general* goal of behavior analysis. It is a general goal because it is common to each of the discipline's three branches. Inasmuch as these three branches have their own independent purposes, which distinguish them from each other, these can be conceptualized as the *specialized* goals of behavior analysis. Prediction and control, then, are not the sole goals of behavior analysis — not its quintessence. Instead, they serve more subtle and complex — even deeper and broader — ends in behavior analysis.

The Primacy of control. Far from diminishing the importance of control in behavior analysis, these specialized goals help explain why control is identified as a general goal of behavior analysis in the first place. First, if control is a general goal by which basic and applied research and conceptual analysis attain their specialized goals, then Skinner's emphasis on control is easy to understand: Control was emphasized because it is ultimately important. Control is "ultimately" important, however, not in the sense of a "summit" or "pinnacle," but in the sense of a "foundation." Control is the foundation on which the specialized goals of each branch of behavior analysis is built. It is the means by which each branch attains its more specialized goal.

A second reason why control is especially emphasized in behavior analysis lies in the relation between control and the specialized goals of the three branches of behavior analysis —and it raises a point about epistemology. As for basic research, Skinner (1956b) wrote:

> The object [of my research] has been to discover the functional relations which prevail between measurable aspects of behavior and various conditions and events in the life of the organism. The success of such a venture is gauged by the extent to which behavior can, as a result of the relationships discovered, actually be predicted and controlled. (p. 77)

Skinner's comments here support our earlier observation about how control, in general, serves the specialized goals of the three branches of behavior analysis. In this case, control serves the goal of basic research in discovering abstract functional relations (see Skinner, 1953, p. 227). Skinner's comments, however, also suggest that we conceive of control as a means by which to judge the "success" of our having attained the specialized goals of behavior analysis, in this case, our success in proving the validity of abstract functional relations

(Skinner, 1953, p. 227). In basic research, then, control is both a means for discovering abstract functional relations *and* an arbiter of the proof of our having done so (see Sidman, 1960, pp. 135-139). As the latter — control as the arbiter of our having proved the validity of functional relations — control is our truth criterion, which is the epistemological point we said it would raise.

This point is clearer in the conceptual analysis of behavior where, for instance, Skinner (1956b) observed:

> If we have achieved a true scientific understanding of man, we should be able to prove this in the actual prediction and control of his behavior. The experimental practices and the concepts emerging from our research on lower organisms have already been extended in this direction. (p. 79)

Here, Skinner was describing the pragmatic implications of the general goal of control for the specialized goal of theory construction or, in Skinner's ordinary-language term, for "understanding" behavior (see Skinner, 1947, p. 26). That is, an inductively-derived theory or understanding of behavior should lend itself to — and be judged "true" on the basis of how it promotes — generalized or improved control. To paraphrase Skinner (1956b, p. 79) above: If we have constructed a "true" theory of behavior, we should be able to prove this through the further — generalized or improved — control of behavior. Our subsequent ability to predict and control behavior, then, might be said to affirm the "truth" of our theory of behavior.

Conclusion

In conclusion, Skinner did not dogmatically or arbitrarily assert that control was a goal of behavior analysis. He adopted this goal for good rational and empirical reasons. First, the assumption that behavior is controlled follows from the natural science assumption that behavior is lawful and orderly. Second, control is the general foundation on which the more specialized goals of the three branches of behavior analysis are based. And third, control is the criterion against which the specialized goals are evaluated. The last takes us into epistemology again and is consistent with the behavior-analytic "pragmatic theory of truth" (see Smith, 1986; Zuriff, 1980).

Interestingly, these conclusions suggest that prediction and control are not equivalent to "understanding," despite apparent commentary to the con-

trary (e.g., Creel, 1987; Keller, 1973, p. 139). Instead, our interpretations of Skinner's observations about prediction and control suggests the following interrelations among control, theory, and understanding. In basic research, the functional relations enter into the construction of an inductively-derived theory of behavior, where "theory" implies an understanding of behavior (Skinner, 1947, pp. 26-27). A theory of behavior, in turn, provides abstract descriptions or "general expressions" (Skinner, 1947, p. 37) of behavior (e.g., reinforcement) (see Baer et al., 1987, p. 318). Additional and more generalized control follows from a theory based on prediction and control and, thereby, affirms the "truth" of the theory (see Killeen, 1987). Thus, like much of traditional psychology, a theory signifies "understanding" for Skinner. Unlike most of psychology, however, control is both antecedent to and a consequence of a theory of behavior.

Prediction and Control: Toward an Broader Understanding

After describing what prediction and control meant for Watson, we addressed the shallow and deep senses of prediction and control. We suggested that the future of contemporary behaviorism may depend, in part, on our explicating the deeper sense, that is, understanding behavior through the prediction and control of the variables of which it is a function — not just any variable at all.

Now that we have described what prediction and control meant for Skinner, we expand still further. In particular, we extend prediction and control as the goals of behaviorism beyond the behavior of other organisms to our own behavior as scientists. The latter — the relationship between prediction and control and our behavior as scientists — speaks to understanding ourselves as sentient, reflective, and introspective basic and applied researchers and theorists. Here, prediction and control are the basis and the arbiter for understanding our understanding of behavior. We are not trying to be opaque in saying this. Rather, we are simply pointing out that behavior analysts have as rich and varied, and finely and deeply structured, a cognitive and meta-cognitive life as any cognitive psychologist (Baer, 1989).

Understanding "the One"

As far as we know, extending the goals of prediction and control to our behavior as scientists has not been addressed in any behavior-analytic material on prediction and control per se. Skinner, however, did raise the possibility in an observation about the consequences of his engaging in conceptual analysis, in this case, behavioral interpretation. In a 1945 reference to work that would eventually become his book, *Verbal Behavior* (Skinner, 1957b), Skinner (1979) wrote:

> I was *interpreting* a complex field using principles that had been verified under simpler, controlled conditions. Except for certain aspects of the solar system, most of astronomy is interpretation in this sense, its principles being derived from laboratory experiments. I decided to leave out all experimental data. (An interesting question then arose: what survived to reinforce writing or reading the book? Was not confirmation the be-all and end-all of science? It was a question concerning my own behavior, and I thought I had an answer: "February 2, 1945. What was motivational substitute for thing-confirmation? Pretty important in teaching method to graduate students. Resulting *order* instead of *confirmation*?" My reinforcers were the discovery of uniformities, the ordering of confusing data, the resolution of puzzlement.) (p. 282)

Discovering uniformities, ordering confusing data, and resolving puzzlement, then, were among the consequences of effective conceptual analysis for Skinner — and, we would add, among the consequences of effective basic and applied research. This is the stuff of thinking, problem-solving, decision-making, intellectual self-management, and self-control, that is, of predicting and controlling the variables of which our behavior as scientists is a function (see, e.g., Skinner, 1953, pp. 227-294).

In some cases, predicting and controlling our own behavior may directly enhance our effectiveness in predicting and controlling behavior as our subject matter, for example, our strategies and tactics for conducting behavioral research (e.g., deciding on control conditions; see Johnston & Pennypacker, 1992). In other cases, the effects are more indirect, acting through social and professional contingencies in the psychology and sociology of science, for example, solving problems in graphing and presenting data (see Parsonson & Baer, 1978) or exercising self-control over which paper to submit to what journal or professional meeting (Hineline, 1990). In either case, they are part of science as a process (Hull, 1988).

Conclusion

Predicting and controlling our own behavior as scientists broadens the meaning of prediction and control as the goals of behavior analysis. Not only do they apply to understanding the behavior of other organisms, but also to understanding our own behavior. Unfortunately, "prediction and control" per se do not easily capture this meaning, either inside or outside of behavior analysis. Our future may depend, in part then, on our ability to clarify and extend this meaning of prediction and control. It may depend on our more clearly and precisely describing the behavior of behavior analysts doing behavior analysis. That is, our future may depend on our predicting and controlling our own behavior with respect to our subject matter, the final arbiter of which, of course, is the prediction and control of the latter —behavior as our subject matter.

General Conclusion

Among the important debts we owe John B. Watson is his having formalized the goals of classical behaviorism as the prediction and control of behavior, which were carried over into B. F. Skinner's radical behaviorism as the goals of behavior analysis. As we mentioned in our introduction, these goals are subtle and complex, and their meaning was sometimes subject to change. As a consequence, they have been misunderstood and mischaracterized.

We suggest that contemporary behaviorism no longer construe its goals simply as prediction and control per se, but expand on them. First, we need to clarify the shallow and deep senses in which the meanings of prediction and control vary as technology and epistemology, respectively. Second, we need to appreciate where prediction and control are the basis for the more specialized goals of the three branches of behavior analysis, where they are the means by which we pragmatically attain these goals and evaluate our success in doing so. And third, we need to expand on prediction and control further by extending them not just to the behavior of other organisms, but also to our own behavior as scientists.

In all of this, we find that prediction and control address goals more aptly addressed by such ordinary-language terms as "knowing," "understanding," and "explaining." Such self-stated ordinary-language goals may be the goals of the behaviorism that survives the centennial of its founding 20 years hence.

This will be a behaviorism whose goals are both empirical —"prediction and control" — and conceptual — "understanding." But perhaps Ernst Mach (1905/1976) said this first:

> The worth of scientific inquiry can be judged by the extent to which an investigator's behavior really leads to practical and intellectual advantages. (p. 11)

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