H A R V A R D M E D I C A L S C H O O L

Department of Psychiatry

B E H A V I O R R E S E A R C H L A B O R A T O R Y

Metropolitan State Hospital, Waltham, Massachusetts

PROGRESS REPORT I

Report for the first year and one half on

AN EXPERIMENTAL ANALYSIS OF PSYCHOTIC BEHAVIOR

Period covered: 1 December 1954 - 1 June 1956

Research Grant MH - 977

from the

National Institute of Mental Health

of the

National Institutes of Health, Public Health Service

Project Number: Research Grant MH - 977 from the National Institute of Mental Health, of the National Institutes of Health, Public Health Service.

Project Title: An Experimental Analysis of Psychotic Behavior

Project Directors: B. F. Skinner, Professor of Psychology, Harvard University.

Harry C. Solomon, Professor of Psychiatry, Harvard Medical School, and Director, Boston Psychopathic Hospital.

Report Prepared By: Odgen R. Lindsley, Research Fellow, Harvard Medical School and Director, Behavior Research Laboratory.

Period Covered: 1 December 1954 to 1 June 1956.

Previous Reports: None.

Additional Support: In addition to the grant from the National Institute of Mental Health, the laboratory was supported by Contract N5-ori-07662 sponsored by the Group Psychology Branch, Office of Naval Research, since 1 June 1953. Work done under the ONR Contract is not included in this report, but will be reported in ONR Status Reports.

A. SUMMARY STATEMENT:

The laboratory was expanded by adding five new experimental rooms, a patients' lounge, toilet, and treatment room to the two experimental rooms previously constructed with Navy funds. The new rooms are of improved standard design containing apertures for social communication between rooms, periscopic observation systems, and destruction-proof work panels and lights. Improved reinforcement magazines, controlling circuits, and a new manipulandum for humans have been constructed. By working closely with local manufacturers we have made all of this equipment commercially available and approved for hospital use.

A battery of standard clinical tests has been administered to provide methodological comparisons and objective descriptions of our patients. Thus we have added more meaning to our measures by showing how they relate to earlier, more widely-known measures of psychotic behavior. Clinical tests could be administered to only 45% of the patients we have studied using the operant method, showing that the method significantly increases the number of patients whose behavior can be objectively measured.

The ratings of the ward behavior of our chronic patients correlated positively (+.82, $P < .001$) with their rates of response, showing that our experimental measures have generality in predicting ward behavior.

The rates of response of unhospitalized individuals have been extensively analyzed and are higher and more stable than the rates of chronic patients.

LABORATORY PERSONNEL

During the period covered by this report the following personnel have been members of the laboratory staff:

B.F. Skinner, Ph.D., Director. Professor of Psychology, Harvard University.

Harry C. Solomon, M.D., Director. Professor of Psychiatry, Harvard Medical School.

Ogden R. Lindsley, Ph.D., Chief Investigator, Research Fellow, Harvard Medical School.

* Martha Mednick, Ph.D., Clinical Psychologist, Harvard Medical School.

*Nathan Azrin, Ph.D., Graduate Research Assistant, Harvard Medical School, Department of Psychiatry.

Richard Flavin, Undergraduate Research Assistant, Harvard Medical School, Department of Psychiatry.

*Herman Teitelbaum, Undergraduate Research Assistant, Harvard Medical School, Department of Psychiatry.

Robert C. Dalrymple, Laboratory Assistant, Harvard Medical School, Department of Psychiatry.

William J. Nichols, Senior Technician, Harvard Medical School, Department of Psychiatry.

Mollie D. Boring, M.A., Secretary, Harvard Medical School, Department of Psychiatry.

*Mary V. Hall, Secretary, Harvard Medical School, Department of Psychiatry.

John Bixby, Laboratory Custodian, Harvard Medical School, Department of Psychiatry.

* The individuals with asterisks before their names are no longer on the laboratory staff. Dr. Mednick is now a USPHS Post Graduate Fellow affiliated with the project.

The following personnel have been of assistance to the project:

Jack Ewalt, M.D., Commissioner of the Massachusetts Department of Mental Health, made available the facilities of the State Hospital system.

LABORATORY PERSONNEL (Cont'd)

William F. McLaughlin, M.D., Superintendent of the Metropolitan State Hospital, provided the research space and hospital facilities.

Myer Asekoff, M.D., Director of Clinical Psychiatry at the Metropolitan State Hospital, assisted in the selection and care of the patients.

Karl Theo Dussik, M.D., Research Fellow, Boston Dispensary, and Assistant Physician at the Metropolitan State Hospital, assisted in the selection, care and medication of the insulin patients.

Sol Sherman, M.D., Senior Physician at the Metropolitan State Hospital, assisted in the care and medication of the patients who received pharmacological treatments.

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B. FULL STATEMENT OF PROGRESS

B1. Laboratory Expansion

Approximately one year was spent in designing, constructing and equipping our 5 new experimental rooms. Figure 1 is a floor plan of the basement of A building in the Metropolitan State Hospital. The laboratory shop and experimental rooms 1 and 2 were constructed three years ago with ONR funds. A room that existed in the basement was occupied as a laboratory data-room and office. The dashed lines in Figure 1 represent the walls constructed with Public Health Service funds. They are of 8 inch cinder block and enclose experimental rooms 3, 4, 5, 6 and 7, the patients' waiting room, toilets, and a treatment room. Rooms 8, 9, 10, 11 and apparatus area B were also constructed with Public Health Service Funds.

The patients' waiting room was placed in operation in October 1955. It is approximately 20 by 30 feet in size and will seat 20 patients at one time. It is used as a comfortable place where the patients wait their turn in the experimental rooms or to be returned to their wards upstairs. A radio plays soft music, and magazines and books are available to the patients while they wait. The walls are painted buff and dark orange, and the chairs are painted different bright colors. We plan to use this lounge as a place in which to record a controlled sample of the patients' behavior for comparison with the experimental behavior and the behavior on the ward. The patients usually spend either mornings or afternoons in the waiting room. It has earned the reputation of being one of the most attractive rooms in the hospital as shown by the requests of some patients to stay in the lounge all day.

The treatment room is a small 7 by 4 foot room containing a sink, scale, table and 2 chairs. It is used for taking oral temperatures, body weights and giving a routine examination to each patient each day. It is also used for any medication that should be given in the laboratory.

Two toilets and a utility room were also constructed. Each is about 7 by 4 feet in size and is painted a combination of pleasant pastel colors.

The experimental rooms are approximately 6 1/2 feet square with 9 1/2 foot celings. They have light blue paint on the cinder-block walls and white acoustic tile on the ceilings. The doors are heavy solid-core metal clad hospital doors painted gray. All 5 new experimental rooms are now in operation.

Room	7	was	placed	in	operation	on 25 August 1955
"	5	"	"	"	"	29 August 1955
"	6	"	"	"	"	8 November 1956
"	3	"	"	"	"	21 March 1956
"	4	"	"	"	"	26 March 1956

Each experimental room contains a chair, ash tray, and the standard manipulandum panel that we have developed for experimentation with human subjects.

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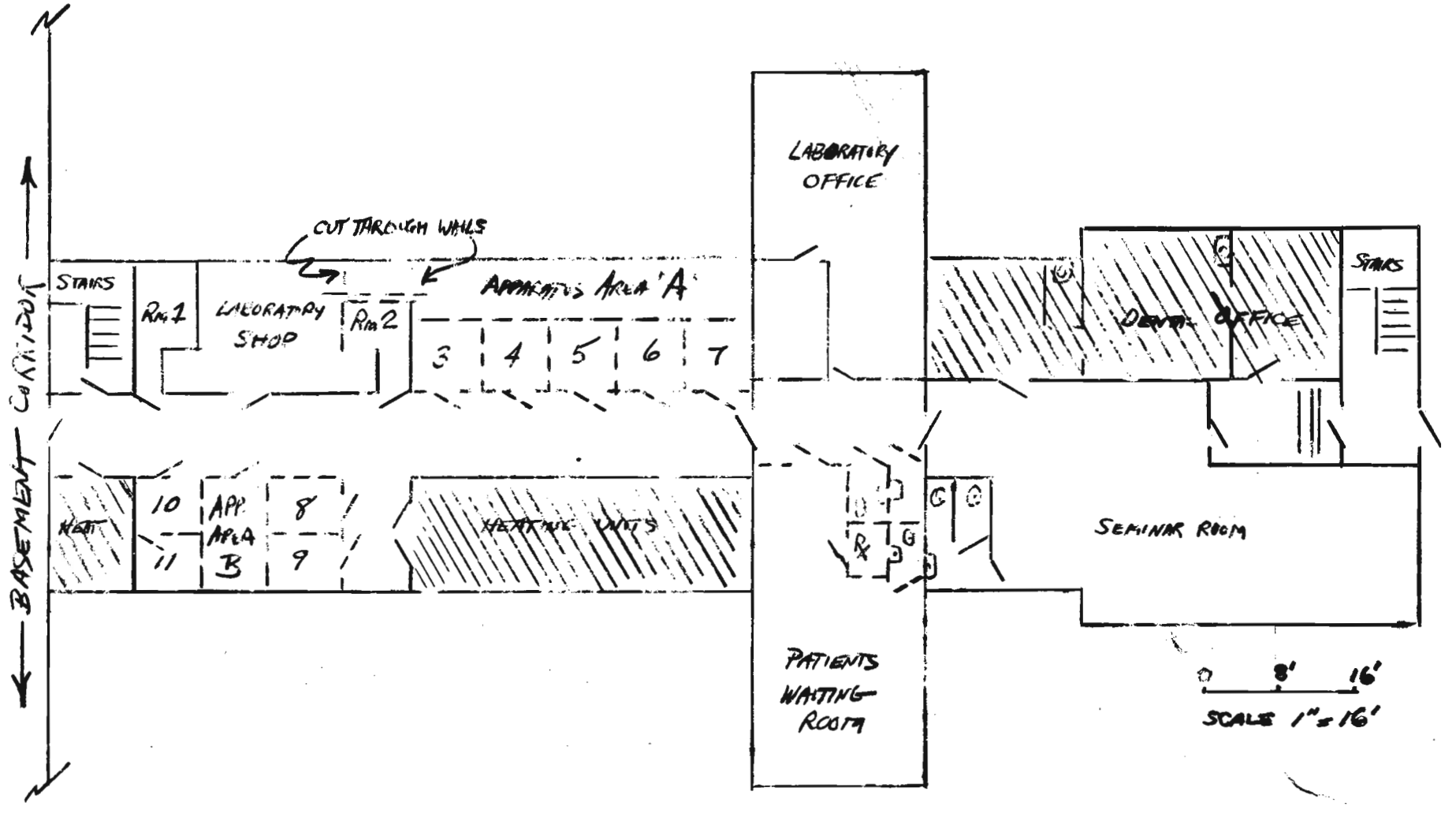

FIGURE 1 - A BASEMENT, METROPOLITAN STATE HOSPITAL

— ALL EXCEPT SHADED AREAS ARE USED BY BEHAVIOR [illegible].
SEMINAR ROOM IS SHARED WITH OTHER HOSPITAL FUNCTIONS.

— DASHED LINES REPRESENT INTERNAL CONSTRUCTION [illegible]
WITH PUBLIC HEALTH SERVICE FUNDS.

The data capacity of these 5 new rooms is 6 patient-hours of data per day per room - a total of 30 patient-hours of data per day. This increases our total laboratory capacity from 12 patient-hours to 42 patient-hours of data per day (200 per week or 10,200 per year). In actual use we cannot maintain this theoretical maximum due to scheduling problems and apparatus repair and modification, but we never drop below 80% of this maximum or 30 patient-hours per day (150 per week or 7,300 per year).

Apparatus Area A is a long narrow corridor with facilities for observing the interior of each new experimental room. It has acoustic tile on the walls and contains the electrical controlling equipment for the automatic operation of each experimental room.

Apparatus Area B is now used for storage, but it is designed to be used as an auxiliary recording and control area in case of further expansion.

Rooms 8, 9, 10, and 11 are constructed in the same fashion as the new experimental rooms 3, 4, 5, 6, and 7. Room 8 is currently used for mental testing. Room 9 is fitted with a couch where a sleep experiment is being conducted. Room 10 is used for storage, and Room 11 houses small animals. These rooms can be used as additional experimental rooms, for small animal research, or as small offices in the case of further expansion.

B2. Experimental Room Standardization

We have successfully constructed indestructable fittings for the experimental rooms which meet all the criteria for good operant conditioning equipment. Psychotic humans appear to be the most destructive subjects yet investigated. All parts of the rooms must be strong enough to be struck with shoes or parts of the chair and still remain operative. The patients will unscrew any bolt or screw-head that is showing and they will poke wires in any crack or crevice that is available. The electrical equipment must be waterproof to prevent shorting in cases of urination.

We have designed and constructed a standard manipulandum for human operant conditioning research. It is sensitive, indestructible, has stood up well under use, and has generated "clean" rates of response. It is being used by 7 of the 18 laboratories planning human operant conditioning programs, which should make our collective data more uniform and more easily interpreted. The device is described in detail in our Navy Status Report V, and it is commercially available from Ralph Gerbrands, 96 Ronald Road, Arlington, Mass.

A standard manipulandum panel has been designed which is mounted in each room. The manipulandum, reinforcement delivery tray, and any visual stimuli that are used are mounted in this sloping 3/4" thick plywood board placed at an angle of 60° against one wall of the rooms.

We have found that a sloping work surface stands up best under rough use and is quite comfortable to work at for long periods of time (8 continuous hours of responding have been recorded).

The walls between the experimental rooms contain thick plexiglass social windows. The interior of each experimental room and the surface of its manipulandum panel can be observed from the neighboring rooms through these windows. This "visual-yoking" of experimental rooms is necessary in studying social behavior (competition or cooperation) that is dependent upon visual communication. We have designed the rooms so a small area is hidden from the view of neighboring rooms. If a patient withdraws into this hidden area during a social experiment, we can automatically record the frequency and duration of these "full social withdrawals". When the rooms are used for individual experimentation an opaque slide is placed between the windows which eliminates visual communication and attenuates auditory communication between the rooms.

Along the ceiling of each room is a ceiling screen of perforated steel with holes so small that nothing behind it can be seen from within the room. Behind this are placed microphones, speakers, bells or horns used in recording behavior or presenting stimuli. An exhaust fan is also behind each screen.

We experienced great difficulty designing an observation periscope to observe the entire interior of each room through the ceiling screen because an extremely wide-angle lens was needed. A suitable lens was finally located in war-surplus and we now have an excellent hidden observation system that can be used for photography and does not have the obvious property of the half-silvered mirrors more commonly used.

B3. Standardization of Controlling Equipment

Previous experience had taught us that some time spent in the design of high quality scheduling equipment would save much time spent in trouble-shooting and experimental break-down. We also wanted equipment that would be "shock-free" and would pass the electrical underwriters test so that it would be safe to use in hospitals. If it was also commercially available other researchers would find it easier to set up laboratories in a hospital setting. In collaboration with Grason-Stadler Company, Concord, Mass. we designed and constructed complete automatic controlling equipment that is standardized, safe, and commercially available. It is rack-mounted to facilitate storage and moving and utilizes high quality 24 volt D.C. equipment where possible. We have found that this time was well spent for in the year that our new equipment has been in operation we have not lost an experimental hour due to apparatus failure. This is very important in research with psychotics because our subjects and their behavior are often so unique that it would be impossible to replace them if the experimental design was destroyed by apparatus failure.

B4. Development of Rate Analyzer

For many years those involved in free operant conditioning have discussed an apparatus that would record rate of response directly. We now record cumulated responses against time, and the slope of this record gives us the rate of response. Since our primary datum is rate, it would seem appropriate to record it directly with some sort of "speedometer". No device with the temporal properties needed in operant conditioning research was commercially available and attempts to construct such a device by using differential gears were not successful. We had an immediate need for such a device so that we could illuminate pictures in front of the patients as a direct function of their rate of response. This apparatus was to be the crucial part of our attempt at using the reinforcing value of pictorial material as a diagnostic device.

It is possible to construct such a device electronically by storing pulses from each response on a capacitor which leaked off this charge at a constant rate. The charge on the capacitor at any instant would represent that rate of incoming pulses or responses. This charge could then operate a servo for recording the rate of response or controlling the intensity of visual or auditory stimuli. From our specifications Grason-Stadler Company designed and constructed a prototype "Rate Analyzer" which is now commercially available. This apparatus has many uses in a free operant conditioning laboratory for recording responses or presenting stimuli as a direct function of the local rate of response.

B5. Clinical Correlates of Rate of Response

Until recently the only clinical measures available for the patients were their admission I.Q.'s, admission diagnoses, and the periodic psychiatric evaluations entered in the patients' case histories. Further clinical testing using standard test devices was conducted for the following three reasons: (1) It would provide an objective description of the patient population we are studying in terms that the clinical psychologist and psychiatrist understand. This is important in evaluating our research and in comparing our population with the populations studied by other research projects. (2) To investigate the possibility of correlations between the standard clinical devices and measures of the free operant rate of response. Such correlations might give promising research leads and would make the operant data more easily interpreted and integrated by the clinically trained persons. (3) To permit a comparison of the standard clinical and the free operant methods of investigation in terms of the percent of the hospital population accessible. Presumably the free operant method should reach a larger proportion of patients because it is non-verbal and non-social and contains the maximum amount of reinforcement.

In our previous ONR Status Reports we suggested a relationship between the rate of response of Chronic Psychotics on a variable-interval schedule of reinforcement and "severity of illness or depth of psychosis".

The patients who responded at the very low, erratic rates were from the disturbed wards, were unable to work in hospital industries, and were untidy and less able to care for themselves than the patients who responded at high, even rates. The nature or topography of the disturbance (i.e. catatonic, manic, depressed, etc.) did not seem to correlate with the rate of response, but the degree of the disturbance did seem to correlate. We had no quantitative measure of this "depth of psychosis". The rate of response correlated positively with the "ability to work" as rated on a ten point scale of our own design. Ratings of the patients' verbal behavior and social rapport did not correlate with the rate, neither did the admission I.Q.'s nor the total years of hospitalization for mental illness. Therefore high correlations with the standard clinical tests were not anticipated.

Dr. Martha Mednick was the clinical psychologist who was hired to initiate this testing program and to select the clinical test battery. She conducted the testing of all the patients when she was completely ignorant of the case histories of each patient and the operant data of each attendant and patient. This precaution was taken to eliminate any possible source of unconcious bias from the testing situation.

Intelligence tests. We used a short form of the Wechsler Bellevue I (WBI) in an effort to explore the relationship of currently tested intelligence to rate of response. This short form consisted of Vocabulary, Comprehension, Picture Completion and Block Design and was found by Patterson[1] to correlate .96 with the full scale WBI in a heterogeneous psychiatric population, as well as in a population of normals. If the WBI could not be used on a patient, the Ammons Full Range Picture Vocabulary Test, Form A (APV) was tried in order to determine whether a less complex type of test (depending very slightly upon verbal instructions) could be administered. The measure of intelligence obtained by use of the Ammons test is of dubious validity, since such patients could scarcely communicate at all.

Personality tests. The Rorschach test was chosen as a personality measure since it could be administered with a minimal amount of verbal communication. Attempts were made to relate the various Rorschach scores to the rate of response.

Psychological test behavior rating scale. The Tulane Behavior Rating Scale (TBS), developed by King in his work on the psychomotor behavior of schizophrenics[2], was also used. This scale represents an attempt to assign a quantitative measure to the behavior of the patient during the actual psychological testing. The TBS consists of 12 sub-scales, each having a possible range of scores from 0 to 40. The highest possible score is thus 480 -- which would represent an adequate adjustment to the testing situation. The TBS was scored by the clinical psychologist immediately following each testing period.

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1. Rabin, A.I., and Guertin, W.H. Research with the Wechsler-Bellevue test: 1945-1950. Psychol. Bull., 1951, 48, 211-241.

2. King, H.E. Psychomotor Aspects of Mental Disease, Cambridge, Mass. Harvard University Press, 1954.

We chose the L-M Fergus Falls Behavior Rating Sheet (LMBS) as a measure of ward behavior[3] because it met the following criteria: (1) It is brief and simple and can be understood and filled out by the average hospital attendant, whose maximal cooperation we enlisted. At this hospital the attendant is the person most likely to have an overall picture of the chronic patient. (2) The LMBS is restricted to currently observable behavior with emphasis upon what the patient is actually doing. It does not deal with constructs and inferences which are almost always less reliable than the behavioral descriptions from which the inferences were drawn. (3) The scale has been used with a chronic population and is sensitive to differences within such a group. (4) It is a simple indicator of gross disturbance, independent of psychiatric diagnosis. (5) The LMBS picks up behavior changes in a patient over a short length of time (two weeks). This is in line with our aim of making periodic correlations of rate of response and these behavior ratings. The LMBS covers eleven areas of behavior. Each ranges from a rank of one for the lowest level to a rank of five for the highest., and the average is taken as the final score.

The results of attempting to test 6 normal attendants and 22 chronic psychotic patients are summarized in Table 1. Ten of the patients were untestable (1 left the room after five minutes, 3 continually hallucinated, and 6 were either unable to understand directions or communicate their answers). Therefore 45% of the patients that will enter the experimental rooms each day and respond at some low rate for candy reinforcers are not testable by the standard clinical tests. To date we can study 70 to 80% of the patients we approach on the wards with the operant method. Twenty per cent of the patients refuse to leave the wards. With special training techniques (starting reinforcement on the wards) we probably can decrease the number of patients who refuse. Thus 80% of the chronic hospital population is reached by the free operant techniques and about 40% by the standard clinical tests.

There was no difference in the total number of years of hospitalization between the testable and untestable patients. Ward Assignment was quantified by assigning a score of 5 to patients on the admission wards, 4 for patients on parole wards, 3 for the locked wards, 2 for the untidy wards, and 1 for the disturbed wards. Note that the median ward score for the testable patients was significantly higher ($P = .06$) than that for the untestable patients. This shows that the untestable patients tend to be on the more restricted wards.

The intelligence test (WBI, scores for the attendants were approximately normal (Median 107) and significantly above ($P = .05$) the I.Q.'s of the testable patients (Median 84). The Rorschach variables reflect the restriction usually found in the chronic psychotic.

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3. Lucero, R. J., and Meyer, B. F. A behavior rating scale suitable for use in mental hospitals. J.clin.Psychol., 1951, 7, 250-254.

Table 1.

A summary of the clinical measures from a group of patients and normal subjects together with three measures of their operant rate of response. Except for "N" all values not in parentheses are medians for the group. The numbers inside the parentheses are P values for two-tailed Median Tests done between the entries immediately above and below the P value concerned. When no P value is entered the test was not significant.

Subjects		N	Yrs. Hosp.	Ward Assgnmt.	WBI	Rorschach R	W	M	F+%	Ratings TBS	LMBS	Rate of Response Measures R/Hr.	IRT	#IRT
Normal Attendants		6	---	---	107	13	8	2	95	480	5.0	9,566	0	2
					(.05)	-	-	-	(.05)	(.01)	(.01)	---	(.01)	--
Testable Patients	(55%)	12	18	3.3	84	11	9	0	86	306	3.1	1,421	41	44
			—	(.06)						(.01)	(.01)	(.04)	(.01)	(.07)
Untestable Patients	(45%)	10	3¼	2.6	-	-	-	-	-	21	1.9	19	58	9

This restriction was particularly evident in the low number of responses (R), poor language usage, and meager content of the responses. The F+% of the testable patients was significantly below that of the attendants ($P \approx .05$).

The attendants scored significantly higher on the Tulane Behavior Scale ratings (median 480) than the testable patients (median 306) who scored significantly higher than the untestable patients (median 21). This shows that the three groups differ significantly in their adjustment to the testing situation. The median rating for all 22 patients in our sample was 100, with a range of 0 to 350. The populations reported by King in his development of the scale received mean scores from 299 to 399. Therefore, it is clear that our patients were more disturbed and less accessible to testing than the patients studied by the Tulane group. To be sure that we were using the scale in the same fashion that King did, we sent him written descriptions of how 5 of our patients behaved in the testing situation. King scored these patients lower than we had originally rated them. The difference between our ratings and King's ratings cannot be attributed to rater bias, therefore.

The Lucero-Meyer Fergus Falls Behavior Ratings (LMBS) also significantly separated the attendants (median 5.0) from the testable patients (median 3.1) who were rated significantly above the untestable patients (median 1.9). The median for the 22 patients was 2.3, with a range of 1.3 to 3.8. These values compare favorably with the median score of 2.5, with a range of 1.3 to 4.7 obtained by Lucero and Meyer in their original reliability studies for the scale. Since the rating scores are so similar we can conclude that our population behaves about the same on the wards as did the population studied by Lucero and Meyer in the Fergus Falls Hospital.

The median number of responses per hour (R/Hr) for candy reinforcers delivered on a one-minute variable-interval reinforcement schedule for the ten hours nearest to the date of the LMBS rating was used as a measure of the operant rate. The median R/Hr. for the attendants (9,566) was not significantly above the median rate for the testable patients (1,421). However, one attendant had a relatively low rate of response. Independently, the tester had reported that the quality of this individual's performance seemed to indicate the presence of serious psychological problems. The attendant later volunteered the information that he was currently undergoing psychotherapeutic treatment, lending support to the clinical impression and the operant recording of a deviation from normal. However, since this person was unhospitalized he met our current experimental definition of "normal". The median R/Hr. for the testable patients (1,421) was significantly above the median R/Hr. for the untestable patients (19).

The median sum of the inter-response times greater than ten seconds (Σ IRT$>$10") and the median number of inter-response times greater than ten seconds (#IRT$>$10") were computed for the same ten experimental sessions (one hour-long sessions per weekday). These two measures measure the amount and frequency of pauses over 10 seconds duration in responding. We have previously reported that pausing on a

variable-interval schedule of reinforcement is one property of psychosis. It is during these pauses that many psychotics engage in their particular individual symptoms (pacing, talking, rolling on floor, etc.). These two measures approximate the duration and frequency of "psychotic" distraction that interferes with the stable rate usually produced by the variable-interval schedule.

The median sum of the inter-response times greater than ten seconds (ΣIRT>10") significantly separates the normal subjects from the testable patients. The significance of the difference between the median ΣIRT>10" for the testable patients and the untestable patients is greater than the significance of the difference between the respective R/Hr. which shows that the ΣIRT>10" is a more sensitive measure of the presence of "psychotic distractions" than is the over-all R/Hr.

The median number of inter-response times greater than ten seconds (*IRT>10") is not as sensitive under these conditions as is the ΣIRT>10", but it does show significant differences between the normals, the testable and the untestable patients.

There are, of course many possible inter-correlations between these measures shown in Table 1. Only two of the more important are reported here. The median R/Hr. was not related significantly to R/Hrs. taken at random at any time the patients were rated on the LMBS. But the R/Hr. nearest to the actual date of rating correlated +.82 with the LMBS score for all 22 patients (Rank-difference correlation, $P < .001$). This indicates that the patients showing good hospital adjustment had a higher rate of response in the experimental rooms and demonstrates some predictive generality of the operant rate. It also fits in with our notion that the "degree of psychosis" or "strength of psychosis" can be measured by the duration and frequency of its interference with a stable rate of adjustive behavior maintained by some strong reinforcer. The TBS and LMBS scores were positively related (Olmstead-Tukey Corner Test, $P < .001$), which shows that adjustment to the testing situation is positively related to adjustment to the hospital situation. The TBS was also related to the R/Hr. but this was not as significant ($P < .02$) as the above relationships, so that although testability is related to the rate it is not as closely related as is the patients' ward behavior.

It must be emphasized that the relationships described here hold only for the chronic psychotic. There is indeed some suggestion that the relationship between rate and severity of illness might not hold or might be reversed in acute patients. G. F. King, et al, found at the V. A. Hospital in Battle Creek Michigan, in a test of our hypothesis, that severity of illness was not related to operant rate in acute psychotics. However, he used rating scales to measure "severity of illness" that placed most of their emphasis upon inferences rather than on direct description of observable behavior as does the LMBS. Most of these inferences are usually based on the patients verbal behavior, and as such would be heavily loaded with verbal factors as are the standard clinical tests. We have shown that the rate in the chronic psychotic does not correlate with his verbal behavior, but does correlate highly with his ward behavior and his

cooperation in the testing situation.

In summary, the clinical testing showed that our patients are representative of the average patients in a large state hospital (Fergus Falls) and they are more severely disturbed and not as accessible via ordinary means of communication as the psychotic patients generally used as experimental subjects (The Tulane Study). Forty-five per cent of the patients who were accessible by operant techniques were inaccessible to clinical tests. These untestable patients were hospitalized no longer, but were assigned to more regressed wards than the testable patients. Normal attendants, testable patients, and untestable patients all scored significantly different on testability, "ward behavior", and rate of response measures, thus showing that the rate of a free operant response correlates highly with other measures of the "degree of psychosis". The free operant method reaches approximately 80% of the chronic population of a large State Hospital, while the standard clinical tests reach only about 40% of such a group.

B6. Normal Control Data

Although it may appear to experienced operant conditioners to be a tour-de-force or a waste of time, we felt that since we were basing so much emphasis on the low and erratic rates of response of the psychotic, we should, perhaps make absolutely sure that these pauses were not a property of the human being. They are not present in the behavior of lower organisms on a variable-interval schedule under these conditions, but data from normal humans held on a variable-interval schedule for a long time have never been collected. (Some critics have suggested that it is "normal" for a human to become bored and pause often when he is "forced" to respond in such a simple situation, etc.,etc.) In order to finally answer such questions we studied 5 normal attendants for 50 hour-long experimental sessions, one session per day, on the same schedule and in the same room we used for the patients. Nickels were used as reinforcers (as they have been with patients also) and a subject could receive as much as $3.00 an hour for pulling the manipulandum. At the end of each experimental session we asked the subject how many responses he made and how many nickels he received.

Results: In general it is clear that the normal subjects respond at high, even rates of response on the variable-interval schedule, and that this rate is maintained for as long as 50 experimental hours. The normals' rates of response were significantly above the patients' rates, and the sum and number of inter-response times greater than ten seconds for the normals were significantly lower than the patients' values. These were the main results we were looking for.

However, a number of interesting phenomena were observed during the course of the experiment which had not been anticipated. Although there was fairly large individual variability, all of these phenomena

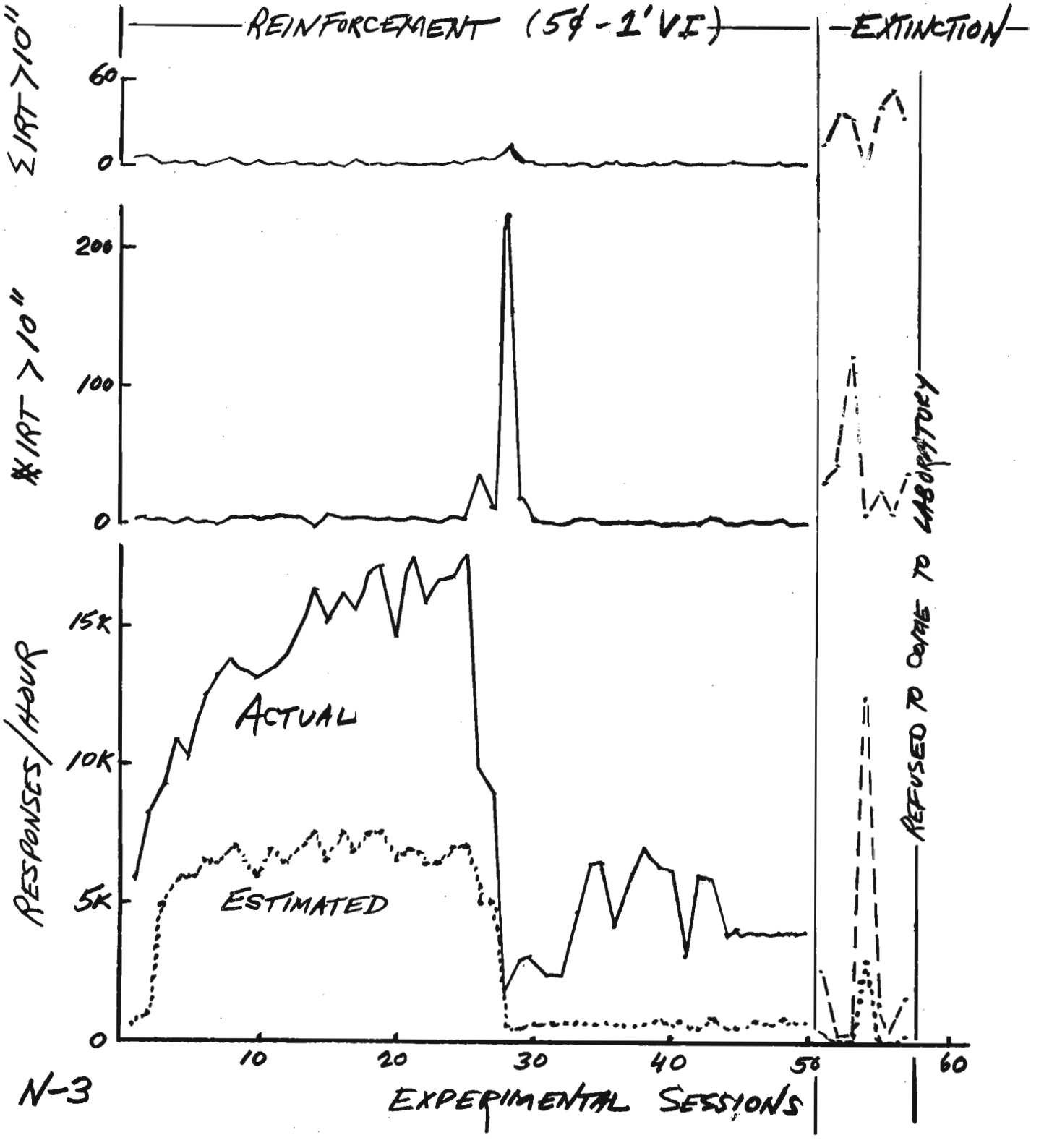

FIGURE 2. DATA FROM A NORMAL ATTENDANT RESPONDING FOR NICKELS ON A ONE-MINUTE VARIABLE-INTERVAL SCHEDULE FOR 50 HOURS, FOLLOWED BY 7 HOURS OF EXTINCTION.

are illustrated in Figure 2, where the number of responses per hour, the number of inter-response times greater than ten seconds, and the sum of the inter-response times greater than ten seconds are plotted for each experimental session. The subject's estimate of the number of responses he made that day is also plotted. There were 50 hours of reinforcement with nickels on a one-minute variable interval schedule followed by 7 hours of extinction, at which time the subject refused to come to the laboratory. Unless the subjects are forced into the rooms or reinforced for just entering the room, very few trials during extinction are recorded before the subjects refuse to participate in the experiment. (Lower animals don't do this because they are forced into the experimental enclosures). All of the normal subjects refused after 7 hours of extinction or less. Some of the patients also refuse to enter the rooms during extinction, but others will go on for years without any reinforcement.

The number of estimated responses is usually less than the actual number of responses, depending upon the absolute rate of response. Note that the estimated responses also follow a different form than the actual responses; they reach an asymptote sooner in most cases.

Note also that the number of actual responses gradually increased for about 20 sessions was stable for about 5 sessions and then sharply fell to a value of about 2,000 R/Hr. This sharp drop in rate to a low value (which is more appropriate to the variable-interval schedule) is similar to the sharp changes in learning curves that used to be described as "insightful". Note that the # IRT > 10" increased only while this change in rate was occurring. The same thing occurred during extinction. This behavior of the # IRT > 10" as the first derivative of the rate, or the second derivative of the responding, might prove useful in measuring the dynamic aspects of psychosis (cycles, rapid discrimination changes, etc.). Note also that the Σ IRT > 10" stays at a low value until extinction (which we would predict in a normal subject).

We plan to continue the use of a limited number of normal control subjects when ever we discover a behavior anomaly that we feel is indicative of psychosis. Thus we can screen our psychotic population looking for behavior patterns that deviate from what we would expect on the basis of the lower animal research of the past 30 years. When we discover such an anomaly we can then run a few normal controls to make absolutely sure we do not have a species difference rather than a form of psychotic aberration.

B7. Pure Tones as Aversive Stimuli

There are many reasons for assuming that the behavior involved in escape, avoidance, fear, and anxiety might be different from the normal with psychotic patients. In order to study these behaviors experimentally, an aversive stimulus is needed. Electric shock-grids are used to deliver shocks to the feet of lower animals for this

purpose in most experiments. This is, of course, out of the question with human subjects (although shocks to the head are often described as therapeutic). Loud noises have been used as aversive stimuli with lower organisms, but they would disturb the hospital personnel since our rooms are not sound proof. Pure tones have produced escape and avoidance behavior in some patients. The tones will elicit escape and avoidance from all normal subjects tested. We have used tones of 120, 2,000, and 3,000 cycles per second of intensities approximately 90 db above the human threshold. At this time an oscillating tone between 2,000 and 3,000 cycles seems to be the most aversive. We have to permit the patients to respond for candy while the tone is on in order to keep them from escaping from the experimental room.

Our preliminary results show that 5 out of 12 patients (42%) have responded to escape a 2,000 cycle tone on regular reinforcement. One of these 5 patients had never responded at a high rate for any of the positive reinforcers we had used to date (candy, nickels, food, cigarettes, pictures, and music). Seven out of the 12 patients had their rate of response for the candy reinforcers suppressed by the tone. Two out of the 12 patients (17%) had their candy rate facilitated or increased by the tone escape behavior. This is very interesting from a theoretical point of view for it shows that a stimulus (and or its elicited responses) can have aversive properties (producing escape behavior) and facilitative properties (increasing the rate for candy reinforcement) at the same time in a single individual. Any attempt to call this a special case will only lead to arbitrary decisions and much trouble in description.

We are currently using the Rate Analyzer (described above) to control the intensity of the aversive tones. In this way the faster the patient responds, the less intense becomes the tone. Such control permits the patient to move gradually from escape to avoidance behavior independent of experimental manipulation. In cases where his avoidance or escape thresholds might shift (due to adaptation or psychotic cycles, etc.) the method is self-corrective. The self-corrective property is also useful if the patient's behavior is so cyclical that he can avoid adequately on one day, but is only capable of escape on the next day. The Sidman technique has some of these properties, but we have found that patients become quite upset before they learn the appropriate response sequences.

B8. Investigation of Social Behavior

The 5 new experimental rooms are designed so that they may be used to study social behavior by opening the "social windows" connecting the rooms. We have not yet progressed beyond the exploratory stage with this research. We have investigated the effect of simply opening the window, so that a slow, regressed patient may observe an active patient responding at a high rate. This "imitation" operation does not appear to increase low rates of response. We have also investigated the effect of imitation, demonstrations and verbal commands from the experimenter. In some cases such aids have increased the

rate of response of slow patients, but in other cases the patients have not reacted to these treatments. We soon plan to investigate the cooperative ability of the patients by reinforcing them for making cooperative responses.

B9. Investigation of Vocal Behavior

We do not have the facilities to extensively investigate the vocal behavior of patients. We need microphones and voice keys so that we can automatically record and present vocal stimuli. Also, the room should have better sound attenuation than the cinder block walls provide. In some exploratory work we have brought the hallucinatory vocalizations of one patient under the control of external stimuli. We have also noticed that certain sounds will elicit large amounts of hallucinatory behavior in some patients.

B10. Publications

The following publication includes work done under this grant and contains a detailed summary of the apparatus and method. A copy of this article and of its discussion is enclosed with this report.

Lindsley, Ogden R., Operant Conditioning Methods Applied to Research in Chronic Schizophrenia, Psychiat. Res. Rep. 1956, 118-139, 147-153.

The following article contains a discussion of the problems involved in measuring psychotic behavior. Reprints are not yet available.

Skinner, B. F. What is Psychotic Behavior? Chap. in Theory and Treatment of Psychosis: Some Newer Aspects., Washington University, 1956 (in press).

C. PLANS FOR THE FUTURE

C1. Clinical Correlates

We plan to continue using the LMBS ward behavior rating scale to determine whether weekly ratings will vary with the cyclical changes we observe in the behavior of some of the patients. We also plan to complete the clinical testing of our patient population so that we will have a complete psychological description of our patients for correlation with the various operant behaviors we generate.

We plan to have a competent psychiatrist evaluate our patients so that we will have a recent evaluation to use in describing our patients to persons trained in Psychiatry. Such evaluations might also suggest interesting research leads to use with individual patients.

In collaboration with Dr. Joseph Matarazzo of Harvard Medical School and Mr. Charles Orth of the E. D. Chapple Co. we plan to measure the verbal behavior of our most adjusted patients in the interview situation using the Chapple Interaction Chronograph. We feel that the use of this device will again add descriptive and interpretive data to our patient population.

C2. Social Behavior

It is planned to "yoke" two experimental rooms for the study of cooperation in the near future. We feel that many of our patients that respond fairly well when alone, will experience difficulty when they must respond in a social situation in cooperation with another patient. We also plan to study altruism, sadism, and competition in a similar fashion.

C3. Vocal Behavior

If we can equip a room with sound attenuation, a microphone and appropriate voice keys, we plan to record the frequency of hallucination at the same time that we record the rate of the operant motor response. We have noticed that the occurrence of these "hallucinatory outbursts" is in many cases a function of events in the immediate physical environment. An experimental analysis of the stimuli controlling hallucinations would tell us much about the nature of psychosis.

With this equipment we could also selectively reinforce certain vocal responses and determine whether they follow the same behavioral laws as do the patients' skeletal motor responses. Thus we could establish wide response generality for the method and also begin to attack the problem of the "magic of the word".

C4. Extensive Analysis of Discrimination and Differentiation

Simultaneous stimulus discrimination and response differentiation will be measured in a room with 2 manipulanda and 2 stimulus lights on the panel. By reinforcing one combination of light and manipulandum, the amount of responding in the other combinations should decrease since these responses would be extinguished. (Not reinforced.) The amount of responding in all combinations will be continuously and separately recorded, and will provide a measure of the acquisition and the final level of discrimination and differentiation. Presumably these are related to generalization, stereotypy, rigidity, and compulsion, all areas that many people feel are different in the behavior of psychotics from that of normal subjects. The apparatus has been constructed and is now in use.

This will be our first screening device. It is planned to study a large group of patients and normals for 4 continuous hours each in order to obtain a measure of the distribution of anomalus discrimination and differentiation within the hospital population.

C5. Conditioned Fear (Conditioned Suppression)

We have established conditioned suppression of knob pulling for candy reinforcement by following a bell (conditioned suppressive stimulus) with a mild electric shock to the manipulandum (combination suppressive and punishing stimulus) in one patient. The conditioned suppression is very stable and has lasted for over 2 months at this time. We plan to condition some more patients in the same manner and determine whether they can make this fearful discrimination. Those that do can be observed when they receive reserpine therapy or any of the other tranquilizing agents. There is evidence from lower animals that these tranquilizers eliminate this conditioned suppressive response. To demonstrate this effect at the human level with psychotic material would be very important.