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THE WATERSHED YEARS OF 1958–1962 IN THE HARVARD PIGEON LAB

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During the years 1958–1962, the final years of support by the National Science Foundation for B. F. Skinner's Pigeon Lab in Memorial Hall at Harvard University, 20 or so pigeon experiments (plus some with other organisms) ran concurrently 7 days a week. The research style emphasized experimental analyses, exploratory procedures, and the parametric exploration of variables. This reminiscence describes some features of the laboratory, the context within which it operated, and the activities of some of those who participated in it.

Key words: experimental analysis, quantitative analysis, B. F. Skinner, George S. Reynolds, Memorial Hall, electromechanical programming, pigeon laboratory

The years 1958–1962 marked the final years of support by the National Science Foundation for B. F. Skinner's Pigeon Lab in Memorial Hall at Harvard University. The Pigeon Lab of the time was a component of what was essentially a Department of Experimental Psychology, with the main strengths of that department residing in the two areas of psychophysics and behavior analysis. Other psychological specialties were housed elsewhere, in the Department of Social Relations. Skinner allowed those working in the lab substantial initiative, and at any time 20 or so pigeon experiments were simultaneously running 7 days a week. The lab also supported research in other locations and with other organisms, so that along with experimental analyses and parametric explorations of schedules of reinforcement it included applications to such other areas as psychopharmacology, physiological processes, ethology, and the beginnings of experimental approaches to verbal behavior. Skinner's last grant proposal to the Foundation, which summarizes some of the history of the laboratory and some of its research directions, appears in Appendix A.

During those watershed years, the emerging schism between cognitive psychology and behavior analysis widened with George A. Miller's departure from the Department of Psychology to become, with Jerome Bruner, one of the founders of the Center for Cognitive Studies. By the end of Skinner's grant in 1962, plans were well under way to move the Department of Psychology from Memorial Hall to the soon-to-be-constructed William James Hall and thence to merge with the Department of Social Relations. Interaction between the two departments was relatively limited during those years, though in psychology there was occasional discussion of activities in the other department, such as research with drugs that Timothy Leary was said to be conducting with some Harvard undergraduates.

In the fall of 1958, Richard J. Herrnstein had arrived as an assistant professor. As was expected of a new faculty member, he maintained his own independent laboratory. After Skinner formally removed himself from involvement in the Pigeon Lab at the end of the spring semester in 1962, the center of gravity of new work with pigeons shifted from

In any reminiscence, one risks errors and omissions. The risk grows when some of the parties are no longer available to present their own versions. Wherever possible, I've tried to check my recollections against contemporaneous records, but too often such checking was not feasible. My main hope is that my enormous indebtedness both to my teachers and to my colleagues comes across clearly and strongly.

The photographs in Figures 2 through 5 were taken on the same day as the photograph labeled "In the laboratory with Richard Herrnstein" in Skinner (1983, fourth photograph in the picture section inserted between pages 218 and 219). The photograph in Figure 6 was taken on the same day as the one labeled "Pigeon Staff meeting" in Skinner (1983, seventh photograph in the same picture section); in the latter, an individual standing next to Bea Barrett is misidentified as Peter Dews.

The full script and a tape recording of the dress rehearsal for the skit, "Psycho City Saga," are deposited with the Archives of the History of American Psychology at the University of Akron.

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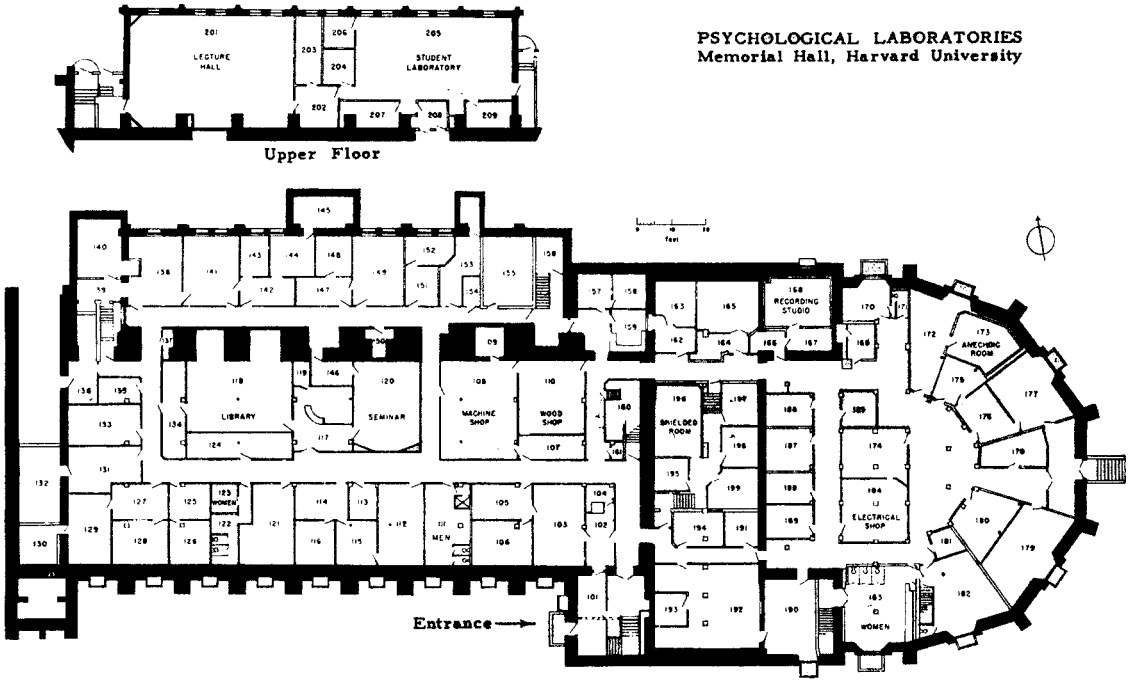

Fig. 1. Memorial Hall floor plans. The Pigeon Lab was located in a cluster of rooms at the lower left (Rooms 127–132). Skinner's office was probably Room 126; the room where he and Ferster prepared the figures for *Schedules of Reinforcement* was probably Room 133. As a graduate student, Catania had a study carrel in Room 124.

experimental to quantitative analyses, especially in support of Herrnstein's matching law research (Herrnstein, 1970).

The Place and the Time

The Psychological Laboratories were located in the basement of Memorial Hall, a monumental Victorian Gothic building just north of Harvard Yard that had been constructed in 1870 to honor Harvard alumni who had died in the Civil War. The Psychoacoustic Laboratory, under the direction of S. S. (Smitty) Stevens, came to be housed at the east end of the basement in 1940. Other psychology laboratories that had been scattered in various Harvard facilities were brought into the rest of the basement in 1946–1947. A floor plan of the basement (along with some upper floor teaching areas used for undergraduate courses) is shown in Figure 1 (Stevens & Boring, 1947).

The Department of Psychology had its own shops, its own library stocked with relevant journals and a large book collection, and a seminar room that served not only for courses, colloquia, and faculty meetings but also for informal meetings such as those of the pigeon staff. A graphics room included drafting tables where one could prepare data figures in India ink and then label them using a Leroy lettering set, and a calculator room included several electric machines where one could extract square roots, calculate correlations, or derive the weightings of the factors revealed by a factor analysis.

Those in the laboratories interacted with the greater Harvard environment in various ways, often but not always to mutual benefit. Sanders Theatre was situated in the east end of the building. The concerts regularly held there could be heard in many areas below. The circuit box for the theatre was located in a small basement room where, some time in the early 1950s, a graduate fellow had maintained a rat laboratory devoted to studies of interresponse-time reinforcement. On the stormy evening of a notable conductor's farewell concert in Sanders Theatre, the fellow is said to have hung a wet raincoat from the handle of the circuit breaker. Looking up when the music from above abruptly stopped, he saw his coat on the floor. Its weight had

pulled down the lever and cut power to the concert hall. The story goes that he turned the power back on and immediately proceeded to a hiding place at the other end of the building where he remained for the rest of the night.

A large auditorium used for varied functions was located above the western end of the basement. On evenings when the scheduled function was folk dancing or some similarly lively activity, the ceiling tiles and light fixtures mostly withstood the thumping from above, but many of the human occupants below migrated to other environments: the Brattle Theater for foreign films (e.g., Eisenstein's *Alexander Nevsky* or Bergman's *The Seventh Seal*), or late-night haunts where Joan Baez sang while the audience consumed exotic teas such as Lapsang Souchong. Other major events occasionally lured those in the laboratories away from their Memorial Hall environs, as when graduate students located a television set (small screen and not yet in color) where they could watch the Kennedy–Nixon debates or presidential election returns together.

Those were the days of attempts by NASA to catch up with the Soviets after the launch of their first orbiting satellite (Sputnik), the construction of the Berlin Wall, Freedom Riders fighting for desegregation in Birmingham and elsewhere in the American South, Fidel Castro's overthrow of Batista in Cuba and the later failed Bay of Pigs invasion, the continuing domination of Soviet biology by Lysenkoism under Nikita Krushchev, the beginnings of the Beatnik movement inspired by Jack Kerouac, and the reversal by a Federal Court of Appeals of a postal ban on D. H. Lawrence's *Lady Chatterley's Lover*. Such matters were noted but typically seemed remote from the daily concerns of the aspiring graduate students in Memorial Hall.

Distinguished scientists, as visitors or in residence, were taken for granted. After colloquia by Hartline or Ratliff or Hubel or Harlow, among many others, a group of students and faculty members often proceeded with the colloquium guest to the MIT Faculty Club for drinks and then into downtown Boston for dinner. When Noam Chomsky visited to give his colloquium, he talked about transformational grammars but did not mention his impending review of Skinner's (1957) book on verbal behavior (Chomsky, 1959; cf. Catania, 1997a).

A student who walked the basement halls late in the evening might encounter Georg von Békésy, emerging from his laboratory on the north side of the basement to pace the corridors quietly while lost in thought. Békésy had routinely declined requests to give colloquia in the department, until one year when the graduate student in charge of colloquium invitations sent a formal one to him through the U.S. mails rather than by approaching him in person or placing the message directly in his departmental mailbox. In spite of the prominence of his research on audition, he had not been promoted from associate to full research professor at the time he received his Nobel Prize in 1961, and though Harvard later promoted him he eventually resigned and took a position at the University of Hawaii.

Skinner's office was located on the south side of the basement (probably Room 126). Herrnstein's office and lab were also located on the south side, but closer to the center of the building. The rooms further along the south side, opposite the machine and wood shops, belonged to the department chair, Edwin B. Newman, and the departmental secretary, Esther Mahr. The secretary's office included a wall chart showing each graduate student's progress through courses, examinations, language requirements, and other hurdles toward the degree (the confidentiality of grades and other student records was not an issue in those days). In the hallway nearby was a series of wall plaques showing by year and name all of the PhDs awarded by the department up to that date.

Graduate students had their own individual study carrels (e.g., in Rooms 124 and 134), so the laboratories were almost always active. With apparatus work, study, data analysis, and discussion often lasting well into the night, some graduate students occasionally worked so late that on leaving the laboratory they met others on their way in to start the morning round of pigeons.

The Pigeon Lab was located in several interconnected rooms in the southwest corner of the Memorial Hall basement. One entered the lab through a large room with workbenches, tools, and equipment (probably Room 127 in Figure 1, but with a different

Fig. 2. Pigeon housing. Details in text.

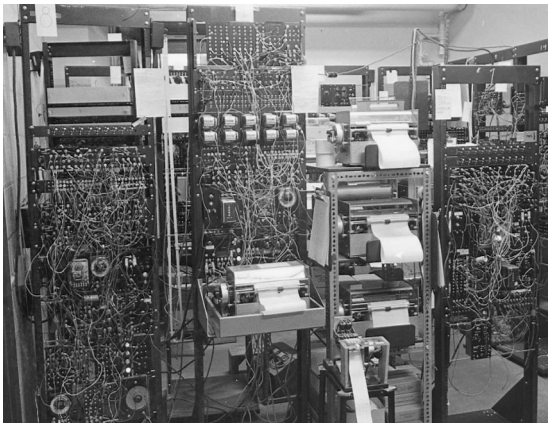

Fig. 4. Relay racks and cumulative recorders in Room 129. Note the variety of electromechanical devices on each rack and the spaghetti-like snap leads that were used to wire up experimental control circuitry.

configuration of connecting doors than the one shown in that 1947 floor plan). Adjoining areas included pigeon housing, experimental chambers, and control equipment. Pigeon housing consisted of custom-made wooden cages with mugs for water and plastic cups for food and grit, as shown in Figure 2 (these pigeons, wearing goggles that allowed one or the other eye to be covered, were subjects in an experiment on interocular transfer; Catania, 1965). The experimental spaces, illustrated by the two-key chamber in Figure 3, were enclosed in large sound-proofed boxes. The buttons next to each chamber were for testing the lamps, feeder, and other equipment before the start of an experimental session.

The most characteristic feature of the rooms that contained the control equipment was the incessant noise of cumulative recorders, relays, stepping switches, and other devices. Figures 4 and 5 show two views of some of the relay racks. Both pictures were taken from the same spot in Room 129. In Figure 4, Room 130 (unseen) is on the right; in Figure 5, the door to Room 130 is straight ahead. At the time the pictures were taken, Rack 7 (to the right of the cumulative recorder rack, with the number 7 in chalk) was devoted to the variable-interval (VI) schedules eventually reported in Catania and Reynolds (1968), Rack 11 was devoted to studies

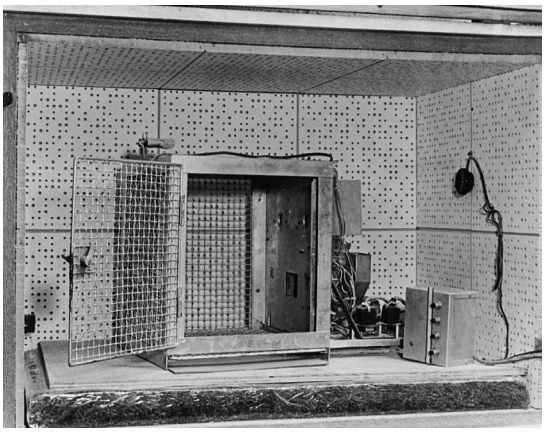

Fig. 3. Two-key pigeon chamber, about 1960. Note the insulated outer shell, the buttons for testing, and the wall-hung speaker for presentation of masking noise.

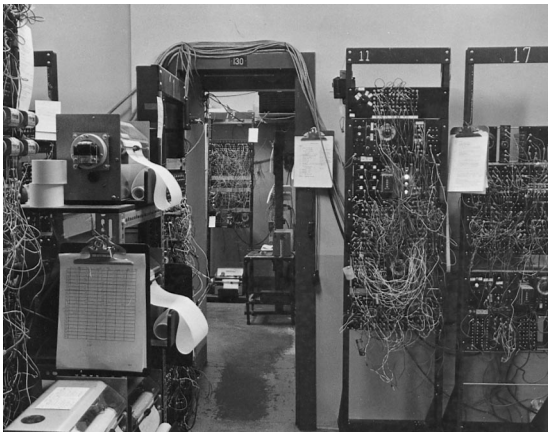

Fig. 5. Relay racks in Room 129 (another perspective). The relay racks facing the camera in Figure 4 are here partially visible on the left.

of interocular transfer (the small plastic cup mounted on the lower left of that rack contained the caps used to cover one or the other eye of each pigeon in that experiment; Catania, 1965), and Rack 17 was devoted to studies of concurrent schedules reported in Catania (1963a, 1963b).

Each relay rack included electromechanical control equipment, usually devoted to a single experiment. As procedures became more complex, equipment sometimes extended to adjoining racks. Almost all racks had attached cumulative recorders, and some that involved more than one response or condition had two or more. The relays, timers, steppers, programmable counters, and other equipment on the face of the rack were sometimes supplemented with VI timers or variable-ratio steppers hung from the sides of the racks. These devices used punched holes in motor driven loops of sprocketed film leader to arrange variable sequences of events (VI timers are mounted on both sides of Rack 8 in Figure 4).

A cable ran from a control panel on the rack to a corresponding chamber in another room. The control circuits on each rack were wired using snap leads of varying lengths. The snaps at each end of each wire could be snapped onto studs, the electrical connections on the various equipment panels on the rack. Where several wires had to run to a particular contact, the snaps could be stacked to create the multiple connection. This made the design of the circuitry for a particular procedure far more efficient and flexible than would have been the case if it had been necessary to hard-wire circuits with a soldering iron. Snap leads were prepared using wires of different colors, to make it easier to see where each one went during the modification of procedures or when troubleshooting was required. Special-purpose snap leads sometimes included other electrical components, such as capacitors or diodes. Commercial electromechanical equipment designed for operant research was not yet commonplace, and most circuits involved 120 V AC and 24 V DC on neighboring poles of relays. Sometimes during the design of an experimental condition the easiest way to tell whether a contact used AC or DC was to brush one's fingers lightly across it.

Various switches and buttons on the racks allowed convenient switching among different conditions if, for example, different birds within a particular chamber were to be exposed to different values of some variable. A good deal of attention was given to minimizing human error, as by adding circuitry that did not allow an experiment to be started unless appropriate switches had been moved to new positions.

Despite the automation, much of the work had to be done by hand. Cumulative records had to be labeled, data accumulated on counters had to be entered on data sheets, counters had to be properly reset when recording was done, and settings of timers and switches and other devices had to be checked against the protocols for each experiment before and after the running of each organism (clipboards for data sheets and cards with protocol instructions can be seen hanging on or near most relay racks in Figures 4 and 5). The animal caretaker, Mrs. Antoinette C. Papp, with one or more assistants, got birds into their chambers, weighed them before and after sessions, and so on. Special attention was given to checking each bird's leg-band every time it was handled, to avoid getting birds in different procedures mixed up. Over the years, the procedures of the Pigeon Lab had become fine tuned and well orchestrated. Although Skinner occasionally asked those working in the lab to design apparatus or experimental conditions for him (e.g., Reynolds & Skinner, 1962), by 1958 his participation in the lab was mostly via the pigeon staff meetings; almost all of the ongoing experiments had been initiated either by postdoctoral staff or graduate students.

The People

I first saw the Harvard Pigeon Lab in the fall of 1957, while I was still a student at Columbia. Encouraged by Fred Keller and Nat Schoenfeld, I applied to the graduate program in the Department of Psychology at Harvard and visited Cambridge for an informal interview. I met B. F. Skinner somewhere in Harvard Yard and as we walked together to Memorial Hall it began to rain. I was without an umbrella and there was no realistic way for Skinner to share his with me, so we made our way awkwardly across the Yard with his umbrella tipping first one way and then another. We talked, mostly about teaching

machines, in the room (probably Room 133 in Figure 1) in which he and Charles B. Ferster had prepared the figures for *Schedules of Reinforcement* (Ferster & Skinner, 1957). The interview must have been reasonably satisfactory, because I returned to Cambridge the next year as a student in the program.

My graduate class, consisting of 12 entering students, was said to be the largest in the history of the department up to that time. It included Harlan Lane, an undergraduate psychology major from Columbia, and George S. Reynolds, from the undergraduate program in the Department of Social Relations at Harvard. Herbert S. Terrace arrived with an undergraduate background in perception from Cornell. Others from that class and from overlapping ones before and after were Gordon Bermant, Dale Brethower, Jerry Hogan, Neil Peterson, Paul Rozin, and, from Australia, Peter van Sommers. Marc Richelle from Belgium and Hannes Eisler from Sweden were visitors to the laboratories during those years.

Richard J. Herrnstein, newly arrived as an assistant professor and just starting up his own laboratory, participated extensively in discussions with graduate students. Skinner's frequent travel and his work routine made him less available, and we students, often intensively competitive, probably learned more in debates with each other than in our formal course work.

Another resource was the pigeon staff meeting, with the frequent participation of, among many others, Peter B. Dews, William H. Morse, and Roger T. Kelleher from Harvard Medical School and Michael Harrison from Boston University. A photograph taken at a pigeon staff meeting is reproduced in Figure 6. The topics covered often extended to other areas; for example, discussions of teaching machines with James Holland, or physiological issues with John Falk, or human operant research with Eugene Long, and Skinner provided occasional reminders of work that had been presented in earlier years (e.g., Og Lindsley's research on the behavior of psychotics). Cumulative recorder paper came in large rolls that accommodated weeks of daily records, so when cumulative records were involved, discussions sometimes moved out into the hallways where substantial lengths of records could be rolled out on the floor for examination and comment.

Fig. 6. Pigeon staff meeting. Seated from left to right are Mike Harrison, Bea Barrett, George Reynolds, and Charles Catania; walking behind George Reynolds is Roger Kelleher. Skinner is standing at the right, and the seated figure behind him is probably Dick Herrnstein.

Some time before my class arrived, Lewis R. Gollub had taken over the direction of the Pigeon Lab from Charlie Ferster. In part of a graduate practicum course, Lew assumed responsibility for teaching each new class of graduate students how to conduct small-scale operant studies, setting us up with older chambers around the periphery of the lab. He conducted informal sessions in the design of switching circuits and organized groups of graduate students for the assemby of relay panels, stepping switches, timers, and other equipment for use in the lab. An important resource was Keister, Ritchie, and Washburn (1951; see also Catania, 1972). Symbolic logic had immediate practical applications in the design of switching circuits, as we translated AND relations into series circuits and OR relations into parallel ones (the expertise acquired then would continue to serve many of us well long after, when the same logical relations eventually became manifested in assembly language and then higher order computer programs).

In conducting their experiments, students were responsible for all the details of programming and recording, and one invaluable lesson was that small differences in contingencies that might depend on subtle features of a circuit design could have substantial behavioral effects. Experimental analysis was often demanded even in the early stages of putting new procedures together.

Students in the practicum course who were conducting their first experiments in the lab

used horizontal racks similar to the one shown in Ferster (1970, Figure 1; also this issue). Occasionally they found that their procedures were not working properly. Rumor spread that when no one was watching Lew Gollub switched connections or removed snap leads to give students practice in troubleshooting apparatus failures. But more likely the problems arose because the students were novices using older equipment. The opportunity to switch to vertical racks such as those shown in Figures 4 and 5 was an important step up, and the privilege of moving one's research into the racks of the Pigeon Lab proper was especially prized, not least because many of the routine chores of running the experiments were taken over by Mrs. Papp and her staff.

The department was supposed to include all aspects of experimental psychology, but with the recent departure of Philip Teitelbaum representing physiological psychology and the sabbatical and then departure of George Miller representing cognitive psychology, the main foci of the laboratories were the Pigeon Lab at the west end and psychophysics under the direction of S. S. Stevens at the other. Students gravitated toward one or the other of these research areas, often with the assumption that it would not be wise to attempt substantive work in both simultaneously. That proved not to be the case, and Lane, Reynolds, and I, among others, were able to publish research in both areas, sometimes with either Stevens or Skinner as a coauthor (e.g., Lane, Catania, & Stevens, 1961; Reynolds, Catania, & Skinner, 1963).

Occasionally one line of research intruded on the other. For example, research on visual dark adaptation required the wearing of red goggles for half an hour or more before the experiment proper. Those who were recruited as subjects in that experiment and hoped to use the time productively by examining emerging cumulative records in the Pigeon Lab were disconcerted to learn that they could not do so. The cumulative recorder ink was red, so the red goggles made the records invisible.

The competition between the two ends of Memorial Hall was especially manifested in an ambitious Christmas skit in December 1959, in which the two main characters were caricatures of Stevens and Skinner. Called ''Psycho City Saga'' and subtitled ''An Elizabethan Psychological Western,'' the skit was set in a western town bossed over by a powerful sheriff, Smutty Smitty, who bullies the townsfolk into serving as subjects in his psychophysical experiments. One day a preacher, Filthy Freddy, arrives to convert the townsfolk to his utopia, based on reinforcers derived from psychopharmacology. In the subsequent struggle, Filthy Freddy entices his adherents with a song, ''What Is Psychology to Me'' (the lyrics of some songs from ''Psycho City Saga'' are provided in Appendix B).

Later, Filthy Freddy advocates an alternative to gunplay, in ''You Can't Make a Law with a Gun.'' But he and Smutty Smitty end up in a gunfight nevertheless, and one of the townsfolk, Gentle Julius (this character has Herrnstein's middle name), is killed when he tries to intervene. He had been dedicated to Psycho City, earlier singing ''Home, Home in the Lab.'' In remorse, Smutty Smitty and Filthy Freddy reconcile their different approaches in a song, ''Maybe We Both Can Be Right.'' Upset by their duplicity, the remaining townsfolk turn on their leaders and then on each other, until only the piano player, Jelly Roll von Békésy, is left. Then the entire cast is revived to sing the grand finale, ''Psycho City'' (sung to the tune of ''Oklahoma'').

''Psycho City Saga'' was collaboratively written, produced, and performed by a group of a dozen or so graduate students and spouses of graduate students. Skinner enjoyed the production enough that when he learned that a tape recording of the dress rehearsal was available, he asked to listen to it (he left at the start of the ''Maybe We Both Can Be Right'' number). In researching his biography of Skinner, Bjork (1993) found a copy of the script in Skinner's files. Instead of recognizing it as Skinner's souvenir of a student production, he reprinted Filthy Freddy's song, ''What Is Psychology to Me,'' in the biography and attributed authorship of the entire script to Skinner. It is difficult to imagine Skinner penning some of those lines (especially the scatological ones).

Somewhere along the way, some in my class began an informal competition, never quite stated explicitly, in which the objective was to demonstrate experimentally that Skinner had erred about something. Harlan Lane, for example, noted the treatment of animal cries as

respondent behavior in Skinner's appendix to *Verbal Behavior* (Skinner, 1957, pp. 462–470), so he reinforced chicks' vocalizations and brought them under the control of schedules. The research eventually became his doctoral dissertation (Lane, 1960). Presumably part of our mutual socialization as graduate students was to demonstrate to each other that we were not intimidated by our mentor.

My own opportunity came relatively late, when I became responsible for preparing the animal demonstrations for Skinner's undergraduate course, Natural Sciences 114. The content had become well established over semesters and Skinner left most details to us. Ogden Lindsley's show was legend. He was said to have entered the classroom with his arms outstretched, one pigeon perched on each wrist and a third on his head. One of the three birds was dyed red and another blue. On the front desk stood a pigeon panel without an enclosure. Each pigeon took a turn being released onto the desk, walking over to the panel and pecking the key according to a different schedule. The colors helped the students keep track of which pigeon and schedule was which.

I was more conservative when my opportunity came. My birds, undyed, worked within the confines of a demonstration chamber with clear plastic walls. When one bird I had started with happened to flap vigorously while facing the feeder, I recalled that Skinner had said that such wing flapping was an emotional response not susceptible to reinforcement. I decided to try reinforcing the flapping with food deliveries. I was teaching my first course, an undergraduate section in comparative psychology, and had just learned about avian wing muscles while preparing lectures on animal locomotion. The two modes of avian flight are the energetic flapping that gets birds off the ground and up to air speed, and sustained flight with wings outstretched as airfoils, with movement mostly restricted to the ends of the wings where the tips of the feathers change orientation as the wings move up and down so as to provide forward thrust. The breast muscles that drive the energetic takeoff flight, low in myoglobin, fatigue rapidly. The muscles of sustained flight, like postural muscles, are richer in myoglobin and less subject to fatigue. Pigeons that cannot reach air speeds that allow them to switch from effortful flapping to the less demanding sustained flight can fly around for only a minute or two before alighting. In brief sessions over the next few days, always stopping before flapping began to fatigue, I established fixed-ratio wing flapping.

On the day of the demonstration, several birds went through their paces, illustrating superstition and schedule control and simple discriminations. Then I placed the last bird in the chamber and demonstrated the fixed-ratio wing flapping, complete with postreinforcement pauses and high-rate runs. I quit after a few ratios and briefly outlined the significance of the bird's muscle physiology, closing with the comment that now that we could reinforce wing flapping our next project would be to teach the bird to fly. Skinner, unflappable, picked up his lecture from there. The only sign of disapproval was his quiet comment after the class that I should have told him my plans for the demonstration ahead of time. He would not argue with data, so he had no problem with the reinforcement of wing flapping.

A rare occasion on which some of us saw Skinner upset occurred soon after the death of his friend and Harvard colleague, Percy W. Bridgman, in August 1961. Bridgman was a Nobel laureate who had pioneered the application of operationism to measurement in physics. He had been gradually losing his memory and his intellectual capacities (perhaps from Alzheimer's disease), and he shot himself in a shed behind his home. Bridgman had earlier shown Skinner a letter that he had written so that it could appear in the newspapers along with his obituary. In it he argued for dignity in dying and criticized the practices that drove him to end his life in a way that he knew would distress his family and others. Skinner was moved not only by the death but also by the family's suppression of Bridgman's letter, which was not published.

The Work

Any summary of the research of the Pigeon Lab would involve serious omissions if it were restricted only to the pigeon work, because studies with other organisms were typically always in progress. Rats and appropriate equipment such as levers and running wheels were

at hand, and ample resources were available for experiments with new organisms. While Lane (1960) worked with chick vocalizations, van Sommers examined schedule control by access to air as a reinforcer for the responses of submerged turtles. Peterson (1960, 1962) began to study both monochromatic rearing and imprinting in ducklings (he found that responses shaped on the first day after hatching were forgotten on the next day, but not so if the ducklings were a little older at the time of shaping), and I managed an experiment on human operant behavior (Catania & Cutts, 1963).

Lew Gollub was winding down his work on chained and related schedules (Gollub, 1977), preparatory to his move to the University of Maryland at College Park in 1960. I had the good fortune to be appointed his successor as the research fellow supervising the Pigeon Lab. Gradually current graduate students took over the chambers that he and others were vacating.

The lab provided graduate students with opportunities to move in various directions, and some of us tried to block out specific areas with which we might become identified. For example, Herb Terrace ran some experiments that demonstrated phenomena the significance of which would later be recognized by others in studies of fading (Sidman & Stoddard, 1967), autoshaping (Brown & Jenkins, 1968), and differential attention to discriminative stimuli (Dinsmoor, 1995), but at the time Terrace interpreted his findings primarily in terms of discrimination learning with and without errors (Terrace, 1963), which Skinner saw as potentially relevant to teaching machines.

I became fascinated with one set of findings that suggested that Parkinson's law (''work expands to fill the time available for its completion'') applied to the behavior of pigeons as well as people (Catania, 1962). Skinner had meanwhile urged me to write up my work on interocular transfer as my doctoral dissertation, to demonstrate an application of behavior analysis to physiological issues, but I preferred something more in the operant mainstream. My first attempt at a dissertation was pretentious: an essay on the concept of inhibition in the analysis of behavior followed by a brief report of an experiment. My manuscript was informally returned to me, and I was told that instead of revising I should seriously consider writing a new one devoted primarily to experimental findings. In November 1960 I defended a complex analysis of behavioral contrast within concurrent schedules that ruled out interpretations in terms of generalized emotional effects (Catania, 1961). I returned later to the issue of inhibition, arguing by analogy with physiological systems that it made more sense to think of each reinforcer as inhibiting the responding engendered by other reinforcers than to think of extinction and related processes as inhibitory (Catania, 1969, 1970; Catania & Gill, 1964).

George Reynolds and I found early on that we had many common interests, and we began trading off on the running of each other's experiments well before we were each able to move our research into the Pigeon Lab. Although he favored multiple schedules (Reynolds, 1961) and I favored concurrent schedules, we were converging on similar research questions. Before we completed our degrees we knew that we would both be continuing in the department, he as a lecturer and I as a postdoctoral research fellow, so we initiated a series of collaborative experiments, supplementing our experimental analyses with the parametric exploration of schedule variables. We saw the possibility of that ''theory in another sense'' that Skinner had described in the conclusion of ''Are Theories of Learning Necessary?'' (Skinner, 1950), and we took to heart the lessons of Skinner's (1956) case history in scientific method. But we did not appreciate how quickly afterwards research agendas would come to be dominated by quantitative rather than experimental analysis, as Skinner had warned in his paper on the flight from the laboratory (Skinner, 1959). Some years later, ''The Flight from Experimental Analysis'' would seem an appropriate title for a critique of some of the features of quantitative analysis (Catania, 1981).

Skinner occasionally awarded those who worked in the Pigeon Lab with an honorary degree of Doctor of Cumulative Recording, and George and I both received one. The degree (see Figure 7) was scratched into an original of one of the smoked drum (kymograph) records Skinner had obtained during the early years of his research, as reported in

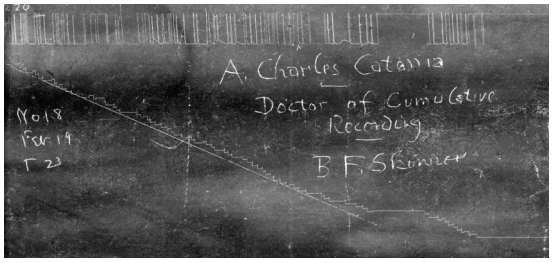

Fig. 7. A Doctor of Cumulative Recording degree, scratched onto an early cumulative record that had been produced on a smoked drum (see Skinner, 1956).

papers he published during the 1930s and in *The Behavior of Organisms* (Skinner, 1938).

George's and my remaining time in the Pigeon Lab was a period of intense activity. Our most ambitious project was a systematic analysis of VI schedules, in which responses become eligible to produce reinforcers at varying times after some event. We saw the schedule as important because it minimized the interaction of response rate with reinforcement rate. As long as response rate exceeds some minimum value determined by the shortest possible interreinforcement interval in the schedule, reinforcement rate does not vary appreciably with response rate. That made VI schedules of practical as well as theoretical interest, because they had become schedules of choice for generating certain kinds of behavioral baselines. We had also been studying fixed-interval (FI) schedules, and once we began to see those schedules as superimposing an additional process, temporal discrimination, on the maintenance of behavior by reinforcers (e.g., Reynolds & Catania, 1962), we came to see VI schedules as behaviorally simpler than FI schedules even though the details of their programming were more complex.

The successive occasions on which responses could produce VI reinforcers were usually arranged by punched tapes driven past a sensing switch (see the VI timers mounted near the top on each side of Rack 8 in Figure 4). Our main technical innovations were substituting a stepping motor for the continuous tape drive, so we could synchronize our recording circuitry with the intervals on the punched tape, and designing our schedules explicitly in terms of reinforcement probability as a function of elapsed time, by analogy with Anger's (1956) statistic of interresponse times per opportunity.

One valuable legacy from my undergraduate days at Columbia was Nat Schoenfeld's recommendation that one can learn much more from parametric studies that sample extreme values along a continuum than from those that sample an equal number of values that lie relatively close together (Catania, 1997b). George and I sketched out an experimental space of parameter values to be explored. Because session durations varied with schedule parameters, one of our more difficult problems was that of ordering the values studied for different pigeons so that all could be run within the available time. Sessions ran daily from June 1960 to May 1962, including weekends and holidays.

Technical issues became interwoven with theoretical ones. For example, the scheduling of interreinforcement intervals by a loop of tape with holes punched in it meant that a finite sequence of intervals would be repeated over and over. We did not know whether the behavior of our pigeons would be sensitive to such sequential patterning, but we did not have any obvious way to reconcile random reordering of the intervals with the manageable recording of response rates in separate temporal cells following each reinforcer. Furthermore, the minimum interreinforcer interval was dictated by the minimum spacing that would allow a switch to throw completely as its sensor cleared one hole and then fell into the next. Probability generators in combination with electronic timers would eventually allow those problems to be solved.

Another equipment artifact with profound implications was the stopping of the VI programming tape each time a punched hole was sensed. This set up a reinforcer for the pigeon's next peck, and the tape started up again only after that reinforcer had been delivered. Without this arrangement, the next hole in the tape could move past the sensor without detection, allowing reinforcers that should have been scheduled to be lost. But stopping the tape adds time to an interreinforcer interval, allowing obtained rates of reinforcement to differ from scheduled ones. Circuits that would have saved each setup for the next peck even while the VI programming tape continued to run would have been unwieldy. Add-subtract steppers might have

provided a solution, with each setup moving the stepper up one step and each reinforcer moving it back down, but add-subtract steppers were expensive and hard to come by. Nevertheless, such arrangements for saved setups would have allowed obtained reinforcement rate easily to catch up with scheduled reinforcement rate, because delays between setups and subsequent reinforced responses would not cumulate. Computers provide convenient means to avoid this artifact (e.g., by incrementing a variable with each setup and decrementing it with each reinforcer). Yet contemporary VI programs still often preserve such artifactual procedural details, even though those details arose solely because of the limitations of electromechanical programming equipment. Some of their effects have yet to be assessed through experimental analysis.

Using our earliest experimental results, George and I wrote, submitted, and then withdrew our first manuscript on the VI research in 1961. We decided that one comprehensive paper was preferable to several short ones, and so collected more data. But soon it was time for us to move on. He took a faculty position at the University of Chicago; I went on to 2 years of psychopharmacology research at the Smith, Kline & French Laboratories in Philadelphia and then to the University Heights campus of New York University. We did not see each other often, but we continued working together through mail and phone on a manuscript based on our collaborative work. In successive drafts, we condensed theory and considerably expanded empirical content, and several revisions and editorial reviews culminated in a *JEAB* monograph supplement (Catania & Reynolds, 1968). We were gratified when it was later chosen as a citation classic by the Institute for Scientific Information (Catania & Reynolds, 1980, p. 16). Most citations of the monograph were probably to the second of our two appendixes, which provided a rationale and formula for constructing VI schedules that generated constant response rates: Our schedule finitely approximated the output of a random generator.

At the time I write this, I have not yet closed down the pigeon laboratory at UMBC, though it operates on a very small scale. In all the intervening years I have often had reason to be grateful that Skinner had left us free to select our own research directions in his laboratory. Those opportunities to conduct our own research were crucial aspects of our early careers, and the subsequent behavior they engendered testifies to the potency of the reinforcers they provided. Finding out about behavior surely must have been one of the primary reinforcers of our laboratory behavior, because other kinds of academic reinforcers were few and far between in those later lean years when behavior analysis was often said to be a dead or dying part of psychology (if academic recognition had been the crucial reinforcer, we would all have become cognitive psychologists years ago). The Harvard Pigeon Lab is now long gone, but with the burgeoning applications made possible by behavior analysis coming into their own, we can look forward to a new watershed on the other side of which our field will move back into the mainstream where it belongs.

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APPENDIX A

Skinner's Last National Science Foundation Grant Request

HARVARD UNIVERSITY
Psychological Laboratories

Memorial Hall
Cambridge, Massachusetts

National Science Foundation
Washington 25, D. C.

ATTENTION: Dr. Henry S. Odbert

Dear Dr. Odbert:

I should like to request a grant to extend for a period of one year the research now supported by Grant NSF - G8621. Since this is probably the last application I shall make, it may be appropriate to sketch the history and present status of this research.

When I came to Harvard in 1948, the University helped me set up a small laboratory for research on the behavior of rats and pigeons. Shortly afterwards, the late Dr. Franklin V. Taylor of the Naval Research Laboratories became interested in the old wartime Project Pigeon and began work at NRL in Washington on the use of pigeons as sensing and homing devices. In connection with that work the Office of Naval Research supported unclassified research here. The Project had expanded greatly by 1955, when it began to be supported by the National Science Foundation. It has continued to receive its major support from the Foundation, the only other major contribution having been made by the Public Health Service in the form of a grant three years ago which permitted us to improve the instrumentation and organization of the laboratory.

Our major publication has been Schedules of Reinforcement by Charles Ferster and the undersigned, published in 1957. This was a sort of atlas, showing more than 900 performances of small organisms under a great variety of schedules. The use which is being made of this work, both here and abroad, continues to expand. At the recent meeting of the American Psychological Association in Chicago, for example, nearly fifty papers described work using methods or results traceable to our Project. The laboratory has also served an important teaching function. More than 40% of Harvard Ph.D.s in Psychology during the past ten years have written theses connected with it.

In addition to stimulating similar research, the methodology and formulation of behavior which have emerged are being extended into other fields--such as child behavior, speech pathology, psychopharmacology, and psychotic behavior. Several kinds of teaching machines have been direct products. A true educational technology is now possible. (In my request for a grant two years ago I indicated that our work here would be closely associated with the teaching machine field. Since then we have received generous funds for work on teaching machines and most of our research in that area, particularly under the direction of Dr. Holland, has been supported from those sources. As predicted, however, much of our work with small animals has been significant as basic research in programmed instruction. As a single example, Mr. Herbert S. Terrace has studied the possibility of learning without errors. His thesis, in preparation, will deal with

this demonstration of the difference between trial and error learning and operant conditioning.) Further extension into other areas is exemplified by an analysis of wage systems based upon our work on schedules of reinforcement by Dr. Owen Aldis who, with a degree in economics, has been closely associated with our Project for the past year and a half. A paper by the undersigned at the American Academy of Arts and Sciences, to be published in Daedalus, is an even broader extension of these principles to the design of a culture as a whole.

A valuable by-product of the Project has been a series of staff meetings which have brought together local workers in these lines of research. We began our Friday afternoon staff meetings mainly for the sake of joint discussions of current experiments. The meetings grew as people in this vicinity learned about them. It is now not unusual for twenty-five or thirty people to attend these Friday sessions. Their original function could not be served very effectively with a group of this size, and we therefore now meet only every other Friday and have added smaller weekly Tuesday meetings for our own purposes. Presentations at both kinds of meetings are always informal.

My personal plans (subject to change) call for a conclusion of my work as an experimentalist in June of 1962. I shall be on sabbatical leave for the following year and will probably be a member of the Harvard faculty for only one year after that, since it is my intention to retire (as Professor Emeritus) in 1964. Our extensive and excellently equipped laboratory will, I hope, continue to be used in related areas. Currently, Professor Herrnstein and Dr. Reynolds, members of this Department, are working closely with the Project, and it is my hope that as their own research activities expand they might come to utilize the present space and equipment. In any case, I do not feel that I am in a position to request funds beyond June, 1962, and am therefore asking only for a one-year grant.

Details of the Present Proposal

1. Institution: President and Fellows of Harvard College, Cambridge, Mass.

2. Title: Analysis of Complex Behavioral Processes

3. Starting Date: June 15, 1961

4. Period: one year

5. Areas to be covered by proposed research:

It is proposed to continue work in all the areas of interest described in our annual report of December 1, 1960 essentially as follows:

1. Some work continues in the field of schedules of reinforcement.

2. The interaction among the components of multiple schedules is under

investigation, particularly with respect to the reinforcing or aversive properties of schedule-correlated stimuli.

3. A large part of current work is concerned with situations involving two or more manipulanda and the extent to which schedule performances and interactions among them will explain "choice" and "decision-making."

4. The analysis of the processes involved in discrimination (based in part on the thesis of a former Research Associate of the Project, Dr. W. H. Morse) continues, in this case in close contact with the teaching machine project.

5. Other experiments now in progress, using techniques and equipment developed in this Project, involve the reinforcing effects of an imprinted stimulus, interocular transfer, taste limens in rats, avoidance schedules, the control of attention, social reinforcers in pigeons and young babies, and gradients of generalization (Professor Norman Guttman of Duke University will be on the Project half-time during the summer of '62, bringing to the Project his experience in the field of stimulus generalization). Two pieces of equipment have been specially constructed to study the social behavior of pigeons and rats, and we have just received our first results in an experiment designed to explore "ethological" responses to positive and negative reinforcing stimuli in an operant situation.

6. Facilities:

The present installation centers around one large unit of twenty "boxes" with associated controlling circuits and recorders, occupying two air-conditioned rooms. This highly reliable equipment operates around the clock 365 days per year. In addition to this central installation, approximately ten other pieces of equipment, each complete in itself, are located in four additional rooms. These are especially adaptable to new experimental designs. Although the original installation and replacement costs for this kind of research are considerable, they are only a small fraction of what it costs to carry out comparable research using research assistants to observe and present variables.

7. Personnel:

Chief Investigator: B. F. Skinner. Biography: Born March 20, 1904. A.B., Hamilton College, 1926; M.A., Harvard Univ., 1930; Ph.D., Harvard Univ., 1931; Sc.D., Hamilton College, 1951; Research Fellow, National Science Council, Harvard Univ., 1931-33; Jr. Fellow, Harvard Soc. of Fellows, 1933-36; Instructor of Psych., Univ. of Minn., 1936-37; Asst. Prof.,1937-39; Assoc. Prof., 1939-45; conducted war research sponsored by General Mills Inc., 1942-43; Guggenheim Fellow, 1944-45; Prof. of Psych. and Chmn. of Dept., Indiana Univ., 1945-48; Prof. of Psych., Harvard Univ. since 1948. William James Lecturer, Havard Univ., 1947. Member of Nat. Acad. of Sci., Am. Phil. Soc., Am. Acad. of Arts and Sci. Selected Bibliography: (1) A series of papers submitted in The

Behavior of Organisms, 1938. (2) A classified report of OSRD "Project Pigeon." (3) Science and Human Behavior, 1952. (4) "Are Theories of Learning Necessary?" Psychol. Rev., vol. 57, July, 1950. (5) "Some Contributions of an Experimental Analysis of Behavior to Psychology as a Whole," Amer. Psychol., vol. 8, Feb., 1953. (6) Ferster, C. B. and Skinner, B. F., Schedules of Reinforcement, 1957.

Research Associate: A. Charles Catania, A.B., Columbia, 1957; M.S., Columbia, 1958; Ph.D., Harvard Univ., 1961 (February); National Science Foundation Fellow, Harvard Univ., 1958-60.

8. Budget:

(A) Salaries	
Research Fellow (Ph.D. level)	7,200
Two Research Assistants, full time	7,150
Secretary	3,000
Clerical help, 2 persons, full time	4,500
Animal Caretaker, 1/3 time	1,200
Four (student) laboratory assistants	5,000
	28,050
Pensions, Social Security, etc.	2,200
(B) Equipment (Additional recorders, timers, and controlling equipment)	3,000
(C) Expendable equipment and supplies	8,500
(D) Travel	200
(E) Telephone, telegraph, freight, postage, etc.	500
	42,450
(F) Indirect Costs (20% of above)	8,490
GRAND TOTAL	50,940

(This increase over the per year figure in our current grant reflects increasing costs and salaries and is intended to assume other charges which

have during the past two years been paid for from other funds although they grew out of the work reported.)

9. Other Sponsors:

Only a small part of the special grant made by the Ford Foundation three years ago will be available since, with the permission of the Foundation, most of the balance will go to support the undersigned during a sabbatical leave. Where research bears on the teaching machine project, grants from the Carnegie Corporation and the Office of Education are related but under the terms of these grants cannot be used extensively for work with small animals.

Respectfully submitted,

B. F. Skinner

Approved:

Edwin B. Newman - Chairman, Department of Psychology

R. W. Pratt - Director, Office for Research Contracts

January 9, 1961

APPENDIX B

''Psycho City Saga'' Excerpts

1. Sung by the Preacher (PR), Filthy Freddy, assisted by Gentle Julius (GJ), a young townsperson, and Leaky Lou (LL), his sidekick, to the tune of ''What Is America to Me?''

PR: What is psychology to me?

GJ: A field

LL: A name

PR: A man I see
And I think that that man is me.
That is psychology to me.

The chair I sit in, its name is Edgar Pierce
I got it with reinforcement, and the competition was fierce
I reinforced the trustees, with a good contingency
Now I'm a rich professor that's psychology to me.

GJ: Now he's a rich professor, that's psychology to he.

LL: Tell us more, big daddy.

PR: And when my holy fluid, begins to take hold
I'll shape all men's behavior, and make them in my mold
And then I'll be your Frazier, your holy S-dee,
And Smutty's your S-delta, and on him you should pee.

First there was Helmholtz, then Darwin, Freud, and James
And now there is your truly, he ranks with the greatest names
And with my great elixir, I will all your troubles heal
So gather round me brethren and with your saviour kneel.

J&LL: (Kneeling) Amen.
PR: What is psychology to you?
A box? A maze?

GJ: A Skinner brew
And we know what that brew can do.

LL: Is that that right answer, big daddy?

PR: The lab we'll work in, the people we'll control,
And as our first project we'll extinguish Smutty's soul

GJ: We'll1 put him on Sidman avoidance, and give him ECS

All: We'll make the whole world over, that's psychology to us.

PR: My dear brethren, you are saved.

2. Sung by the preacher, Filthy Freddy, to the tune of ''You Can't Get a Man with a Gun''

Oh the head of this outfit is a violent man
A hard tyrant, a ruthless big shot!
I am here to reform him in what manner I can
Does that mean I should shoot him, or not?

I was still in the nursery when I learned in my versery
Laws of science aren't easily won
But Big Smutty thinks that science is a matter of compliance,
That its laws can be made with a gun.

Some say that apparatus is the only thing that mattas
Any setup less than perfect they shun
But ol' Smutty doesn't care if the lab'ratory's bare
Just as long as experiments get done!

Where's my gu-un?
Where's my gu-un?
Should I lay down the law with my gun?

Smutty's such a belly-acher, a logarithmic troublemaker
He thinks browbeating subjects is fun
He demands a power function, prods men on without compunction
But now he's about to go out in a spout
Of hot retribution from my gun!

But wait, just a minute, there is really nothing in it
There are better ways than shooting someone
Take be-havioristics, it's lots better than ballistics
Valid laws aren't made with a gun!

I think that instead you'll see me put him on a schedule
And condition him A-number one.
Though the curves may look awful his behavior will be lawful
And the law won't depend on a gun!

On a gu-un
On a gu-un
You just can't depend on a gun.

Oh, the likelihood is ample that he'll follow my example
And hereafter will violence shun
A better man he'll be, and it'll all be 'cause of me,
Yes at work and at play he will say every day
That you can't make a law with a gun.

3. Sung by Gentle Julius, to the tune of ''Home on the Range,'' in country style, gently

Don't give me a home where the buffalo roam
And the skies are not cloudy all day
I live in the lab where the people all crab

And I like it much better that way.

Oh give me a home in the great pleasure dome
Where S-dee and S-delta abound
I love the time clocks that program the box
And the relays that chatter all 'round.

Home, home in the lab
Where the rat and the white carneaux play
Where never is heard a discouraging word
You're just shot if you get in the way.

Yes that's why I say that I'll never stray
And in steadfastness I'll never fail
I'll stay right at eighty percent body weight
And follow the reinforcement trail.

Oh I'll never swerve from the cumulative curve
That tells me that I'm on home ground
Let others declare, "Give me sun and fresh air,"
Right here's where I'll always be found.

Home, home in the lab
Where the rat and the white carneaux play
Where never is heard a discouraging word
You're just shot if you get in the way.

4. Sung by Smutty Smitty and Filthy Freddy to the tune of "People Will Say We're in Love"

Smutty: Please have a drink with me
Julie would like it so
End our antipathy
Maybe we both can be right.

Freddy: I'll have a drink of yours
If you'll have one of mine,
Without regrets, of course.
Maybe we both can be right.

Both: We'll try each other's drink,
It can't be bad as all that,
And we will begin to think
Maybe we're both right at that.
(They drink)

Both: Our drinks identical,
We've been the same all along.
How coincidental,
It seems we both have been right.

5. Sung by the entire cast to the tune of "Oklahoma"

Psycho City, where the newest power functions grow
It's the quantum town
Which has won renown,
And we know that Smutty's made it so.

Psycho City, run by Smutty Smitty and his crew (Power functions!)
He's got Big Joe's gun
To make brave men run,
And there's sheriff Dirty Eddie, too.

Subjected to all kinds of laws,
All we subjects will work without pause,
Because we know (yeah!) that Smutty's said it's so (yeah!)
And since he said it,
We'll go on turning out functions and we'll function—okay!

Psycho City, where it's pigeons that will run the show,
Reinforcement's tops,
And it never stops
And we know that Filthy's made it so.

Psycho City, run by Filthy Freddy and his guys (Reinforcement!)
There is Leaky Lou
Set to pee on you,
And there's Julie here to theorize.

Oh, the lab we belong to is drab,
And the price of a coke is a joke.
But still we know (yeah!) that we're stuck in it, so (yeah!)
Since we are in it
We'll keep collecting our data, it won't matta—at all!