B.F. Skinner: A Pioneer of Research and Instructional Technology

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Burrhus Frederic “B. F.” Skinner was born on March 20, 1904 to William and Grace Skinner in Susquehanna, Pennsylvania, where his father worked as a lawyer. His grandmother was evidently a very religious woman and, following an attempt by a Christian teacher to alleviate his fear of his grandmother’s description of hell, Skinner began to think critically of his faith and become an atheist. Aspiring to become a Writer, he attended Hamilton College in Clinton, New York where he became a member of Lambda Chi Alpha Fraternity. Despite this, his ability to socialize with his peers was hampered by his intellectual attitude. (Bjork, 1997) He wrote for the school newspaper, however, as an atheist, he was critical of the school which held in high regard its history and principles of having been founded by missionaries to the Oneida Indians. Unfortunately, it was during Skinner’s time at Hamilton College that his brother Edward, two and a half years his junior, died of a cerebral hemorrhage. As he moved forward with his life, Skinner’s dream of becoming a professional writer did not work out, at least not in the way that he had originally intended. At the age of twenty four, after receiving a B.A. in English Literature from Hamilton College, he applied and was accepted to Harvard University in their Psychology graduate program. However, it was in the Physiology Department at Harvard where Skinner first met William Crozier. (Millis, 2003)

Crozier was a fervent advocate for animal studies and behavioral measures, who later served as editor of The Journal of General Physiology, a peer-reviewed scientific journal published by the Rockefeller University Press. Skinner tailored his studies according to Crozier's highly functional, behaviorist framework. In the psychology department at Harvard, Skinner had also met a fellow student, Fred Keller, who later became a pioneer in experimental psychology and went on to teach at Columbia University, for 26 years, where he developed the Keller Plan. This plan, also called the Personalized System of Instruction (PSI), was developed as an
application of Skinner’s learning theories, rooted in operant conditioning strategies of behaviorism. Early on at Harvard, Keller had convinced Skinner that through the study of behavior, he could create his own experimental science. Skinner joined Keller in creating different tools for their small experiments. This led Skinner to develop the prototype for his operant conditioning chamber which later became known as the “Skinner Box”. In 1930, Skinner received his Masters, and in 1931 he received his PhD, from Harvard University where he remained as a researcher until 1936. He then moved to Minneapolis, where he taught at the University of Minnesota, until 1945 when he moved to Bloomington, Indiana to teach at Indiana University. Skinner served as chair of the Department of Psychology at Indiana University from 1946-1947. Finally Skinner returned to Harvard as a tenured professor in 1948 where he remained until the end of his life. Skinner published and experimented extensively during the 1950s and 60s while working with numerous graduate students, many of whom became noted psychologists in their own right. In 1957, Skinner published his book Verbal Behavior, in which he attempted to account for language development in humans. In his later years, Skinner focused primarily on the social implications of his theories. He died of leukemia on August 18, 1990, and is buried in Mount Auburn Cemetery in Cambridge, Massachusetts. (Bjork, 1997)

The essence of behaviorist learning theory is the idea that all human and animal behavior is determined by learning and reinforcement. With the publication of his article “Psychology as the Behaviorist Views It” in 1913, John Broadus Watson essentially established the psychological school of behaviorism as a reaction to the predominant mentalistic (hypothetical) psychology of the time. Mentalism, or "Classical Mentalism" as it is sometimes called, dates back to the very founding of the field of psychology. The perspective of behaviorism has been concurrently thriving alongside mentalism since the very inception of psychology. (Paivio, 1975)
However, Watson's ideas sparked what some have called a paradigm shift in the world of psychology, allowing behaviorism to begin to capture more attention than classical mentalism. This shift lead to the objective and experimental study of human behavior, rather than the subjective, introspective study of human consciousness. (Sperry, 1993) The idea that psychology should focus on observable behavior rather than the unobservable events that may take place in their minds, is a primary tenant of behaviorism. (Skinner, 1984) While in graduate school at Harvard, Skinner and Keller were both following in the footsteps of Edward Thorndike, who had had been a graduate student at Harvard over thirty years earlier, where he helped pioneer behaviorism through the study of animals and wrote his doctoral dissertation “Animal Intelligence: An Experimental Study of the Associative Processes in Animals”, the first in psychology where the subjects were nonhumans. (Hergenhahn & Olson, 2005) Working across disciplines, Skinner integrated methods and theories from both physiology and psychology in order to develop new ways of recording and analyzing data. Most of his theories were supposed to be based on self-observation, stemming from Thorndike’s Puzzle Box, a direct antecedent to Skinner’s Box. Skinner expanded on Thorndike’s earlier work by introducing the concept of Reinforcement to Thorndike’s Law of Effect. (Bjork, 1997) It is easy to see why Skinner, as an atheist, was attracted to the behaviorist school of thought, considering that it maintains that behaviors can and should be described and understood scientifically, without turning to hypothetical constructs such as beliefs, thoughts, or other internal physiological events. (Baum, 1994) Following Watson in 1913, behaviorism had continued to become the dominant perspective in psychology, advanced by such notables as Ivan Pavlov and Edward Thorndike, until it reached its pinnacle with Skinner in the late 1950s.
Skinner named his particular brand of behaviorism “Radical behaviorism”. Radical behaviorism is the philosophy of the science of behavior. He considered it to be “radical” because it expanded behavioral principles to processes within the organism. Skinner believed that this was in sharp contrast to Watson’s methodological behaviorism, most notably in accepting feelings, states of mind, and introspection as existent and scientifically treatable, with some instances being identified through physiological conditions or behavior, and others getting a more extended “analysis” in terms of behavior. However, radical behaviorism stops short of identifying feelings as causes of behavior. (Skinner, 1984) Skinner believed that all phenomena considered in evaluation must be observable, at least to the individual experiencing them. He contended that regardless of whether it is by classical conditioning or operant conditioning, animal species, including humans, acquire new skills subsequent to the effects these skills have on their surrounding environment. This is illustrated clearly through the use of the Skinner box where the test subject is either rewarded or punished for certain behaviors. Through the experience of positive or negative outcomes from the subject’s behavior, any given organism will choose to either repeat the behavior, or not. Skinner, and other adherents to Stimulus-Response, believed that they could infer a learning history, figuring out what had previously been reinforced, by observing a subject’s current behavior. Conversely, the application of this behavior analysis could be used to determine how to change or modify behavior, especially as a part of a learning or treatment process.

In 1937, Skinner developed operant conditioning which deals with the modification of voluntary or "operant" behavior. Any behavior affecting an individual's environment is considered operant behavior and Skinner contended that this behavior is maintained by its consequences. The core tools of operant conditioning, reinforcement and punishment, are either
positive (delivered following a response), or negative (withdrawn following a response).

Following in the tradition of Thorndike’s Puzzle Box, he created the operant conditioning chamber, or Skinner Box, to test the effects of operant conditioning principles on rats. The main principles of operant conditioning, as defined by Skinner, are reinforcement, punishment, shaping, extinction, discrimination, and generalization. Expanding on the earlier trial and error research from pioneers like Thorndike and Edwin Guthrie, Skinner's empirical work included both conceptual and methodological reformulations. Through this method, Skinner carried out extensive experimental work regarding the rates of operant responses made by rats and pigeons due to the effects of different schedules and rates of reinforcement, achieving remarkable success and training animals to perform large numbers of responses, unexpected responses, and the demonstration of numerous observable regularities at the behavioral level, lending credibility to his conceptual analysis. His conceptual analysis was primarily what made his work much more rigorous than that of his peers'. (Commons, 2001)

Skinner's early experimental work with rats and pigeons, summarized in his books *The Behavior of Organisms* and *Schedules of Reinforcement* had led to his concept of the operant response, an example of which was the rat's lever-press. The concept of reinforcement is central to Behaviorism, and was seen as a key mechanism in the control and shaping of behavior. Skinner's analysis of behavior involved, in part, not only the power of a single instance of reinforcement, but the effects of particular schedules of reinforcement over time. An animal’s behavior patterns, even complex ones, become predictable after reinforcement in controlled surroundings. A schedule of reinforcement is a program or rule that determines when and how the occurrence of a particular response will be followed by the delivery of the reinforcer, and extinction, in which no response is reinforced. Instrumental responses may be learned and
maintained through the influence of schedules of reinforcement. The most notable schedules of reinforcement presented by Skinner were interval (fixed or variable) and ratio (fixed or variable).

In addition to his “operant conditioning chamber”, or “Skinner box”, Skinner tried his hand at inventing several other devices. One of these was his “cumulative recorder”. This instrument was developed to help in recording the data from his experiments by automatically recording the behavior of his subjects graphically. Similar to barographs or seismographs of the time, the graphing mechanism of Skinner’s device consisted of a rotating paper covered drum and a marking needle. The cumulative recorder was used to record the subject’s behavior in the Skinner box and produced accurate and consistent records of behavior. Another unique invention by Skinner was the “air crib”. Although this invention was not successful in attracting many customers commercially, it is estimated that over 300 children were raised in them, including Skinners second child, his daughter Deborah. Conceptually, the crib was intended to keep the child more comfortable and, subsequently, make things easier on the parents. At the time that Skinner and his wife were expecting their second child, they were living in Minnesota and he was concerned about how to deal with the harsh winter temperatures which would traditionally require the child to be wrapped in layers of clothes and blankets to keep it warm. He was concerned that this was not only uncomfortable for the child, and restricted their self-directed movement, but could cause the child to overheat as well. This also required considerable effort on the part of the parents by creating more laundry, constant attention required by the child, and the necessity of frequent bathing of the child. The air crib was designed to alleviate these concerns by allowing the parents to regulate the temperature and humidity of the crib using a control box on the top of the crib while clean air was filtered into the crib from below. The crib design also considered ergonomics by allowing easier access to the child without having to bend
over. However, the common public knowledge of his famous Skinner boxes and their use in scientific experimentation led to a serious perception problem when this crib was seen as a “baby in a box”. This perception problem was compounded by Skinner’s unfortunate use of the word “experiment” to describe the experience, highlighting the tensions of the time between science, technology, and everyday life. Unfortunately, people ignored the potential benefits of the device because they were so worried about the possible negative ramifications. Perhaps one of Skinner’s most forward thinking inventions was the “teaching machine”. Designed as a device to administer curriculum of programmed instruction, this could be seen as a forerunner to the educational computer programs of today. Skinner advocated the use of teaching machines for a broad range of students from preschool aged to adult. One of the supporting arguments for the use of teaching machines and programmed instruction was the fact that these new mediums allowed students to learn at their own pace. However, after reviewing several studies where programmed instruction and teaching machines were used, competition among students was evident. Some students stated that in order to compete amongst their peers for speed, they had to proceed through the program at such a rapid pace that they did not gain an understanding of the material covered. (Carpenter & Fillmer, 1965) There has been a resurgence of interest in the idea of the teaching machine and its relationship to adaptive learning systems of the early 21st Century. One of the most unusual of Skinner’s inventions was the pigeon guided missile. Project Pigeon was conceived of by the US Navy during World War II as a weapon to use against German battleships. The nose cone of the missile was divided into three compartments, each containing a pigeon. In each of the compartments, a lens was used to project an image of what was in front of the missile. The pigeons would then peck at the object and consequently guide the missile toward the target. Despite an effective demonstration, the project was abandoned when
more conventional options, such as the use of radar, became available. Skinner complained “our problem was no one would take us seriously.” (“Skinner's Utopia: Panacea, or Path to Hell?”, 1971) Yet another one of his inventions, similar to an auditory version of Rorschach inkblots, was Skinner’s “verbal summator” was a device for discovering what he called “latent speech”, in other words, to project subconscious thoughts. Skinner used this invention as a tool to create data for his verbal behavior theory.

In the 1950s behaviorists believed that, with the major exception of language, they could explain almost every aspect of human and animal behavior through the association between actions, stimuli, and responses. That is until Skinner published his book, *Verbal Behavior*, in 1957. In this book, Skinner attempts to explain the most complex of all human behaviors: communication. To achieve this, he applied his theory of operant conditioning to the process of learning and comprehending language, including both spoken dialog and internal dialog or thought. The basic concept of this is that all language is a behavior that humans develop through the same process of operant conditioning as any other skill. Skinner believed that sentences are merely a “behavior chain, each element of which provides a conditional stimulus for the production of the succeeding element”. (Fodor, Bever, & Garrett, 1975) He went on to propose that language could be categorized by the way in which it was reinforced. This allowed him to sort speech into five basic types including:

1. **Echoic Behavior** – The primary verbal behavior of language learners, including repeated utterances.
2. **Mand** – Short for “demand”, these are defined as the utterances which are reinforced by deprivation, motivating the behavior of speech asking for the thing the individual is being deprived of, as well as directives such as “stop”, “go”, “wait”, etc.
3. Tact – Short for “contact”, and similar in some ways to “mands”, these are defined as utterances that are produced when the speaker is not being deprived of anything. “Tacts” are verbalizations used to provide information.

4. Interverbals – These include “please” and “thank you” which are not necessary to provide any information. Instead, they pertain to the interaction of the dialog.

5. Autoclitic – With the final category Skinner attempted to deal with internal speech or thought. He believed that these are still subject to the same effects of reinforcement as verbalized speech and that current and future thought, as well as verbal behaviors, are influenced by previously reinforced internal thought behaviors.

Although Skinner’s book, *Verbal Behavior*, was considered a tribute to the behaviorist paradigm, the pervasive psychology of the day, in many ways it created more questions than it answered. In 1959, a critique was published by a then little known linguist at MIT named Noam Chomsky. In a resurgence of the intellectual elitist attitude that had held him back socially in his undergraduate years, he chose not to respond publicly or privately to the issues brought up by this person that he felt was beneath him. This miscalculation, in tandem with the growing dissatisfaction with the behaviorist paradigm and the influence of advancements in technology, computers, and information processing, allowed for the unchecked growth of what became known as the cognitive revolution in psychology and other social sciences. In the broader context, the cognitive revolution was the intellectual movement that began through greater interdisciplinary communication and research in what are now known collectively as the cognitive sciences of psychology, anthropology, and linguistics with approaches developed within the fields of artificial intelligence, computer science, and neuroscience. Through the development and study of successful functions in computer science and artificial intelligence,
cognitive psychology contends that it is then possible to make inferences about human mental processes that are then testable through scientific experimentation.

However, this cognitive revolution was in many ways just a swing of the pendulum back toward mentalism. The advances in neurosciences as well as technology that allowed for the mapping of the brain, among other advances, were critical to the resurgence of consciousness, or the mind, as the focus of psychological inquiry. This allowed mentalism to finally have an objective way to study the mind through scientific experimentation, eliminating the primary criticism that had led to its downfall fifty years earlier. However, Chomsky’s insights did not completely overthrow the behaviorist empire, although the first blow had been struck and behaviorism was forced to either evolve or face complete removal. Ironically, in some ways the reverse engineering approach of cognitive psychology is somewhat similar to the way behaviorists try to infer the conditioned history of an individual by observing their current behavior, often in order to achieve behavior modification through applied behavior analysis. Even though elements of behaviorism, such as cognitive-behaviorist approaches to psychotherapy, still permeate various aspects of modern psychology, the preeminence that behaviorism enjoyed throughout the first half of the twentieth century is now over.

Active learning was favored by Skinner, in the sense that students were not merely passive recipients of information doled out by teachers. Skinner was convinced that students must take action; “to acquire behavior, the student must engage in behavior” (Skinner, 1961) He advocated that teachers must learn how to teach and said that they need only to be taught more effective ways of teaching. Skinner asserted that positive reinforcement is more effective at changing and establishing behavior than punishment. This has obvious implications for the widespread practice of rote learning and punitive discipline in education. In his book, *The
Technology of Teaching, Skinner dedicates a chapter to the reasons teachers fail, basically stating that teachers have not been given an in depth understanding of teaching and learning and without knowing the underlying science of teaching and learning, teachers rely on procedures that work poorly, or do not work. Additionally, Skinner associated punishment with avoidance. He believed, for example, that if a child were forced to practice playing an instrument as a form of seemingly productive discipline, the child would then associate practicing with punishment, and thus learn to hate and avoid practicing the instrument. Consequently, teachers who use educational activities to punish children could inadvertently cause inclinations towards rebellious behavior such as aversion to education or even possibly vandalism. (Holland, 1992)

Although he may not have become the kind of professional writer that he originally aspired to be, Skinner's influence through his literature and ideology on both education and psychology is palpable. According to Skinner, the two major purposes of education are:

1. To teach both verbal and nonverbal repertoires of behavior.
2. To the display of interest in instruction by the students.

Popularly, Skinner is known for his books Walden Two and Beyond Freedom and Dignity which landed him on the cover of Time Magazine in 1971. Like Thoreau’s Walden, Skinner’s Walden Two heralds an idealistic lifestyle that does not foster competition, social strife, or war. The book champions a lifestyle of personal happiness, minimal consumption, rich social relationships, satisfying work and leisure. The fictional, experimental community described in the book is set in the United States of the 1940s, where the citizens’ productivity and happiness are much better than that of the outside world due to their raising their children using operant conditioning and their practice of scientific social planning. In his book Beyond Freedom and Dignity, Skinner
proposes that free will is an illusion and that we might use the technology of behavior to help create a better society. However, we would need to accept his supposition that free will and the moral autonomy of the individual (Skinner refers to this as “dignity”) hinders our ability to use scientific methods to modify behavior in order to build a better organized and happier society through what Skinner called “cultural engineering”. “In the traditional view, a person is free. He is autonomous in the sense that his behavior is uncaused. He can therefore be held responsible for what he does and justly punished if he offends. That view, together with its associated practices, must be re-examined when a scientific analysis reveals unsuspected controlling relations between behavior and environment.” (Skinner, 1971) Some may be shocked or surprised by his view since it seems to overlook, or intentionally ignore, the traditional view of human consciousness or soul. However, we must remind ourselves that this perspective is not out of step with Skinner’s adherence to atheism. “The picture which emerges from a scientific analysis is not of a body with a person inside, but of a body which is a person in the sense that it displays a complex repertoire of behavior. . . . What is being abolished is autonomous man — the inner man, the homunculus, the possessing demon, the man defended by the literatures of freedom and dignity. His abolition has long been overdue. . . . Science does not dehumanize man, it de-homunculizes him.” (Skinner, 1971)
References


