The Behavior Analyst 1996, 19, 199–210 No. 2 (Fall)

The Four Free-Operant Freedoms

Ogden R. Lindsley
University of Kansas and Behavior Research Company

This article reviews early free-operant conditioning laboratory research and applications. The seldom-mentioned four free-operant freedoms are described for the first time in detail. Most current behavior analysts do not realize that the freedom to form responses and the freedom to speed responses were crucial steps in designing free-operant operanda in the 1950s. These four freedoms were known by the laboratory researchers of the 1950s to the point that, along with operanda design, Sidman (1960) did not feel the need to detail them in his classic, *Tactics of Scientific Research.* The dimensions of freedom in the operant were so well understood and accepted in the 1950s that most thought it redundant to use the term *free operant.* These issues are reviewed in some detail for younger behavior analysts who did not have the opportunity of learning them firsthand.

Key words: fluency, free operant, frequency, operant conditioning, rate of response

---

This paper is dedicated to Israel Goldiamond, my close friend and beloved colleague, who succumbed to multiple cancer on November 19, 1995. Although we seldom met more than once a year, we were bonded by a mutual respect for measurement and the free-operant method. I called him "Is"[1] and he called me "Og," and our relationship went back 43 years. Is understood the power of the free operant over discrete trials and used it, creatively, in both laboratory and clinic from the 1950s on. Along with other pioneers in behavior analysis, Is regretted the fact that the less sensitive controlled operant later dominated research in both laboratory and applied behavior analysis. Eight of the 11 doctoral dissertations advised by Goldiamond in the 1980s and 1990s were highly creative free-operant designs. Topics ranged from symbolic aggression in pigeons (Andronis, 1983), through head banging in pigeons (Layng, 1994), to schedule-induced defecation (Rayfield, Segal, & Goldiamond, 1982).

In the early days we both lived in the academic fast lane. Rushing to meetings, staying too late, never getting enough sleep, always perfectionistic, always trying to do too much. Sometimes I thought we were trying to make up for the time we spent in the service during World War II. This went on until Is had his accident. Driving back to Chicago from staying too late talking to graduate students after an invited colloquium address at the University of Illinois, Is demolished his Checker car. This made him a paraplegic and me a diesel Mercedes driver. Both my father and my brother had been killed in speeding automobiles, but Is survived his crash and went on to do still more wonderful things.

We will all miss the spark of his laugh and stories. I can close my eyes and see and hear Is say, "Have I told you about the two boys who were asked by their father, 'Who pushed outhouse off high cliff into Pacific Ocean?'" I can also hear the equal joy and excitement as he related the successful history of one of his creative nonlinear clinical behavior analysis cases. Life and science to Is were one big grand adventure. If you couldn't have fun doing it, it wasn't worth doing.

Is is now gone, and the lucky ones among us have fond memories of him in addition to the record he left: his extensive, high-quality research publications. Even more important, he graduated over a dozen skillful, well-

Address correspondence to the author, 366 North 1600 Road, Lawrence, Kansas 66049-9199 (E-mail: OLindsley@aol.com).

[1] Most of his students called him "Izzy," but to me he was always "Is." Certainly not one to wear a diminutive! And, he always responded rapidly in good humor when I called him "Is."

trained behavior analysts who are carrying on the Goldiamond zest, research traditions, and life-style adventures.

THE FREE OPERANT

In separate telephone conversations on July 5, 1995, neither Charles Catania, Jack Michael, nor Scott Wood, all experts on the writings of B. F. Skinner, could recall that Skinner wrote the term *free operant.* All remembered that Ferster (1953) used the term in an early *Psychological Bulletin* article. I suggested to Catania, Michael, and Wood that Skinner considered all operants to be free; hence, free operant would be redundant. All experts agreed that my suggestion was probably the case.

"Free-responding" is in the index of *Tactics of Scientific Research.* Sidman's (1960) description follows.

> The experimental situations that I have used for illustration all share at least one important feature: the experimental organism is free to respond at any time. There are no harnesses to restrain the animal forcibly; the lever is never withdrawn from the experimental space to prevent the subject from responding at times that would be inconvenient for the investigator's theory. The only restrictions placed upon the subject's recorded behavior are those inherent in the laws of behavior. This is called a free-responding situation. (p. 409)

In the 1950s and early 1960s, several laboratory researchers began to use the term *free operant* to differentiate situations in which the learner was free to make more than one response to each stimulus from the *controlled operant,* in which trials were used and the learner responded only once to each discriminative signal (Ferster, 1953). Because many operant conditioners were beginning to do single-trial research, the others sometimes used "free operant" in the titles of their articles (Barrett, 1962; Creed & Ferster, 1972; Ferster, 1953; Levin & Stigall, 1965; Lindsley, 1960, 1963b; Lovitt, 1967) in attempts to keep rate of response alive. These researchers usually described the power of the free operant in their method sections. For example,

> We see in the method of free-operant conditioning probably one of the most rigorous techniques yet developed by experimental psychology for the development, maintenance, modification and analysis of acquired motor behavior in an experimental setting. B. F. Skinner perfected this method, and he and his collaborators have been using it successfully for the past twenty-five years in analyzing the behavior of laboratory animals. In application an animal is placed unfettered and alone in a small enclosure where he is *free* to make any response at any time—hence the term "free." If the animal *operates* a small lever, wheel, key, plunger or similar device, he is promptly rewarded or reinforced—hence the term "operant." Through varying the nature and conditions of the reinforcement, complex behaviors have been developed and measured which are similar to symbolic behavior, "superstition," time-telling, counting, fear, anxiety, competition, cooperation, and so on. . . . The free-operant method can be used, with very little modification, to measure the behavior of any animal from a turtle to normal genius. (Lindsley, 1956, p. 118)

It was also the custom during the 1950s and 1960s for operant conditioners to present the advantages of the free operant over the use of trials (i.e., controlled or restricted operants) in their method sections. Here again,

> Over the past 30 years Skinner has stressed the value of the free operant, wherein the subject is *free* to respond at any time. The rate of occurrence of this response is the primary datum. Use of the free operant dispenses with burdensome time-consuming trials and eliminates the confounding stimulation of the trials themselves. Also subtle variations in the behavior being studied, which could occur between trials, are fully recorded in the continuous monitoring of the free-operant technique. (Lindsley, Hobika, & Etsten, 1961, p. 937)

Before adopting the free operant and rate of response as its measure, many researchers had used experimental psychological methods employing trials and either probability of occurrence (percentage), amplitude, latency, or trials to extinction, the four Hullian response measures (Hull, 1943). This experimental history produced an acute awareness of the vastly superior sensitivity of the free-operant method and rate of response as a measure. For this reason, concern was raised when some operant conditioners began using single-response trials, with percentages and latencies as the response measures.

The tendency to revert to trials rather than the free operant was very strong in regular and special education and in child development applications. In the University of Washington Child Behavior Laboratory School in the late 1950s, Bijou and his students used plunger operanda and cumulative recorders with the children in their free-operant laboratory, but used trials and percentage correct with the same children in their nearby classrooms. Bijou was Spence's[2] second doctoral student, and from 1941 through 1955 was a confirmed Hull–Spence behaviorist and experimenter (Krasner, 1977). Being a Hullian, he turned to Sears' model for research with children and started with a ball-drop response (Bijou, 1955). Later Bijou replaced the discrete-trials ball-drop with a free operant in which the child pushed the nose on a clown's face, but he still used an event recorder for stimulus and response occurrences rather than the free-operant cumulative response recorder (Bijou, 1957). My laboratory visitors' book shows that on April 1, 1957, Bijou spent the day at my Harvard Medical School Behavior Research Laboratory in Metropolitan State Hospital, Waltham, Massachusetts. There he saw the plungers that I had designed for human free-operant work that he later ordered from Ralph Gerbrands Company for use in his own laboratory at the University of Washington. The plunger operanda were used in some of Bijou's later laboratory research (Bijou, 1958). From the Iowa Child Welfare Station, Bijou also picked up the method of "percentage of time observed on task," the traditional and entrenched child development measure (Goodenough, 1928).

The tendency to drop the free operant in human applications was so strong that even Skinner used controlled operants in his applications with teaching machines (Skinner, 1958). I did not support Skinner's work with teaching machines for three reasons. First, there was no opportunity to repeat a response in the presence of its stimulus. Second, the response measure was percentage of frames correct. Third, there was no provision for external reinforcement. Teaching machine proponents said that getting the answer right was the reinforcement. At that time, I would say, "If getting it right is ample reward, everybody in the world would be getting more and more right, just at different rates." True, there was a "free" aspect to teaching machines and programmed instruction. Learners were free to answer the questions at their own pace and free to present the questions, but they were not free to respond more than once to each question presentation.

Others started to record latencies or interresponse times in place of rate of response. Some took the position that latencies or interresponse times measured the same thing that rate did, but did so more precisely; they believed that rate and cumulative records were nothing more than a primitive way of recording latencies. This is really a neo-Hullian position, because it implies that rate of response, latency, interresponse time, duration, and amplitude are just alternative ways of measuring response strength. And response strength is what you really are after. Response strength is an intervening variable, an hypothesis, and it is never directly measured. Later, matching-to-sample and stimulus equivalence research became popular, and these researchers also rejected the free operant and used trials. Because trial research

[2] Kenneth Spence, professor of experimental psychology at Iowa, popularized Hull's mathematico-deductive theory approach. Spence had a map of North America on his office wall with pins stuck in the locations of the universities where his doctorates were employed. The Spence-Hullians controlled experimental psychology and its journals. I was taught by Greg Kimball, a Spence PhD, when I was a graduate student at Brown. At that time I was a graduate student in physiological psychology and a Hullian when it came to learning. I belonged to the "postulate of the month club" and got dittoed copies of upgrades to the theory from Hull's office at Yale. I realized the theory was doomed when I couldn't keep up with the upgrades.

gained so much favor among behavior analysts (the new name for operant conditioners), cumulative records gradually all but disappeared from the *Journal of the Experimental Analysis of Behavior*[3] (Barrett, 1987). They had only rarely been published in the *Journal of Applied Behavior Analysis.*

Skinner regretted this noticeable decline in the use of cumulative recording (Skinner, 1976). He should also have regretted the decline of the free-operant method that fell from favor at the same time. The decline of the free-operant method is probably why the cumulative record went out of favor. A cumulative record of a learner's responses in a situation in which stimuli are presented in fixed order, at a time selected by the experimenter, run by a timer, in which the learner can make only one response to each stimulus, and cannot skip or correct or repeat responses, would record the experimenter's behavior, not the learner's response. In these controlled conditions a cumulative record added little value, and a table or chart of percentage of correct responding over trials was adequate for such research.

I closed my human free-operant behavior research laboratory at Harvard Medical School and Metropolitan State Hospital and accepted a faculty appointment in the University of Kansas Special Education Department to advocate using rate of response in educational research and classroom teaching (Lindsley, 1966, 1971, 1972). I did this because most behavior analysts working in educational settings used percentage correct as the measure of classroom academic performance. The preponderance of percentage measures in application and the decline of rate measures in the basic laboratories and journals required drastic action[4] if rate of response was to survive. Obviously laboratory research and commentaries about the glories and power of the free operant and cumulative recording failed to stem the tide of regression to the four Hullian response measures. At the time one occasionally heard a free-operant supporter ask a friend who had gone back to trials research "Did you go back to Hull, or to Hull and back?"

This lack of interest and use of rate of response and cumulative records resulted in little writing about them and very little study of the advantages and features of the free operant. The free operant or free responding do not appear in the index to *Strategies and Tactics of Human Behavioral Research* (Johnston & Pennypacker, 1980). In a recent count of pages devoted to the topic of the free operant in 17 books authored by Skinner and four method publications by other authors,[5] I tallied only 12 of over 5,000 pages describing the free operant.[6]

FOUR FREE-OPERANT FREEDOMS

For this article, I have recalled and spelled out the details of what the zealous laboratory proponents of free-operant research knew in the 1950s and 1960s. In fact, operant freedoms exceed the commonly known freedom to present stimuli and the less well-known freedom to repeat responses. Other freedoms include little-known but equally important freedoms to form and to speed responses. These four freedoms are crucial to developing and maintaining fluent performances.

[3] One of the main reasons for establishing the *Journal of the Experimental Analysis of Behavior* was to provide a place to publish cumulative records. In the 1950s both the *Journal of Experimental Psychology* and the *Journal of Comparative and Physiological Psychology* routinely rejected articles that contained cumulative records.

[4] This is not to imply that going from Cambridge to Kansas City is drastic; rather, closing a really productive laboratory is drastic.

[5] The four method books by other authors were Keller and Schoenfeld (1950), Sidman (1960), Ferster and Culbertson (1982), and Johnston and Pennypacker (1980).

[6] A table of the counts of pages devoted to the free operant, shaping, chaining, and functional recording is available from the author.

Free to Present Stimuli

The learner is always ideally ready and is never caught napping or off balance when free to present stimuli; the freedom to "self-pace" or "self-present" is the best known operant freedom. The destructive effect of external pacers on the development of fluent performances, and the constructive effects of freedom to stop, start over, correct, and skip, however, are less well known so are touched on here in a little more detail. My classroom use of SAFMEDS ("say all fast a minute each day shuffled") fluency cards showed that the learner's frequency drops to about half the self-held frequency when another student held the learner's cards, exposing the next card right after the learner responds. Self-presenting was twice as fast as partner presenting.

The freedom to present the stimuli fosters response rhythms (e.g., pointing to the next frame on a practice sheet, sliding the top card off the SAFMEDS deck and exposing the next card question). Response rhythms are crucial for developing high-fluency frequencies. I tried three forms of external pacing to speed up responding: an external metronome clicking at 60 per minute, a telephone busy signal at 72 buzzes per minute (learners dialed their own number), and a partner tapping a pencil on a table, regularly, at 60 taps per minute. All of these regular, clock-like, external pacing attempts failed. Most learners could not keep up with the pacing and "clutched" to a stop after 10 or 15 cards. Regular external pacing broke the learner's natural rhythm and rattled the learner trying to build fluency.

Alfredo Lagmay, a 1950s graduate student of Skinner's from the Philippines, made a classic study of pacing, in which reinforcement was contingent upon pecking at a steady rate. When the schedule would otherwise have generated a higher rate, the pigeon would break through and "get rid of extra responses" in a sudden burst (Skinner, 1983, p. 38). Here, from the pigeon laboratory, is more evidence that learners need to repeat at their own rhythmical pattern, and cannot long endure regular external pacing.

Irregular, rhythmical, external pacing by a partner tapping the table with a pencil at a speed slightly faster than the learner's responding worked. The tapper matched the tapping to the rhythm of the learner's responding, varying the speed from time to time, but always trying to lead the learner up to 60 responses per minute as rapidly as possible without losing the learner. This rhythmical, synchronized pacing is similar to what a well-trained coxswain does in pacing a rowing crew. It also is what skilled direct-instruction teachers do when they pace their learners to "firm " the performance.

Freedom to stop and start over is another presentation freedom, which is almost always used by precision teachers in fluency building. Quite often a student will "clutch" in the middle of a 1-min timing, especially during final timings with the teacher or professor for a course grade. That is why precision teachers usually permit three or four timings in a course grade checkout and use the timing with the highest frequency of correct responses (with some students this is the first timing and others it is the last of the four). It is also standard practice to permit a second check-out a day or a week later if the learner wishes to practice some more for a higher grade.

Freedom to skip can be permitted if the teacher chooses. In building fluency with SAFMEDS, learners reach the instructional frequency aims sooner when they start out at high overall frequencies, showing steeper accelerations in frequency. They start at high speed (60 per minute) and low accuracy (one hit for every 20 misses). This procedure requires high curricular courage from both teacher and student, but it produces the steepest learning. To foster these high beginning frequencies, I encourage learners to say "go" to cards for which they cannot give an immediate answer. When learners hesitate and then say a correct answer, they learn to grope and to pause, which defeats fluency development. When learners mumble and say "I don't know," that also takes time and tends to emotionally depress them and they go even slower. I urge SAFMEDS learners to say "go" for every card that the answer does not jump right out. The shortness of "go" does not slow responding. The emotional effect of "go" speeds or hustles responding. The single syllable of "go" does not break the learner's "slide-see-say" rhythm. In this sense "go" responses are carefully designed, highly specified, and approved skips.

Free to Form Responses

Very little has been written on the design of manipulanda. It was essential to select a class of responses that were not identical in form and that yielded a smooth and lasting variable-interval (VI) response rate. The learner was free to select the most comfortable response form and to vary that form during experimental sessions to overcome boredom and fatigue. The wide response class also permitted different individuals to use their own, unique, most comfortable response form. Read what Reese wrote about operanda in the "Free Operant Method" section of her popular textbook, *The Analysis of Human Operant Behavior* (1966).

> The gerbil in Figure 2 is pressing one kind of mouse lever. When the lever is depressed a certain distance, it operates a microswitch which defines the response. The gerbil may press with ether paw or both paws, or he may climb on the lever or straddle it. Only those behaviors—but all of those behaviors—which operate the microswitch are defined as lever-pressing responses. (p. 5)

Many weeks (sometimes years) were spent in the early 1950s designing operanda that would produce smooth, even rates of response on the 1-min VI reinforcement schedule that produced regular stable responding. Only the few of us who actually designed operanda for a new species were acutely aware of the uneven rates of response produced by operanda that narrowed the form of the response too far. With too narrow a response form requirement fatigue set in early, and sometimes choppy rates would occur on a schedule that was designed to produce even rates.

For example, in designing an operandum for beagle dogs, I (Jetter, Lindsley, & Wohlwill, 1953; Lindsley, 1957) at first tried a lever very much like a rat lever only larger and at an appropriate height. It promptly produced a chopped rather than a smooth, even VI rate, because the dogs chewed the lever at times rather than pressing it. To rule out chewing,[7] I built a panel at the end of a shallow tube. The dogs put one paw into the tube and pressed the panel at the end. This eliminated chewing entirely, but produced an uneven VI rate as the dogs' toenails got sore and sometimes caught on the edge of the tube. Next, I mounted a square operandum panel hinged at its top at the right side of the chamber.[8] This eliminated both chewing and nail tenderness, but the rate of response was still uneven, because the dogs shifted their weight and their right paw would tire. Next, I mounted the operandum in the middle of the end of the chamber and the dogs alternated either front paw, both paws, or their muzzles. This operandum produced the widest response class so far, and the rate of response was now almost smooth with the VI schedule. Occasionally a dog would paw at the top of the panel, however, and this pawing would not operate the microswitch because the panel was hinged at that point and would not depress. This added occasional chop in the record that should be smooth, so I hinged the operandum

[7] In those days one never ruled out chewing by ruling out dogs that chewed. All laboratory free-operant conditioners were proud of never having to discard an animal. That proved our behavioral power, knowledge, and control. One would have been ashamed to be caught discarding subjects!

[8] The panel had a Plexiglas window behind which stimulus lights were mounted.

panel on internal struts about 24 in. above the panel on the outside of the chamber end to produce the final successful design. The top of the panel and the bottom moved the same distance to trip the microswitch response counter, and right front paw, left front paw, and muzzle presses were recorded at the top as well as at the bottom and sides of the panel. Now the 1-min VI schedule produced a smooth, even response rate over a period of several hours, and we finally had an appropriate dog operandum that gave the beagles freedom to form their responses.

The Ferster–Skinner pigeon key finally marketed by Ralph Gerbrands also went through many versions before it recorded the proper response class width. This key permitted the birds to peck in many different forms such as front tap, side swipe, and slightly open peck; each bird used its own particular response form. The key eliminated chatter (switch closures unrelated to responding) and recorded a wide range of peck forces. The key also had to be durable enough to operate at six million responses per month over periods as long as 2 years without failure (Ferster & Skinner, 1957, p. 17). Most important, the final version of the key produced smooth, even responding at high rates for sessions as long as 15 hr. The Anger[9] rat lever was also designed to produce even responding on a VI schedule, and rats could respond with their left paw, right paw, and even their chin. The indestructible Lindsley plunger operandum[10] for humans permitted participants to use either or both hands in responding at even rates for 7 hr on VI schedules.

It also helps to let the learners make their own abbreviations to lift the ceiling on rate imposed by the length of the answer words during fluency building with practice sheets using the point-see-say channel (Lindsley, 1994). For example, if the correct answer to a card was "increase," then "inc," "incre," or "i" could be accepted as an abbreviated answer, lifting the answer ceiling and permitting a higher answer frequency. If the channel was point-see-write, the learner could abbreviate the answer with an up-arrow in place of writing or abbreviating "increase." This freedom to form the response class lets the learners invent their own abbreviations that are often superior to any the teacher might devise.

Freedom to make your own is the ultimate freedom to form.[11] For the first 3 years of using SAFMEDS in my university graduate classes, I had students make their own deck of cards from blank index cards as the first week's assignment. The cards were made from a list of questions (front of card) and answers (back of card) that were displayed on an overhead screen in the first class. Student objection to the viewing problem caused me to pass out a sheet with columns of card fronts and backs. I believed strongly that the students valued their SAFMEDS decks more when they made the deck themselves. No student ever lost a self-made SAFMEDS deck, but every semester several students lost their deck when I succumbed to student pressure and provided ready-made SAFMEDS decks.

This freedom to make one's own includes the entire construction of learning materials and the choice of content. Given instructions, most students can select a textbook section, choose their own important topic points, write questions and answers for these points, construct their own SAFMEDS deck, and use SAFMEDS on their own. With the freedom to make one's own, students learn how to develop fluent perfor-

[9] Douglas Anger was a graduate student of Skinner's and a Junior Fellow at Harvard.

[10] The Lindsley plunger was also manufactured and sold by Ralph Gerbrands Company.

[11] Harold Kunzelmann told me to be sure to mention "free to make your own" when I recently telephoned him to ask permission to cite Harold's extinction by public education in an article dedication. Harold is now gainfully self-employed in the private sector.

mances, and at the same time acquire the skills to become fluent in most future learning tasks. That is the ultimate in personal freedom to form.

Free to Repeat Responses

The freedom to repeat responses many times to each signal was an important feature of the laboratory research using free operants. Repeating responses permitted researchers to directly and continuously record the learner's degree of assurance to each signal in a discrimination experiment. There was no need for recourse to statistics, as required with trials that permitted only one response per signal.

We studied discriminations in the early 1950s by using free operants with the freedom to repeat rather than the cumbersome and insensitive trials. Skinner described beautifully the free-operant discriminations from student projects for his first graduate seminar at Harvard in 1950.

> The students "shaped behavior through successive approximation," reinforced on intermittent schedules, and brought the behavior under the control of discriminative stimuli. William McGill, produced a rough "generalization gradient" by intermittently reinforcing pecks on a yellow triangle and noting how fast the pigeon then pecked triangles of other colors during extinction. George Heise recorded a gradient for the size of a spot on the key. When pecking a particular size of the spot was reinforced, how fast would the pigeon peck other sizes? My laboratory assistant, Sam McLaughlin, used the same method to test a pigeon's ability to tell the difference between the figures used on license plates. He built up a high rate of pecking to the figure 6 and then, during extinction, replaced the 6 for short periods with other figures from 0 to 9. The pigeons pecked at rates which reflected what would be called in the human case, "perceived differences between the figures." (Skinner, 1983, pp. 6–7)

Many current researchers have forgotten or never knew how to use the free-operant measurement in the way that Skinner described. They believe that researchers must use trials with only one response per stimulation to study discrimination, matching to sample, or stimulus equivalence. They have forgotten the fantastically high sensitivity of Blough's dark adaptation (1956) and generalization experiments (1957, 1967) with pigeons.

Skinner also eliminated the freedom to repeat answers, to self-correct, and to skip questions when he designed teaching machines. Speech pathologists know that in improving pronunciation there is a stage in which learners cannot pronounce correctly, but can recognize their own incorrect pronunciation as they hear themselves speaking. Speech pathologists find it valuable to permit learners to immediately repeat and self-correct their incorrect pronunciation. Programmed instruction, following Skinner's example, permitted only one response per question. Precision teaching practice sheets[12] and SAFMEDS also permit only one response to each stimulus, although some precision teachers encourage self-correcting in the point-see-say learning channel.

Free to Speed

The freedom to speed in repeating responses to a single stimulus was very important to early laboratory free-operant research. Researchers spent months and years designing operanda that operated faster than the learners could move to prevent putting an operandum ceiling on the response rate. Most behavior analysts do not realize that all the charts published in Skinner's classic, *The Behavior of Organisms* (1938), had a ceiling at 60 responses per minute.

> In the first experiments with this method a needle attached to the lever-arm dipped into a small cup of mercury. When the lever was moved slowly there was a tendency for the contact to chatter, and this was corrected by inserting into the circuit to the recorder a device which made it impossible for a second contact to be recorded within, say, one second. (p. 60)

This false recording apparatus ceiling would not permit recording response speeds above 60 per minute (one per

---

[12] Practice sheets have also been called skill builders (Beck, Conrad, & Anderson, 1995) and fluency sheets (Binder, 1993).

second). This limitation bothered Skinner, so in later experiments he used a commercial mercury tube switch that did not require the 1-s limiting delay.

The Ferster–Skinner pigeon key and Gerbrands recorder could eventually follow frequencies as high as 15 per second (900 a minute), well above the highest pigeon frequencies of 800 per minute. In contrast, during initial attempts to apply fluency research methods to computer-assisted instruction, most of the early personal computers required as much as 3 s to refresh the screen and display a graphic image for the next question (Silverman, Lindsley, & Porter, 1991). This limited the learner's response frequency to less than 20 per minute, which was not fast enough to develop true fluency.

FREE-OPERANT RESEARCH DESIGN AND TRAINING PROCEDURES

Two different procedures developed in the 1950s are still used today by a few of us to design both laboratory and applied free-operant research. Both are also useful in training students to think free operant. The first I called "externalizing the behavior." The second I called "freeing up the operant." Little was written about these powerful procedures because they were commonplace in the laboratory jargon of the 1950s and thus do not appear in Sidman (1960), Johnson and Pennypacker (1980), or any of the laboratory manuals and college texts that I have read. I used both in my workshops and graduate classes throughout my teaching career, and they successfully overcame many students' ingrained tendencies to attempt complete control in experimental design. These powerful procedures are offered here in the hope that they may facilitate free-operant research and practice.

Externalizing the Behavior

I can still hear Skinner telling me, "You externalized empathy!" when he looked at the cumulative records of one of my psychotic patients' responding to feed a hungry kitten (Lindsley, 1963a). "Externalizing the behavior" was a common phrase in the 1950s and 1960s among those of us who were bringing socially important behavior into the free-operant laboratory for the first time. At the University of Kansas during the late 1960s, we successfully advised parents, teachers, and students in Special Education on how to conduct self-modification projects. These projects included not only stopping hitting, swearing, and smoking and reducing weight, but also stopping hitting, swearing, smoking, and eating *urges*. The urges were externalized by having the clients push a button on one wrist counter each time they did it, and a button on second wrist counter each time they had an urge to do it (Duncan, 1969, 1971).

One of the most telling indicators in the 20-timing assessment battery of the Haughton Learning Center (Napa, California) is "see-say" nouns. Prospective students are handed a Veeder-Root hand tally counter that they click each time they say the name of an object in the room as fast as they can during a 1-min timing. Adjectives are not counted (e.g., red binder, green binder, blue binder, yellow binder). Most first graders start at about 20 nouns per minute, and after several weeks of practice are up to their aim of 50 to 70 nouns said and counted per minute. The next step is to time think-say nouns recalled and visualized from one's bedroom at home, from the kitchen, or from the garage. The last step is to time think-say nouns from categories such as vegetables, animals, or minerals. Because students enjoy see-say nouns more than any other practice task at the center, it is usually used as a warm-up exercise each day. Recently, an 18-year-old student with a university water polo scholarship was only able to see-say nouns at 31 per minute in his assessment. This college-bound man desperately needed practice in basic description and word use (E.

F. Haughton, personal communication, July 14, 1996).

Good chess teachers ask their learners to think out loud; with their thoughts externalized, the teachers can more easily advise their learners. Morningside Academy (Seattle) uses Whimbey's (1989, 1995) think-aloud problem solving (TAPS) to teach problem solving. These methods greatly facilitate teaching the more complex reading analysis and problem solving (Kent Johnson, personal communication, June 4, 1996), and they are special cases of externalizing the operant. Externalizing the behavior is still a useful exercise in teaching students to use the free operant in place of the discrete trials of the controlled operant. Learners and teachers prefer the free operant over a controlled operant (or even worse, rating scales) once they know how to externalize it.

Freeing Up the Operant

Perhaps even more useful in design and training is freeing up the operant. This became especially important in my years teaching graduate courses in special education. There, due to the influence of physical rehabilitation, the controlled-trial procedures were ingrained in almost all remedial programs. Experienced teachers who came back to graduate school for certification in special education had great difficulty thinking of how they could make teaching a pupil to catch a ball into a free operant. Three examples of freeing up ingrained controlled operants follow.

Catching a ball is usually taught by slowly tossing a large ball at a short distance to the learner. One might even start with rolling the ball across the floor. The ball is retrieved by the teacher and another toss is made; the ball is seldom tossed more than once per minute. The size of the ball and the distance are selected to make almost all of the catches successful. Gradually the ball size is decreased, the distance is lengthened, and the speed is increased. Usually only one ball of each size is available, so the catching is not timed and there are usually no more than 30 catches in the half hour of class time. Full attention of one aide is required to toss and retrieve the ball. One method of freeing up the operant is to get a bushel basket of spent tennis balls from the local tennis club. Set a 1-min timer, and at a distance of about 15 feet throw balls at the learner at a frequency of 60 balls per minute.[13] Most will not be caught, but one or two will stick between the learner's arms and body—those are caught! Count catches and misses and have 10 or 15 1-min ball-catching trials per day. In the first 30-min 15-trial day, the learner may catch 35 balls and miss 865 balls from a total of 900 (15 times 60 tosses). These 900 tosses in one free-operant day give 30 times more practice than the 30 tosses in a 1-min discrete-trials day. Learners count and chart their catches and misses each day.

Walking a balance board is usually taught by having the learner walk down a raised plank (6 ft long, 6 in. wide) on the floor. An aide may at first hold the learner's hand to guide him or her. Sometimes the learner is walked back to the front of the plank for another trial. Sometimes the learner is turned around and walked back down the plank for a second trial. Slips off the plank are counted as errors. This operant is freed up by making a plank in a circle (6 ft inside diameter) (or painting one on the floor). The aide may stand in the center and time 1-min walks and count correct steps on the plank and misses off the plank aloud, with the learner also counting out loud. Ten or 15 1-min timings per day can be practiced and the hits and misses charted by the learner.

Saying "good morning" meaningfully is usually taught with one trial a day as the learner enters the classroom.

[13] It is even better when another student tosses the balls, because then two students are learning and the teacher could coach three or four ball-tossing, ball-counting teams at once.

Some more enlightened teachers may have the learner greet every other child in the room, and have each greetee count whether he or she was greeted warmly and meaningfully or not. That would give as many learning opportunities each day as children in the room. The "good morning" operant is still not really free. The "good morning" operant could be totally freed by forming the children in a large circle and having the greeter child go around the circle greeting each child in the circle, and not being able to go on to the next child until the greetee signals with his other arm "warm and meaningful." The number of warm and meaningful greetings per minute is the hit frequency for the learning greeter.

IMPORTANCE OF THE FOUR FREE-OPERANT FREEDOMS FOR THE FUTURE

Some of us never forgot the power and greater sensitivity of the free operant and taught our students free-operant research design and clinical and educational practice. Goldiamond directed eight free-operant dissertations during the 1980s and early 1990s (e.g., Andronis, 1983; Layng, 1994) and only three discrete-trials dissertations testing the yes-no design of traditional signal-detection research. Other young researchers are aware of how they can do stimulus equivalence research using a free operant (Rosales-Ruiz & Fitzimmons, 1996).

One purpose of this article is to caution those researchers who believe that they can study fluency systems and one or more of their products (Lindsley, 1995) using controlled-operant research designs, with discrete trials and latencies as the response measure. Another major purpose is to open the rich field of free-operant laboratory research and the even richer field of free-operant clinical and educational practice to the next generation of behavior analysts. You are empowered and are now free to use your four free-operant freedoms.

REFERENCES

Andronis, P. T. (1983). *Symbolic aggression by pigeons: Contingency coadduction.* Unpublished doctoral dissertation, University of Chicago.

Barrett, B. H. (1962). Reduction in rate of multiple tics by free operant conditioning methods. *Journal of Nervous and Mental Disease, 135,* 187–195.

Barrett, B. H. (1987). Drifting? Course? Destination?: A review of research methods in applied behavior analysis: Issues and advances. *The Behavior Analyst, 10,* 253–276.

Beck, R., Conrad, D., & Anderson, P. (1995). *Basic skill builders handbook.* Longmont, CO: Sopris West.

Bijou, S. W. (1955). A systematic approach to an experimental analysis of young children. *Child Development, 26,* 161–168.

Bijou, S. W. (1957). Methodology for an experimental analysis of child behavior. *Psychological Reports, 3,* 243–250.

Bijou, S. W. (1958). A child study laboratory on wheels. *Child Development, 29,* 425–427.

Binder, C. (1993). Behavioral fluency: A new paradigm. *Educational Technology, 33*(10), 8–14.

Blough, D. S. (1956). Dark adaptation in the pigeon. *Journal of Comparative and Physiological Psychology, 49,* 425–430.

Blough, D. S. (1957). Spectral sensitivity in the pigeon. *Journal of the Optical Society of America, 47,* 827–833.

Blough, D. S. (1967). Stimulus generalization as signal detection in pigeons. *Science, 158,* 940–941.

Creed, T. L., & Ferster, C. B. (1972). Space as a reinforcer in a free-operant environment. *Psychological Record, 22,* 161–167.

Duncan, A. D. (1969). Self application of behavior modification techniques by teen-agers. *Adolescence, 6*(4), 541–556.

Duncan, A. D. (1971). The view from the inner eye: Personal management of inner and outer behaviors. *Teaching Exceptional Children, 3*(3), 152–156.

Ferster, C. B. (1953). The use of the free operant in the analysis of behavior. *Psychological Bulletin, 50*(4), 263–274.

Ferster, C. B., & Culbertson, S. A. (1982). *Behavior principles* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement.* New York: Appleton-Century-Crofts.

Goodenough, F. (1928). Measuring behavior traits by means of repeated short samples. *The Journal of Juvenile Research, 12,* 230–235.

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

Jetter, W. W., Lindsley, O. R., & Wohlwill, F. J. (1953). *The effects of irradiation on physical exercise and behavior in the dog: Related hematological and pathological control studies.* Boston University Medical School, Final Report, AEC Contract AT(30-1)1201. Microcard number: NYO-4548.

Johnston, J. M., & Pennypacker, H. S. (1980). *Strategies and tactics of human behavioral research.* Hillsdale, NJ: Erlbaum.

Keller, F. S., & Schoenfeld, W. N. (1950). *Principles of psychology.* New York: Appleton-Century-Crofts.

Krasner, L. (1977). An interview with Sidney W. Bijou. In B C. Etzel, J. M. LeBlanc, & D. M. Baer (Eds.), *New developments in behavioral research: Theory, method, and application* (pp. 587–599). Hillsdale, NJ: Erlbaum.

Layng, T. V. J. (1994). *Programmed headbanging by pigeons: Cessation and return.* Unpublished doctoral dissertation, University of Chicago.

Levin, R. H., & Stigall, T. T. (1965). Effect of nonverbal social reinforcement on rate of speech in a free operant paradigm [Abstract]. *American Psychologist, 20,* 535.

Lindsley, O. R. (1956). Operant conditioning methods applied to research in chronic schizophrenia. *Psychiatric Research Reports, 5,* 118–139.

Lindsley, O. R. (1957). *Conditioned suppression of behavior in the dog and some sodium pentobarbital effects.* Unpublished doctoral dissertation, Harvard University.

Lindsley, O. R. (1960). Characteristics of the behavior of chronic psychotics as revealed by free-operant conditioning methods. *Diseases of the Nervous System* (Monograph Supplement 21), 66–78.

Lindsley, O. R. (1963a). Experimental analysis of social reinforcement: Terms and methods. *American Journal of Orthopsychiatry, 33,* 624–633.

Lindsley, O. R. (1963b). Free-operant conditioning and psychotherapy. In J. H. Masserman (Ed.), *Current psychiatric therapies* (Vol. 3, pp. 47–56). New York: Grune and Stratton.

Lindsley, O. R. (1966). An experiment with parents handling behavior at home. In J. J. Parnicky (Ed.), *A Johnstone bulletin* (Vol. 9, No. 1, pp. 27–36). Bordentown, NJ: Edward R. Johnstone Training and Research Center.

Lindsley, O. R. (1971). Precision teaching in perspective: An interview with Ogden R. Lindsley, Ann Duncan interviewer. *Teaching Exceptional Children, 3*(3), 114–119.

Lindsley, O. R. (1972). From Skinner to precision teaching: The child knows best. In J. B. Jordan & L. S. Robbins (Eds.), *Let's try doing something else kind of thing: Behavioral principles and the exceptional child* (pp. 1–11). Arlington, VA: Council for Exceptional Children.

Lindsley, O. R. (1994). "Point/see/say" or "slide/see/say" learning channels. *Journal of Precision Teaching, 12*(1), 2–7.

Lindsley, O. R. (1995). Ten products of fluency. *Journal of Precision Teaching, 13*(1), 2–11.

Lindsley, O. R., Hobika, J. H., & Etsten, B. E. (1961). Operant behavior during anesthesia recovery: A continuous and objective method. *Anesthesiology, 22,* 937–946.

Lovitt, T. C. (1967). Free-operant preference for one of two stories: A methodological note. *Journal of Educational Psychology, 58,* 84–87.

Rayfield, F., Segal, M., & Goldiamond, I. (1982). Schedule induced defecation. *Journal of the Experimental Analysis of Behavior, 38,* 19–34.

Reese, E. P. (1966). *The analysis of human operant behavior.* Dubuque, IA: William C. Brown.

Rosales-Ruiz, J., & Fitzimmons, P. A. (1996, May). *The effects of response fluency on discrimination learning.* Poster presented at the meeting of the Association for Behavior Analysis, San Francisco.

Sidman, M. (1960). *Tactics of scientific research.* New York: Basic Books.

Silverman, K., Lindsley, O. R., & Porter, K. L. (1991). Overt responding in computer-based training. *Current Psychology: Research and Reviews, 9*(4), 373–384.

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

Skinner, B. F. (1958). Teaching machines. *Science, 128,* 969–977.

Skinner, B. F. (1976). Farewell, my LOVELY! *Journal of the Experimental Analysis of Behavior, 25,* 218.

Skinner, B. F. (1983). *A matter of consequences.* New York: Knopf.

Whimbey, A. (1989). *Analytical reading and reasoning.* Stamford, CT: Innovative Sciences.

Whimbey, A. (1995). *Analytical reading and reasoning* (2nd ed.). Stamford, CT: Innovative Sciences.