JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 2004, **82,** 317–328 NUMBER 3 (NOVEMBER)

A DAY OF GREAT ILLUMINATION: B. F. SKINNER'S DISCOVERY *OF SHAPING*

GAIL B. PETERSON

UNIVERSITY OF MINNESOTA—TWIN CITIES

Despite the seminal studies of response differentiation by the method of successive approximation detailed in chapter 8 of *The Behavior of Organisms* (1938), B. F. Skinner never actually shaped an operant response by hand until a memorable incident of startling serendipity on the top floor of a flour mill in Minneapolis in 1943. That occasion appears to have been a genuine eureka experience for Skinner, causing him to appreciate as never before the significance of reinforcement mediated by biological connections with the animate social environment, as opposed to purely mechanical connections with the inanimate physical environment. This insight stimulated him to coin a new term (shaping), and also led directly to a shift in his perspective on verbal behavior from an emphasis on antecedents and molecular topographical details to an emphasis on consequences and more molar, functional properties in which the social dyad inherent to the shaping process became the definitive property of verbal behavior. Moreover, the insight seems to have emboldened Skinner to explore the greater implications of his behaviorism for human behavior writ large, an enterprise that characterized the bulk of his post-World War II scholarship.

Key words: Skinner, shaping, mediated reinforcement, verbal behavior

Most, if not all, *JEAB* readers are familiar with the story of B. F. Skinner's venture into the world of weapon-systems design and development during World War II (cf. Skinner, 1960). To pursue that wartime research project, Skinner took a 1-year leave of absence from his duties on the faculty of the University of Minnesota and moved his workplace off campus to a secret laboratory provided by General Mills, Inc. Figure 1 is a photograph from that time that shows the large Gold Medal Flour railroad yard and flour-milling complex in downtown Minneapolis immediately adjacent to St. Anthony Falls on the Mississippi River. Skinner's lab was located in the half-floor space at the top of the building holding the large water tanks in the upper center portion of the photo, on the same level on which the gigantic sign saying ''Eventually'' was mounted. The photograph of Skinner (see Figure 2) shows him standing on the roof just outside his top floor lab, with some of the script of Eventually (in reverse) visible above and behind him. (Eventually referred to Gold Medal Flour's popular marketing slogan of that era: ''Eventually you will use Gold Medal Flour, so why not now?'' In response, rival Pillsbury Mills, located directly across the river, adopted as their marketing slogan: ''Because Pillsbury's Best!'').

Much less well known than the Project Pigeon story, however, is a smaller but ultimately more important story within that story: Skinner's discovery of what he later dubbed *shaping,* and the impact that discovery had on his outlook on the determinants of complex human behavior. The purpose of this article is to tell that inside story.

Rather remarkably often in his various writings over the years (e.g., 1958, 1972, 1979, 1983), Skinner recounted the following incident:

> In 1943 Keller Breland, Norman Guttman, and I were working on a war-time project sponsored by General Mills, Inc. Our laboratory was the top floor of a flour mill in Minneapolis, where we spent a good deal of time waiting for decisions to be made in Washington. All day long, around the mill, wheeled great flocks of pigeons. They were easily snared on the window sills and proved to be an irresistible supply of experimental subjects. . . . This was serious research, but we had our lighter moments. One day we decided to teach a pigeon to bowl. The pigeon was to send a wooden ball down a miniature alley toward a set of toy pins by swiping the ball with a sharp

An earlier version of this essay appeared under the title ''The Discovery of Shaping, or B. F. Skinner's Big Surprise'' in *The Clicker Journal: The Magazine for Animal Trainers,* Issue # 43 (July/August 2000), pp. 6–13. That version is also available on the website of the Cambridge Center for Behavioral Studies, www.behavior.org. I am especially grateful to my colleague Edward K. Morris of the University of Kansas and to the Harvard University Archives for providing me with copies of the Schrader/Skinner correspondence presented in this article.

Reprint requests should be addressed to Gail B. Peterson, 75 East River Road, Minneapolis, Minnesota 55455 (e-mail: peter004@umn.edu).

Fig. 1. The General Mills, Inc., railroad yard and Gold Medal Flour milling complex in Minneapolis circa 1943. B. F. Skinner's wartime laboratory was located in the half-floor space immediately beneath the large water tanks on the top story of the building marked by the ''Eventually'' sign in the top center part of the picture. (Photo courtesy of the Minnesota Historical Society.)

> sideward movement of the beak. To condition the response, we put the ball on the floor of an experimental box and prepared to operate the food-magazine as soon as the first swipe occurred. But nothing happened. Though we had all the time in the world, we grew tired of waiting. We decided to reinforce any response which had the slightest resemblance to a swipe—perhaps, at first, merely the behavior of looking at the ball—and then to select responses which more closely approximated the final form. The result amazed us. In a few minutes, the ball was caroming off the walls of the box as if the pigeon had been a champion squash player. The spectacle so impressed Keller Breland that he gave up a promising career in psychology and went into the commercial production of behavior. (1958, p. 94)

This anecdote is only mildly interesting in its own right. It is somewhat amusing, for example, to imagine the great and famous B. F. Skinner and two of his most prominent students snaring pigeons from the window sills of a flour mill and taking time to teach one of them to bowl. However, there is also something tantalizingly intriguing in Skinner's exposition here that makes this story potentially more significant: ''The result,'' he wrote, ''amazed us.'' Why? Why should they have been *amazed* by what had happened? And why was it that the ''spectacle so impressed Keller Breland that he gave up a promising career in psychology and went into the commercial production of behavior''?

The questions above are prompted by at least three considerations. First, note that the occasion Skinner describes here occurred in 1943, 5 years *after* the publication of *The Behavior of Organisms* (1938). That book had

Fig. 2. B. F. Skinner standing on the roof of the General Mills Utility Building, just outside his wartime laboratory. The script of the "Eventually" sign (see Figure 1) is visible behind him. (Photo courtesy of Robert Bailey.)

contained a whole chapter (chapter 8) on "The differentiation of a response" in which Skinner had described the results of his experiments using the method of successive approximation to develop differentiated operant lever-pressing behavior in rats. In that work he had found that, when he gradually increased response force or duration requirements, the rat pressed more forcefully or held the lever down longer, respectively. Wasn't that shaping? Of course it was. But why, then, was he so amazed by what he saw in the bowling pigeon in 1943? One might understand his being impressed in 1933, 10 years earlier, when he was still in the process of discovering the basic principles of operant conditioning. But 1943?

Second, even before the publication of *The Behavior of Organisms,* Skinner had been involved in an historic academic exchange with Konorski and Miller over whether operant conditioning was distinctively different from respondent conditioning (Konorski & Miller, 1937; Miller & Konorski, 1928, 1969; Skinner 1935, 1937). Part of that exchange included Skinner's vivid description of what sounds like the process of hand shaping a rat's lever-press response:

> But elaborate and peculiar forms of response may be generated from undifferentiated operant behavior through successive approximation to a final form. This is sometimes true of the example of pressing the lever. A rat may be found (very infrequently) not to press the lever spontaneously during a prolonged period of observation. The response in its final form may be obtained by basing the reinforcement upon the following steps in succession: approach to the site of the lever, lifting the nose into the air toward the lever, lifting the fore-part of the body into the air, touching the lever with the feet, and pressing the lever downward. When one step has been conditioned, the reinforcement is withdrawn and made contingent upon the next. (1937, p. 277)

This sounds like the description of an actual, empirical event. But if Skinner had never actually shaped a behavior by hand until 1943, then this description in the 1937 article must have been entirely speculative. As we shall see, that, indeed, appears to be the case.

The third thing that makes his expression of surprise at this 1943 event intriguing is the fact that the power of positive reinforcement for creating unlikely behavioral performances by an animal had already been widely publicized in a 1937 story in *Life* magazine about Skinner's lab rat Pliny. Skinner had trained Pliny to perform a behavior chain consisting of:

> . . . pulling a string to obtain a marble from a rack, picking the marble up with the forepaws, lifting it to the top of the tube, and dropping it inside. Every step in the process had to be worked out through a series of approximations, since the component responses were not in the original repertoire of the rat. (1938, p. 340)

Skinner characterized this demonstration with Pliny as a tour de force of operant con-

ditioning. Surely he had used shaping in training Pliny—hadn't he? In fact, hadn't he said as much? True, he hadn't actually used the word shaping, but surely that is what he meant when he described the behavior as having been "worked out through a series of approximations"? If so, why, then, was he so amazed years later when he trained a pigeon to perform a very similar but considerably simpler behavior?

Hints at answers to some of these questions are contained in one of Skinner's other renderings of the story:

> Possibly our most impressive experiment concerned the shaping of behavior. I had used successive approximation in my experiments on the force and duration of lever-pressing, and we had seen how important it was in teaching a pigeon to peck hard. Pliny's complex behavior had been put together step by step by making slight changes in the apparatus. But one exciting day on the top floor of that flour mill we programmed contingencies by hand.
>
> We put a pigeon in a large cardboard carton, on one wall of which was a food dispenser operated by a hand switch. We put a wooden ball the size of a Ping-Pong ball on the floor and undertook to teach the pigeon to knock it about the box. We began by reinforcing merely looking at the ball, then moving the head toward it, then making contact with it, and eventually knocking it to one side with a swiping motion. The pigeon was soon batting the ball about the box like a squash player. We had shaped a very complex topography of behavior through successive approximation in a matter of minutes, and we "gazed at one another in wild surmise."
>
> I remember that day as one of great illumination. We had discovered how much easier it was to shape behavior by hand than by changing a mechanical device. (1979, p. 268)

Again, very emphatic and, indeed, dramatic language: "Possibly our most impressive experiment" from among many innovative techniques explored during Project Pigeon; "we 'gazed at one another in wild surmise,'" a literary allusion to John Keats' famous 1816 sonnet *On First Looking into Chapman's Homer* exalting the exhilaration that accompanies pioneering exploration and great discovery; and "I remember that day as one of great illumination," a significant statement indeed coming from a man whose career was characterized by many penetrating insights.

A description of the same event in another piece provides further clarification:

> I well remember the day when Norman Guttman, Keller Breland, and I discovered how wrong all this [making small changes in the physical environment in order to implement a program of successive approximation] was by dispensing with the mechanical contingencies and reinforcing successive approximations to a complex response by hand. By operating a food dispenser with a hand switch we taught a pigeon to strike a wooden ball with a swiping motion of its beak and to knock the ball about its cage, rather in the manner of a squash player. Shaping complex behavior through a programmed sequence of contingencies is now so commonplace that it is hard to understand why we should have been amazed at the speed with which this was done. (1972, p. 3)

This particular passage makes two points about Skinner's illuminating surprise: it revolved around (a) the efficacy of implementing a program of successive approximation by simply watching the animal and operating the reinforcement-delivery device *by hand,* rather than making small mechanical adjustments of the physical environment, as he had always done before, and (b) the rapidity with which dramatic changes in response topography can be brought about when one does this. In addition, it validates the bewilderment contemporary readers might have at the fact that he was so surprised that day in 1943; in hindsight, Skinner himself admitted that "it is hard to understand why we should have been amazed."

Evidently, then, it was the efficacy and efficiency of free-form shaping by hand that had amazed Skinner and company. But that implies that, despite all the lever- pressing experiments he had performed with rats between 1930 and 1943, he had never actually shaped a behavior by hand before that fateful day in the flour mill. Could that be true? It appears that it well may be. Close reading of Skinner's biography reveals that, yes, indeed, it is most likely the case that, in his 1937 "reply" to Konorski and Miller, the description of how one could go about shaping lever pressing by a rat had been purely hypothetical. In commenting on the matter some 40 years later, Skinner confessed:

> I do not remember actually shaping lever-

> pressing in such explicit stages, but I was sure it could be done, and I had certainly changed the ''value of a single property'' through successive approximation in producing very forceful responses. (1979, p. 185)

The final set of historical texts consistent with the main thesis of this article has been uncovered only recently. Shortly after I had submitted the original draft of this manuscript to *JEAB,* Professor Edward Morris of the University of Kansas sent me copies of two interesting letters he had come across inadvertently this past spring while perusing the historical material on Skinner held by the Harvard University Archives. Aware of my earlier research on this story, he immediately recognized these documents as being directly pertinent. They are reproduced here in Figures 3 and 4.

A brief correspondence was initiated in the spring of 1965 by a Miss Peggy Schrader, then an undergraduate at Illinois State University. Her letter (Figure 3) reads:

> 4/5/65
>
> Dear Dr. Skinner,
>
> I am a beginning student of psychology. Right now I am being overwhelmed by the thought of all I have to learn before I will know a little about the subject. There is a small question, though, that has gotten me to thinking and wondering so much that I cannot wait to learn the answer.
>
> My professor used your experiments with teaching pigeons to bowl as an example in a recent lecture. I later realized that this was the earliest use of successive approximations as such that I had heard of so I ran up to his office and asked him if this was the first experimental use of the technique. He wasn't certain but referred me to several articles such as the one written by you in the American Psychologist in 1958. My curiosity has not yet been satisfied. Could you please tell me—or tell my professor so that he can tell me—whether successive approximations were first used as an experimental technique in 1943. My professor is:
>
> Dr. Walter H. Friedhoff
> Professor of Psychology
> Illinois State University
> Normal, Illinois, 61761
>
> Thank you very much.
> Sincerely,
> Peggy Schrader
> 402 Broadway
> Normal, Illinois, 61761

Skinner responded to Peggy within the week (see Figure 4):

> Dear Miss Schrader:
>
> The date 1943 is, I think, correct for the first deliberate use of successive approximation. I assume that the article you mention is the enclosed. The description of our experience with a pigeon there is, I think, accurate.
> Sincerely yours,
> B. F. Skinner

Clearly, Peggy Schrader was an unusually astute student, as well as a charmingly concise and meticulous letter writer. She obviously recognized something that appears to have been largely overlooked and underappreciated by academic psychologists, including dedicated Skinner aficionados. Strictly speaking, however, the 1943 occasion was not ''the earliest use of successive approximations as such,'' given the work with Pliny and the studies of response differentiation noted above. However, it very likely truly was the earliest use of free-form hand shaping, as such, by an academic psychologist. In this connection, Skinner's qualifying the occasion as ''the first deliberate use of successive approximation'' is, I think, significant given conventional definitions of the adjective *deliberate,* that is, carefully weighed or considered, studied, intentional, careful or slow in deciding, steady in movement or action, slow and even, unhurried.

Thus it appears that neither the lever pressing by rats in *Behavior of Organisms* nor Pliny's behaviors had been shaped *by hand.* All that pre-1943 behavior, including Pliny's complex repertoire, had come about purely as a result of the way the physical environment had been set up, together with contingencies controlled by mechanical and electrical programming apparatus. Skinner had taken a completely hands-off approach in all that early work. The first real hands-on shaping was that day in the flour mill.

Frankly, this isn't all that hard to believe. As we all know, in his early writings Skinner often characterized operant behavior as behavior that is *spontaneously emitted,* as opposed to being *elicited* by antecedent stimuli in the environment. On this spontaneous emission view, a given operant was conceived as having some natural base rate of occurrence (the *operant level*) prior to that rate being modified

Illinois State University
Normal, Illinois

4/3/65

Dear Dr. Skinner,

I am a beginning student of psychology. Right now I am being overwhelmed by the thought of all I have to learn before I will know a little about the subject. There is a small question, though, that has gotten me to thinking and wondering so much that I cannot wait to learn the answer.

My professor used your experiments with teaching pigeons to bowl as an example in a recent lecture. I later realized that this was the earliest use of successive approximations as such that I had heard of so I am going to his office and asked him if this was the first experimental use of the technique. He was certainly not referring me to several articles such as the one written by you in the American Psychologist in 1958. My curiosity has not yet been satisfied. Could you please tell me — or tell my professor so that he can tell me — whether successive approximations were first used as an experimental technique in 1943. My professor is:

Dr. Walter W. Swidhoff
Professor of Psychology
Illinois State University
Normal, Illinois, 61761

Thank you very much.

Sincerely,
Peggy Schrader
102 Broadway
Normal, Illinois, 61761

Fig. 3. Illinois State University student Peggy Schrader's April 1965 letter to B. F. Skinner inquiring about the first use of the successive approximations technique. (Courtesy of Edward K. Morris and the Harvard University Archives.)

April 9, 1965

Miss Peggy Schrader
402 Broadway
Normal, Illinois 61761

Dear Miss Schrader:

The date 1943 is, I think, correct for the first deliberate use of successive approximation. I assume that the article you mention is the enclosed. The description of our experience with a pigeon there is, I think, accurate.

Sincerely yours,

B. F. Skinner

BFS:su
Enclosure

Fig. 4. The unsigned file copy Skinner retained of his reply to Peggy Schrader. (Courtesy of Edward K. Morris and the Harvard University Archives.)

by response consequences. The operant level may be very low, on this view, but it's never zero. If one waits long enough, to paraphrase the old Gold Medal Flour slogan, eventually, a response will be emitted. In this connection, recall Skinner's description of the situation immediately preceding the decision to do hand shaping that day in the flour mill: "Though we had all the time in the world, we grew tired of waiting." The classic lab rat lever-pressing operant conforms quite nicely to this spontaneous-emission formulation. In actual lab practice, as opposed to instructional lab exercises, it is virtually never necessary

to shape lever pressing in a rat. A magazine-trained but otherwise naive lab rat will begin to press a lever quite nicely on its own if it simply is put in the box with the control apparatus programmed on a fixed-ratio 1 schedule. And that's the way Skinner used to do it. Thus it is well within the realm of possibility that seeing that pigeon knock that little wooden bowling ball around that day in 1943 was, in fact, the first time that Skinner or anyone else in the history of academic psychology had seen behavior *shaped by hand and had recognized the significance of the observation*. And the significance of the observation went beyond the speed and efficiency that Skinner explicitly noted above: also brought into sudden and sharp relief was the potential of the social dyad as an unusually effective medium of operant conditioning.

But surely behavior had been shaped by hand before. Yes, one would certainly think so. Indeed, even Skinner seems to have thought so. In reflecting critically on his apparent discovery of hand shaping, he commented that ''Thorndike had shaped the behavior of a cat by hand'' (1979, p. 268). However, unless Thorndike related something to that effect to Skinner personally when he visited Skinner's lab during the 1937 APA convention on the University of Minnesota campus, there is little reason for Skinner to have thought that Thorndike had ever done any actual shaping. To be sure, Thorndike may have administered reinforcing consequences by hand (he did not have the benefit of electrical control apparatus), and perhaps that's what Skinner was referring to, but delivering reinforcers by hand does not, in and of itself, qualify as shaping. Furthermore, close reading of Thorndike's classic work (1911) finds no description of his genuinely shaping the behavior of cats to any purpose. Also, because his dependent variable was response latency, Thorndike's cats were required to make the full response (e.g., operating a latch) from the beginning of training, trial after trial. Response topographies may well have changed as the latencies decreased, but not because Thorndike was watching and deliberately reinforcing selected variations. The closest thing to hand shaping Thorndike appears to have done was the method he used to tame his monkeys:

> In getting them so that they would let themselves be handled it was of almost no service to take them and feed them while holding them or otherwise make that state pleasant for them. By far the best way is to wait patiently till they do come near, then feed them; wait patiently till they do take hold of your arm, then feed them. If you do take them and hold them partly by force, you must feed them only when they are comparatively still. In short, in taming them one comes unconsciously to adopt the method of rewarding certain of their impulses rather than certain *conditions* which might be associated in their minds with ideas, had they such. (p. 234)

Mazes and straight runways would be even less likely to call for hand shaping than Thorndike's puzzle boxes, and therefore it is understandable why one finds no description of a shaping process in the early writings of Tolman or Hull. It is worth noting, however, that Hull (1943) was much impressed by Skinner's experiments on the differentiation of lever pressing force, replicating those studies and relating the findings to his concept of behavior oscillation. And in his 1952 book, Hull devoted an entire chapter to the theoretical problem of response differentiation, again relying considerably on Skinner's work on response force and also on the Pliny demonstration, concluding that chapter with the statement:

> . . . the principles of behavior oscillation and correlated reinforcement as stated in the preceding paragraph have yielded an understanding of how *needed novel acts never previously performed may come into existence* so that their reinforcement may occur in the conventional manner, a problem that has greatly disturbed some theorists. (p. 214)

Thus Hull obviously appreciated the theoretical significance of response shaping for the genesis of new behavior (cf. Logan, 1959, pp. 339–348), but nowhere in Hull's writings or in the writings of the other classic early learning theorists does one encounter a description of hand shaping and the significance of the dyadic process it entails.

Although the concept of response shaping may have gone unappreciated by academic psychologists until the middle of the 20th century, people had no doubt shaped one another's behavior as well as that of their ''beasts'' for eons prior to that time. Burch

and Pickel (1990), for example, have noted the early work of the German dog trainer Colonel Konrad Most (1910/1954) and its anticipation of many modern operant conditioning concepts, including shaping. In *Abrichtung des Hundes: Individuell und ohne Strafen* (1910), which translates as ''The Training of Dogs: Individually and without punishments'' (the subtitle prophetically emblematic of Skinner's future approach), Most described both response prompting and shaping, as this excerpt from the 1954 translation clearly shows:

> . . . In providing it [a physical response prompt] the trainer will find his best chance to give rein to the most exuberant expression of the warmth of his feelings. He ought, as soon as the required act is performed and also when even the slightest progress is apparent, not only to utter such words as ''good boy'' repeatedly in caressing tones, and fondle the dog, but also, if the exercise in hand permits it, to execute a dance of joy with the animal. . . . All the physical movements which excite a dog's instinct to play are capable of arousing the utmost delight in him. (pp. 33–34)

Evidence of an intuitive understanding and application of shaping can be found in the writings of early popular authors as well. For example, in his novel *White Fang,* Jack London (1906) referred to ''the plasticity of his clay, of his capacity for being moulded by the pressure of the environment'' (p. 143) as he described the behavior of the story's main character, the wolf dog White Fang. London also provided a clear, detailed, and extended description in that book (pp. 164–170) of what we today would call systematic desensitization.

Thus the essential elements of hand shaping had been described both in popular fiction and in technical manuals prior to 1943, and the method had no doubt been employed pragmatically by at least some of our ancestors for millennia. But it is one thing for a phenomenon to occur in nature, be observed, and even be exploited deliberately, and quite another for it to be recognized as something of fundamental scientific significance. For example, people certainly knew that response consequences affect behavior long before Thorndike formulated the Law of Effect; surely no one has ever been surprised to hear that rewards strengthen behavior. What was unappreciated, however, was how this simple fact could be employed to account for an enormous volume of behavior in a wide range of species. That's what Thorndike was the first to recognize. Similarly, it was the scientific significance of direct shaping, both theoretical and practical, that Skinner appears to have been the first to recognize.

As discussed in more detail below, Skinner's *discovery* that day in the flour mill appears to have been very much a personal intellectual watershed for him. He obviously saw it as something special because he adopted a new term for it: *shaping*. He had used the term *successive approximation* before (for the first time in the ''Reply to Konorski & Miller'' paper, 1937) as well as the phrase *differentiation of a response,* but he never once used the word shaping until after that ''day of great illumination.'' The word does not appear anywhere in *The Behavior of Organisms*[1], nor can it be found in any other papers by Skinner prior to 1951. Although he never said so, the term may have been suggested to him by his reading of J. B. Watson's *Behaviorism* (1930, e.g., pp. 98, 102). In any event, the first time it appears in the literature of modern psychology denoting the specific process of behavior-change we all associate with it today was in Skinner's little 1951 *Scientific American* article titled ''How to Teach Animals'':

> The reinforcement gives you a means of control over the behavior of the animal. It rests on the simple principle that whenever something reinforces a particular activity of an organism, it increases the chances that the organism will repeat that behavior. *This makes it possible to shape an animal's behavior almost as a sculptor shapes a lump of clay* [italics added]. There is, of course, nothing new in this principle. What is new is a better understanding of the conditions under which reinforcement works best. (pp. 26–27)

It is irresistible to conclude that Skinner decided a special term was in order for what he had observed up there in the flour mill,

[1] Skeptical readers will probably doubt this assertion and immediately consult their copies of *Behavior of Organisms,* where they will find the word ''shaping'' on p. xiv in the Preface to the Seventh Printing. But this is the only place in the book where the word appears, and this preface was written in 1966, 28 years after the original publication and 23 years after the episode in the flour mill.

one that would suggest a distinction between the process of behavioral elaboration directed by constraints in the physical environment with mechanical connections to sources of reinforcement from behavioral elaboration directed by the social environment, a parent, a teacher, a trainer, a therapist, who controlled reinforcer delivery. His analogy with the behavior of a sculptor, a creative artist, conveys a hint of this, and he employed that metaphor again later and at greater length (cf., Skinner, 1953). The inanimate, physical environment can correctly be said to shape behavior, of course, and indeed it does. But the most complex repertoires are those that are shaped by the social environment, by other living, breathing, behaving creatures. It was this special dynamic that struck Skinner like a bolt from the blue that day in 1943, and it turned his attention to the analysis of complex human behavior to a significantly greater extent than before.

For example, there was a definite shift in Skinner's approach to verbal behavior after the ''day of great illumination.'' He had been interested in the psychology of language and literature since very early on, had created and taught a special course on it, and had published some novel analytical and empirical studies of it (Skinner, 1936, 1939, 1942). But his initial approach to the analysis of verbal behavior now seems uncharacteristically statistical and molecular for Skinner. It focused almost exclusively on the role of antecedent events and on the frequencies of certain topographies of response (e.g., the frequency of a specific consonant in a line of poetry). Concern with base rates and what we would today probably call *behavioral momentum* predominate in those Shakespeare and Swinburne studies, for example, but there's absolutely nothing in them about the role of social reinforcement. Much the same can be said for the verbal summator work. And, as Bjork (1993) has cogently pointed out, Skinner's early course on the psychology of literature was actually more psychoanalytic than behavior-analytic. Although the concept of multiple causation continued to figure prominently in his overall analysis of verbal behavior, the role of consequences and contingencies of reinforcement in verbal behavior became much more important after 1943.

Skinner began concentrated effort on his manuscript on verbal behavior under the auspices of a Guggenheim Fellowship in 1944, which then became the William James Lectures at Harvard in 1947, and from there evolved into *Science and Human Behavior* (1953) and ultimately his 1957 treatise *Verbal Behavior.* Reinforcement by other people became definitive of verbal behavior. ''Verbal behavior always involves social reinforcement and derives its characteristic properties from this fact'' (Skinner, 1953, p. 299). In *Verbal Behavior,* Skinner defined verbal behavior generically as ''behavior shaped and maintained by mediated consequences'' (p. 2). (Please note the conspicuous presence of the S-word in the preceding quotation.) By *mediated consequences,* of course, he meant consequences controlled by another person, as was the case, for the first time, in the bowling pigeon episode in the flour mill. The social mediation of the reinforcement process became the primary defining factor whereas all other aspects became secondary:

> In defining verbal behavior as behavior reinforced through the mediation of other persons we do not, and cannot, specify any one form, mode, or medium. Any movement capable of affecting another organism may be verbal. (1957, p. 14)

The definitiveness of the dyadic interaction was given further emphasis when he wrote of ''the behavior of a speaker'' and ''the behavior of a listener,'' the two most fundamental aspects of ''the total verbal episode'':

> In explaining the behavior of the speaker we assume a listener who will reinforce his behavior in certain ways. In accounting for the behavior of the listener we assume a speaker whose behavior bears a certain relation to environmental conditions. The interchanges between them must explain all the conditions thus assumed. The account of the whole episode is then complete. (1957, p. 34)

Thus the behavior of the speaker is shaped by reinforcers administered by the listener, just as the behavior of the bowling pigeon was shaped by Skinner or Breland or Guttman or whichever one of them it was who operated the feeder. At the same time, the behavior of the speaker changes the immediate environment of the listener so as to set the occasion for the listener's behavior of presenting the reinforcer, just as that pigeon's successive ap-

proximations to pecking the ball had set the occasion for the shaper to operate the feeder. All the controlling variables of the behavioral episode were encapsulated in this dyadic interaction or ''interchange.'' The scientific account was complete, its potential scope monumental. No wonder they ''gazed at one another in wild surmise.''

But, it seems reasonable to ask, did the flour mill episode really prompt a major shift in Skinner's perspective on verbal behavior, or is this merely a fanciful suggestion derived from a wily assemblage of selected historical tidbits? In his own words:

> The techniques of shaping behavior and of bringing it under stimulus control which can be traced, as I have suggested elsewhere, to a memorable episode on the top floor of that flour mill in Minneapolis needed only a detailed reformulation of verbal behavior to be directly applicable to education. (1960, p. 37)

Skinner was an erudite etymologist and a meticulous writer. He chose his words and crafted his sentences carefully. Please note that, in the quotation above, he did *not* say the techniques of shaping behavior and bringing it under stimulus control ''needed only to be incorporated into my existing formulation of verbal behavior''; he said they ''needed only *a detailed reformulation* [italics added] of verbal behavior.'' And in that reformulation of verbal behavior, the dyadic interchange inherent to the shaping process became the central and defining feature.

Skinner's insightful appreciation of the ubiquity and power of socially mediated consequences of behavior did more than prompt him to reformulate and finally publish his account of human verbal behavior. It also emboldened him to extend the basic concepts of operant conditioning from the behavior of rats and pigeons in the laboratory to the behavior of people writ large. He had been quite reticent on this front prior to the discovery of shaping. Aside from a few, extremely cautious statements in the closing pages of *The Behavior of Organisms* (1938, pp. 441–442), Skinner unapologetically confined his analysis to the lever pressing of his rats: ''The book presents nothing more than an experimental analysis of a representative sample of behavior. Let him extrapolate who will'' (p. 442). But following the 1943 episode in the flour mill came large extrapolations in the form of *Walden Two* (1948), *Science and Human Behavior* (1953), and *Verbal Behavior* (1957). In the preface of the second printing (1976) of *Walden Two,* in commenting on his outlook in 1945 following the end of the war, Skinner wrote: ''In *Behavior of Organisms,* published 7 years earlier, I had refused to apply my results outside the laboratory'' (p. v). His policy on this changed dramatically after World War II, with most of the rest of his career being devoted to extensions outside the laboratory to the behavior of people as individuals, groups, societies, and cultures. He became the champion of the cause for extending the principles of behavior analysis to the betterment of the human condition on personal, local, national, and global scales. In commenting on *Walden Two* as well as in closing his account of Project Pigeon, Skinner wrote:

> I still believe the same kind of wide-ranging speculation about human affairs, supported by studies of compensating rigor, will make a substantial contribution toward that world of the future in which, among other things, there will be no need for guided missiles. (1960, p. 37)

Skinner's ingenuity as an inventor, creative gadgeteer, and classic bench scientist is justifiably legendary. The clever pieces of automatic apparatus he devised for recording behavior, programming contingencies, delivering reinforcers, and graphically depicting the course of behavior change truly revolutionized and advanced the field. This early emphasis on automation, however, also biased him toward thinking primarily in terms of mechanical connections between an organism's behavior and its environment, effectively preventing him from considering the potential of biological connections with the social environment—until that day of great illumination in the flour mill. In the more than 60 years that have transpired since then, shaping has come to be taken largely for granted, probably as much because of its intuitive appeal and sheer plausibility as for its demonstrated validity. It is hard to imagine a time in the formal field of psychology when the shaping process was essentially unknown, but that was clearly once the case. At the same time, we continue to be rightly impressed by

demonstrations of its effectiveness, for example, in teaching speech to individuals who lack it (e.g., Isaacs, Thomas, & Goldiamond, 1960; Lovaas, Berberich, Perdoff, & Schaeffer, 1960), or, more recently, in helping individuals with brain damage recover lost limb function even after many years of nonuse (e.g., Taub et al., 1994). And in the futuristic field of artificial intelligence, a generic capacity for behavior to be shaped by its consequences is recognized as key to eventual success in the design of versatile robots (e.g., Saksida, Raymond, & Toutetzky, 1997; Savage, 1998, 2001). Thus B. F. Skinner's studies of response differentiation and his subsequent insight about shaping, each a genuinely original set of observations, deserve to be delineated among the most important findings, in terms of both theoretical and practical significance, in the history of behavioral science.

REFERENCES

Bjork, D. W. (1993). *B. F. Skinner: A life.* New York: Basic Books.

Burch, M. R., & Pickel, D. (1990). A toast to Most: Konrad Most, a 1910 pioneer in animal training. *Journal of Applied Behavior Analysis, 23,* 263–264.

Hull, C. L. (1943). *Principles of behavior.* New York: Appleton-Century-Crofts.

Hull, C. L. (1952). *A behavior system.* New Haven: Yale University Press.

Isaacs, W., Thomas, J., & Goldiamond, I. (1960). Application of operant conditioning to reinstate verbal behavior in psychotics. *Journal of Speech and Hearing Disorders, 25,* 8–12.

Konorski, J., & Miller, S. (1937). On two types of conditioned reflex. *Journal of General Psychology, 16,* 264–272.

Logan, F. A. (1959). The Hull-Spence approach. In S. Koch (Ed.), *Psychology: A study of a science. Study I. Conceptual and systematic. Volume 2. General systematic formulations, learning, and special processes* (pp. 293–358). New York: McGraw Hill.

London, J. (1906). *White Fang.* New York: Macmillan.

Lovaas, O. I., Berberich, J. P., Perdoff, B. F., & Schaeffer, B. (1960). Acquisition of imitative speech by schizophrenic children. *Science, 151,* 705–706.

Miller, S., & Konorski, J. (1928). Sur une forme particuliere des reflexes conditionnels. *Comples Rendus des Seances de La Societe Polonaise de Biologie, 49,* 1155–1157.

Miller, S., & Konorski, J. (1969). On a particular form of conditioned reflex (B. F. Skinner, Trans.). *Journal of the Experimental Analysis of Behavior, 12,* 187–189.

Most, K. (1954). *Training dogs: A manual.* London: Popular Dogs Publishing Company Ltd. (Original work published 1910 as *Abrichtung des Hundes: Individuell und ohne Strafen.*)

Saksida, L. M., Raymond, S. M., & Toutetzky, D. S. (1997). Shaping robot behavior using principles from instrumental conditioning. *Robotics and Autonomous Systems, 22,* 231–249.

Savage, T. (1998). Shaping: The link between rats and robots. *Connection Science, 10,* 321–340.

Savage, T. (2001). Shaping: A multiple contingencies analysis and its relevance to behaviour-based robotics. *Connection Science, 13,* 199–234.

Skinner, B. F. (1935). Two types of conditioned reflex and a pseudo-type. *The Journal of General Psychology, 12,* 66–77.

Skinner, B. F. (1936). The verbal summator and a method for the study of latent speech. *Journal of Psychology, 2,* 71–107.

Skinner, B. F. (1937). Two types of conditioned reflex: A reply to Konorski and Miller. *The Journal of General Psychology, 16,* 272–279.

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1939). The alliteration in Shakespeare's sonnets: A study of literary behavior. *Psychological Record, 3,* 186–192.

Skinner, B. F. (1942). A quantitative estimate of certain types of sound-patterning in poetry. *The American Journal of Psychology, 30,* 64–79.

Skinner, B. F. (1948/1976). *Walden two.* New York: Macmillan.

Skinner, B. F. (1951). How to teach animals. *Scientific American, 185,* 26–29.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1958). Reinforcement today. *American Psychologist, 13,* 94–99.

Skinner, B. F. (1960). Pigeons in a pelican. *American Psychologist, 15,* 28–37.

Skinner, B. F. (1972). Some relations between behavior modification and basic research. In S.W. Bijou & E. Ribes-Inesta (Eds.), *Behavior modification: Issues and extensions* (pp. 1–6). New York: Academic Press.

Skinner, B. F. (1979). *The shaping of a behaviorist: Part two of an autobiography.* New York: New York University Press.

Skinner, B. F. (1983). *A matter of consequences: Part three of an autobiography.* New York: New York University Press.

Taub, E., Crago, J. E., Burgio, L. D., Groomes, T. E., Cook, E. W. III, DeLuca, S. C., et al. (1994). An operant approach to rehabilitation medicine: Overcoming learned nonuse by shaping. *Journal of the Experimental Analysis of Behavior, 61,* 281–293.

This smart University of Minnesota rat works slot machine for a living. (1937, May 31). *Life,* 80–81.

Thorndike, E. L. (1911). *Animal intelligence.* New York: Macmillan.

Watson, J. B. (1930). *Behaviorism.* University of Chicago Press.