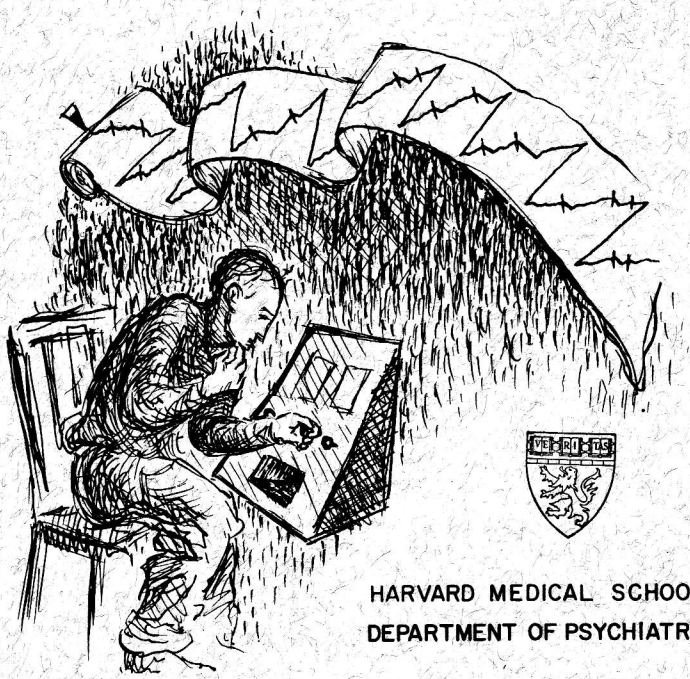
ANNUAL TECHNICAL REPORT 3

Report for the third year on

NEW TECHNIQUES OF ANALYSIS OF PSYCHOTIC BEHAVIOR
and
FINAL TECHNICAL REPORT FOR CONTRACT N5-ori-07662

Period Covered: 1 September 1955 - 15 November 1956



BEHAVIOR RESEARCH LABORATORY
METROPOLITAN STATE HOSPITAL, WALTHAM, MASS.

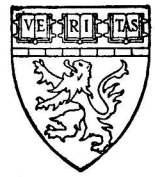
Research under Contract
with the
OFFICE OF NAVAL RESEARCH, U. S. NAVY
Contracts N5-ori-07662 and Nonr-1866(18)
Authority NR 174-220

HARVARD MEDICAL SCHOOL

Department of Psychiatry

BEHAVIOR RESEARCH LABORATORY

Metropolitan State Hospital, Waltham, Massachusetts



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Project Number: Contracts N5-ori-07662 and Nonr-1866(18) sponsored by the Group Psychology Branch, Office of Naval Research, Authority NR 174-220.

Project Title: New Techniques of Analysis of Psychotic Behavior.

Project Directors: B. F. Skinner, Professor of Psychology, Harvard University.
Harry C. Solomon, Professor of Psychiatry, Harvard Medical School.

Report Prepared By: Ogden R. Lindsley, Research Associate, Harvard Medical School.

Period Covered: 1 September 1955 to 15 November 1956.

Previous Reports:

Status Report I,	30 November 1953
Status Report II,	31 May 1954 (Annual Technical Report 1)
Status Report III,	31 December 1954
Status Report IV,	31 August 1955 (Annual Technical Report 2)
Status Report 5,	15 May 1956
Status Report 6,	15 August 1956

Change of Report Terminology:

Since our report titles are not in accord with the titles suggested by the Office of Naval Research, we are altering our terms. Status Reports II and IV summarized the results of the first and second years' work and should be titled "Annual Technical Report" 1 and 2, respectively. Hereafter our Status Reports will be dated 15 February, 15 May, and 15 August and will be sent only to the Office of Naval Research (5 copies). Our Annual Technical Reports will be dated 15 November and will be mailed to our complete distribution list. Our Interim Technical Reports (reprints) will appear when completed and will be mailed to the complete distribution list.

Availability of Reports:

Our supply of Status Reports I, II, and III is exhausted. Rather than mimeograph additional copies of our old reports we have made them available on Microcards from the Microcard Foundation, Madison 5, Wisconsin.

Publications:

1. Lindsley, O. R. & Skinner, B. F. A method for the experimental analysis of the behavior of psychotic patients. Amer. Psychologist, 1954, 9, 419-420. (Abstract.)

2. Skinner, B. F., Solomon, H. C. & Lindsley, O. R. A new method for the experimental analysis of the behavior of psychotic patients. J.Nerv.Ment.Dis., 1954, 120, 403-406. (Interim Tech. Rept. 1.)

3. Skinner, B. F. Critique of Psychoanalytic Concepts and Theories. Scientific Monthly, 1954, 79, 300-305.

4. Azrin, N. H. & Lindsley, O. R. The reinforcement of cooperation between children. J.Abnorm.Soc.Psychol., 1956, 52, 100-102. (Interim Technical Rept. 2.)

5. Lindsley, O. R. Operant conditioning methods applied to research in chronic schizophrenia. Psychiat.Res.Rep., 1956, 5, 118-139. (Interim Technical Rept. 3.)

6. Raines, G. N., Chairman. Discussion of paper presented by Ogden R. Lindsley. Psychiat.Res.Rep., 1956, 5, 140-153. (Interim Technical Rept. 4.)

7. Skinner, B. F. What is Psychotic Behavior? In Theory and Treatment of the Psychoses: Some Newer Aspects. St. Louis, Mo.: Washington University Studies, 1956, 77-99. (Interim Technical Rept. 5.)

Additional Support:

In addition to the contract with the Office of Naval Research, the laboratory was supported by research grant MH-977 from the National Institute of Mental Health, of the National Institutes of Health, Public Health Service, since 1 December 1954. Work done under the Public Health Grant is not included in this report, but is described in Progress Report I of PHS grant MH-977, 1 June 1956.

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, Sc.M., Chief Investigator, Research Associate, Harvard Medical School.

*Martha Mednick, Ph.D., Clinical Psychologist.

*Nathan Azrin, Ph.D., Graduate Research Assistant.

*Richard Wylie, A.B., Graduate Research Assistant, (part time).

Richard Flavin, Undergraduate Research Assistant, (part time).

Lawrence Gilbert, Undergraduate Research Assistant, (part time).

Robert C. Dalrymple, Laboratory Assistant.

William J. Nichols, Senior Technician.

Mollie D. Boring, M.A., Secretary, (part time).

Rita J. Wanner, Secretary, (part time).

*Mary V. Hall, Secretary.

John Bixby, Laboratory Custodian, (part time).

*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 list of personnel contained in our last report, (Progress Report I, Grant MH-977, National Institute of Mental Health, Public Health Service) was in error and the present list of personnel is to be considered as the correct list for the period covered by both reports.

LABORATORY PERSONNEL (Cont'd)

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.

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.

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

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.

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GENERAL SUMMARY

Method[1] The purpose of this project is to analyze the behavior of chronic psychotic patients, using the methods of operant conditioning that have been proved effective in the study of the behavior of lower organisms. In brief, a volunteer patient is placed alone in a small room containing a chair and a modified vending machine. When the patient pulls the vending machine levers, pieces of candy or other suitable reinforcements are delivered. The number and distribution of responses are automatically recorded over a specified length of time. In this manner the quantity and regularity of operant or adjustive behavior[2] of each patient can be ascertained under controlled conditions.

The method is not limited to such simple behavior, for when the experimental conditions are varied a wide range of behavior can be objectively studied. Complex response development, discriminations, concept formation, motivational conflict, fear, anxiety, and verbal behavior have been successfully studied with this method. With two individuals placed in "yoked" rooms, many forms of elementary social behavior (for example, competition, cooperation, imitation, negativism, altruism, sadism, etc.) may be studied. The differences in the rates of such behaviors between different individuals (psychotic or non-psychotic) as well as the effects of different agents (environmental, pharmacological, neurological) upon these rates can readily be studied.

Previous Results[3] Suitable apparatuses and procedures for the study of the operant behavior of chronic psychotic patients have been developed and standardized. Since the apparatuses are similar to those currently used with lower organisms by many experimental and physiological psychologists, our results can be directly compared with theirs. This brings theoretical and experimental continuity to the fields of clinical, physiological and experimental psychology.

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1. The method is described in detail in Status Report II and in Interim Technical Report 3; Lindsley, O. R. Operant conditioning methods applied to research in chronic schizophrenia. Psychiat. Res. Rep., 1956, 5, 118-139.

2. An operant response is a segment of behavior that manipulates a part of the environment. If it is followed by a reinforcement its rate increases. The clinical term "adjustive behavior" is often used to describe reinforced operant behavior. Many patients were hospitalized because they did not have enough adjustive behavior to function in society.

3. These results are described in detail in our previous reports and publications (see pages 2 and 3).

Approximately 50% of the adult patients responded at significantly lower and more erratic rates than unhospitalized adults, psychotic children, or lower organisms. When the adult patients were not responding they engaged in their particular psychotic behavior (pacing, sitting "depressed," gesticulating, talking violently, etc., depending upon their symptoms). This psychotic behavior interferes with and displaces the operant behavior. The topography of the psychotic behavior correlates with the psychiatric diagnosis, but the diagnosis gives no indication of the degree to which the psychotic mannerisms interfere with the operant behavior. Each patient has a characteristic pattern of psychotic "distraction," some showing frequent distractions of short duration, others showing infrequent periods of very long duration. Minute-to-minute, hour-to-hour, day-to-day, and month-to-month rhythms in the degree of this psychotic distraction have been recorded and are characteristic of different patients. We have succeeded in altering the frequency, duration, and patterning of these distractions by manipulating the nature or schedule of reinforcement with some patients. Individual differences are the rule and appear to be our subject matter. We cannot employ large-sample screening methods (wherein a large number of subjects are observed for a short period of time each) because of these rhythms and individual differences. Our research is in the main intensive with many hours of observation accumulated on a relatively small group of patients (N = 50).

Present Status of Research We have completed the methodological phase of our research and are now ready to spend our full research time on the analysis of psychosis. In the past three years we have investigated many aspects of psychotic behavior, but much of our time has been spent designing and constructing equipment, looking for suitable reinforcers, and testing the reliability and stability of our data. We now have suitable equipment for the free operant conditioning of psychotics. It can be used to study any individual from out-patient to the most severely disturbed violent patient. It has been tested in operation, is standardized and is commercially available. We can provide other researchers with equipment, standardized data, and counsel concerning the initial problems of patient handling, research design and hospital integration and cooperation. To this end we can draw upon a file of over 10,000 patient-hours of data with a median of 94 experimental sessions on 51 adult and 35 child psychotic patients.

We are embarking on a comprehensive analysis of the behavior of chronic psychotics. It promises to be a long-term investigation with all the advantages and disadvantages of "pure research" in any field. We plan to spend approximately 25% of our laboratory time in the application of promising research "leads." Our investigations of the effects of the standard therapies and the new tranquilizing drugs fall in this category.

The data generated are stable over long periods of time (years), and reveal striking individual differences between patients and unhospitalized individuals. We have located a few behavioral anomalies in our patients and now plan to search for other behavioral differences between our patients. Having located such anomalies, we plan to screen a sample of 25 patients to obtain a rough estimate of the frequency of occurrence of each anomaly in a hospital population. If we use the same sample of patients for each screening, inter-correlations of anomalies are possible and "behavioral disease syndromes" might be collected. It is becoming apparent that one of our most important assets here in Waltham is the large body of data we have accumulated on each of our fifty patients.

1.0 WORK ACCOMPLISHED SINCE 1 SEPTEMBER 1955

1.1 Observations on New Patients:

We have studied the behavior of 15 new patients since our last annual report. This increases our total sample to 51 adult psychotic patients (three of these were female) and 35 child psychotic patients (two of these were female). The distribution of staff diagnoses for the adult patients we have studied to date follows:

Psychoneurotic	1
Psychotic	2
Dementia Praecox, Undifferentiated type	4
" " Other types	7
" " Paranoid type	12
" " Catatonic type	13
" " Hebephrenic type	3
Mentally Defective with Psychosis	5
Manic-Depressive	1
Alcoholic Psychosis	2
CNS Syphilis	1
Total	51

Five of these patients were also described as having some organic involvement. These psychiatric diagnoses have so far not correlated with the different measures of the patients' operant behavior in the experiments, and we include them only as descriptions of our population until we can obtain more detailed and more recent psychiatric evaluations.

As we have previously stated, the psychiatric diagnoses do rather loosely describe the pattern of each patient's psychotic symptoms. They describe what the patient is apt to be doing in the experimental room when he is not responding. They do not give information about the nature of the patient's behavior anomalies or deficits. They do not say that this patient does not work because he is not motivated, nor that that patient is motivated, but cannot learn the task. The psychiatric diagnoses seem to say: when this patient is not working he will be pacing, and that patient will be mumbling, and this one laughing, etc.

The patients' ages ranged from 18 to 63 years, with a median age of 39 years. Total hospitalization for mental ilness ranged from 1 to 47 years with a median of 15 years. Six percent of our patients were hospitalized less than 1 year and 27 percent were hospitalized 5 years or less. I.Q.'s were available on only 23 patients (approximately 45 percent were untestable).[1] The most recent I.Q.'s ranged from 9 to 116, with a median of 82. Such depressed I.Q.'s are usually found in chronic psychotics.

On the L-M Fergus Falls scale[2] for rating the ward behavior of chronic psychotics, our patients received ratings from 1.3 to 5.0 with a median of 2.4. (1.0 is severely disturbed and 5.0 represents normal adjustment to the ward.) These values compare favorably with the range of 1.3 to 4.7 and the median of 2.5 obtained by Lucero and Meyer in their original standardization of the scale on over 50 patients in the Fergus Falls State Hospital, Minnesota.

Further evidence of the representativeness of our sample is given by the following distribution of the percentages of patients in the different type wards for the total male population of Metropolitan State Hospital compared with our sample of that population.

Population	N	Type of Ward				
		Admission (Reception)	Parole (Open)	Closed (Locked)	Disturbed (Violent)	Regressed (Untidy)
Total Hospital (Male)	622	7%	50%	27%	6%	10%
Exptl. Group	51	8%	36%	40%	12%	4%

Therefore our sample is representative of the patients in large state mental hospitals.

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1. The results of our clinical testing program, which was conducted by Dr. Martha T. Mednick, are reported in detail in: Lindsley, O.R., Progress Report I, Research Grant MH-977, National Institute of Mental Health, National Institutes of Health, Public Health Service and Harva Medical School, June 1956.

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

During the past three years, five of our patients have been discharged, one escaped and has not been found, and one died. Therefore, seven patients (14%) are no longer available for study. However, this figure includes three discharged acute patients with whom we were studying the effects of insulin therapy and who cannot properly be called chronic patients. At the current rates we can expect to lose about 3% of our chronic patients per year, due to discharge, escape and death.

Tripling the size of our patient population since our first annual report (Status Report II, 31 May 1954) has not changed the nature of our initial conclusions. By increasing the size of our sample, we have, of course, increased the probability that our conclusions will apply to psychotics in general, and we have been able to make more conclusions about the behavior of psychotics as we complicate our experiments and study more complex behaviors.

1.2 Quantification of "Psychotic" Properties of Records:

In our first status report we said that the most disturbed patients responded irregularly, with pauses separating periods of responding. During these pauses a patient would engage in his particular psychotic symptoms. Since then, we have accumulated a convincing body of data showing that this irregular response rate indicates severe psychosis if the patient is not physically ill or handicapped, unduly fatigued, or suffering from recent punishment or extinction. In other words, many factors can cause an irregular rate of response, but if the conditions under which normal individuals respond at irregular rates are ruled out, then an irregular response rate does indicate the presence of severe psychosis. The following evidence has been accumulated:

1) Patients assigned to the most regressed wards pause longer than those on open wards.

2) Patients rated as the most disturbed by the L-M Fergus Falls behavior rating scale pause longer than those rated high in hospital adjustment.

3) Normal attendants and psychotic children do not make these long pauses.

4) Patients with cycles of psychotic disturbance have long pauses when they are most disturbed and shorter pauses when they are in periods of better adjustment.

5) Most patients show roughly the same amount of pausing regardless of the reinforcement.

6) The frequency and/or duration of pausing is not related to psychiatric diagnosis or duration of hospitalization. It measures, therefore, the degree of debilitation caused by the psychosis, but does not describe the topographical nature of the symptoms.

It has been possible to exert some degree of experimental control over these "psychotic" pauses. In a few cases, they have been reduced in duration and frequency through months of daily conditioning on a one-minute variable-interval schedule of reinforcement in which the first response after a long pause is usually reinforced. The pauses have been increased in duration and frequency by experimental extinction. In other cases, we have "forced" the psychotic pauses (and the symptoms filling them) into temporal position following each reinforcement on a fixed-ratio schedule (i.e., every twentieth response is reinforced). On the fixed-ratio schedules, the pauses tend to be lengthened as well as positioned after reinforcement.

Since the pauses provide a measure of the severity of a psychosis by calibrating the degree to which it interferes with a standard task, and since the pauses can be changed in frequency and duration by experimental manipulation, a careful quantification of these pauses was demanded for further experimentation.

An analysis of the cumulative records and a few inter-response time distributions taken from both patients and normals disclosed that few normal records showed any pauses greater than ten seconds. This is about the length of time it takes the normal individual to look at his watch, light a cigarette, adjust his chair, or engage in any one of a host of "normal distractions." Distractions which consumed longer periods of time tended to be bizarre and in most cases were made only by disturbed patients.

On 10 December 1955 we started automatically measuring the amount of time consumed by pauses over ten seconds in length by the use of a clock (elapsed time indicator) which started ten seconds after each response and ran until the next response. The clock also ran during the initial delay in responding from the start of the experimental session (latency). This measure, described as "the sum of the inter-response times greater than ten seconds" (Σ IRT$>$10"), was automatically computed by the clock for each experimental session with an accuracy to tenths of a minute. Since pauses of ten seconds duration or less (normal pausing) are not timed, the clock provides a measure of the amount of time consumed by abnormal pauses in each experimental session.

On 25 January 1956 we started recording the number of these pauses greater than ten seconds because the patients who made one

long pause of, say, 30 minutes were not being separated from the patients who made, say, 10 equally spaced 3-minute pauses during each 60-minute session by the Σ IRT>10". A counter was placed in the circuit which recorded "the number of inter-response times greater than ten seconds" (#IRT>10"). This measure must be used with caution for it can be ambiguous, since patients responding at high, even rates might have only a few inter-response times greater than ten seconds and patients responding at very low rates might have only one or two very long inter-response times over ten seconds. However, with this ambiguity kept in mind the measure has proven to be a sensitive indicator of properties of the rate which are not measured by the Σ IRT>10", the M IRT>10", or the total number of responses per hour.

Both measures can be reclaimed from earlier records that were collected before the recording circuits had been devised by reading the cumulative response curves with a grid. This is a time-consuming procedure, and economically unfeasible for large-scale research, but it illustrates one advantage of continuous experimental records which can be later analyzed using a system which was undiscovered at the time the behavior was recorded.

"The mean inter-response time greater than ten seconds" (M IRT>10") can be computed from these two measures by dividing the Σ IRT>10" by the #IRT>10". The mean provides a single measure combining the properties of both the sum and the number, and for this reason might be more economical than using both measures. However, we have continued to use both measures since we have found them to vary independently of each other in certain experimental situations (see below). Also, the labor of computing the mean is saved by using the automatically derived measures.

Table 1 shows the advantage of the Σ IRT>10" over the other measures of the rate of response in differentiating most disturbed patients from the less disturbed patients and from the normal individuals. The table also shows the non-monotonic nature of the #IRT>10" as related to the responses per hour and the resultant low P values caused by the ambiguity of this measure.

The untestable patients had significantly lower ratings on the Tulane Behavior Scale[1] of clinical testability (P>.01) and the Lucero-Meyer Scale[2] of ward behavior (P>.01). They also were assigned to the more regressed wards of the hospital (P>.06). These

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1. King, H.E. Psychomotor aspects of Mental Disease, Cambridge, Mass., Harvard University Press, 1954.

2. Lucero, R.J., & 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 four rate of response measures from normal subjects compared with the same measures from a group of patients that could be tested by standard psychological tests and a group of untestable patients (45% of the patient population). The rate of response measures are medians for each group of the medians for the first 10 hours of one-minute variable-interval reinforcement with penny candies for each patient and five-cent pieces for each normal subject. The median number of responses per hour (Resp./Hr.), the median number of inter-response times greater than ten seconds (#IRT >10"), the median mean inter-response time greater than ten seconds (M IRT>10"), and the median sum of the inter-response times greater than ten seconds are presented. 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. Where three dashes are entered, the test was not significant. The table shows that the ΣIRT>10" is most sensitive to the presence of severe psychosis.

Subjects	N	Resps/Hr	#IRT>10"	M IRT>10"	ΣIRT>10"
Normal Attendants	6	9,566	2	.1'	.0'
		(---)	(---)	(---)	(.007)
Testable Patients (55%)	12	1,421	44	.8'	41'
		(.040)	(.070)	(.006)	(.006)
Untestable Patients (45%)	10	21	9	2.7'	58'

relationships add validity to the rate of response measures in showing that the patients with the lowest rates of response and longest inter-response times scored the lowest on three independent measures of severity of psychosis.[3]

Figure 1 shows the total number of responses per hour, #IRT >10", and Σ IRT >10", for one normal subject responding on a one-minute variable-interval schedule for five-cent pieces as reinforcers plotted against experimental sessions (one hour per day). Note that the rate of response sharply dropped at about the 25th experimental session. This sharp drop in rate to a lower value more in accord with the variable-interval schedule is similar to the abrupt changes in behavior which used to be called "insightful." Such changes may be more prevalent in the behavior of humans than with lower organisms. Note that there was a significant increase in the #IRT>10" at the time of the rate change only. The #IRT>10" here acted as the derivative of the rate of response and represents the kind of searching activity (exploring different sized inter-response times) the subject went through in adjusting his rate of response to a lower value. Note that since the Σ IRT > 10" did not markedly change at this time, the independence of the #IRT> 10" from the Σ IRT >10" is empirically demonstrated.

Another situation demonstrating this independence, in which the Σ IRT >10" is markedly changed with no apparent change in the #IRT > 10" is shown in Figure 2.

Here the #IRT > 10" and the Σ IRT > 10" are plotted against the hour-long experimental sessions for one patient responding for 260 hours on a one-minute variable-interval schedule for candy reinforcement followed by 90 hours of no reinforcement (experimental extinction). Ten-day medians are plotted to condense the graph. During the first 20 hours of extinction there was a sharp drop in the rate of response, showing that the gradual increase in rate of response over 260 experimental sessions (over a year) was directly related to the reinforcing stimuli (candy) rather than to the attention paid the patient by removing him from the ward environment each day. Figure 2 shows that this sharp drop in rate of response during the first 20 extinction sessions was due to an increase in the duration of inter-response times greater than ten seconds (Σ IRT >10") rather than an increase in the frequency of these long inter-response

3. These results are described in detail in Progress Report I, Research Grant MH-977, National Institute of Mental Health, Public Health Service, Behavior Research Laboratory, Harvard Medical School, June 1956.

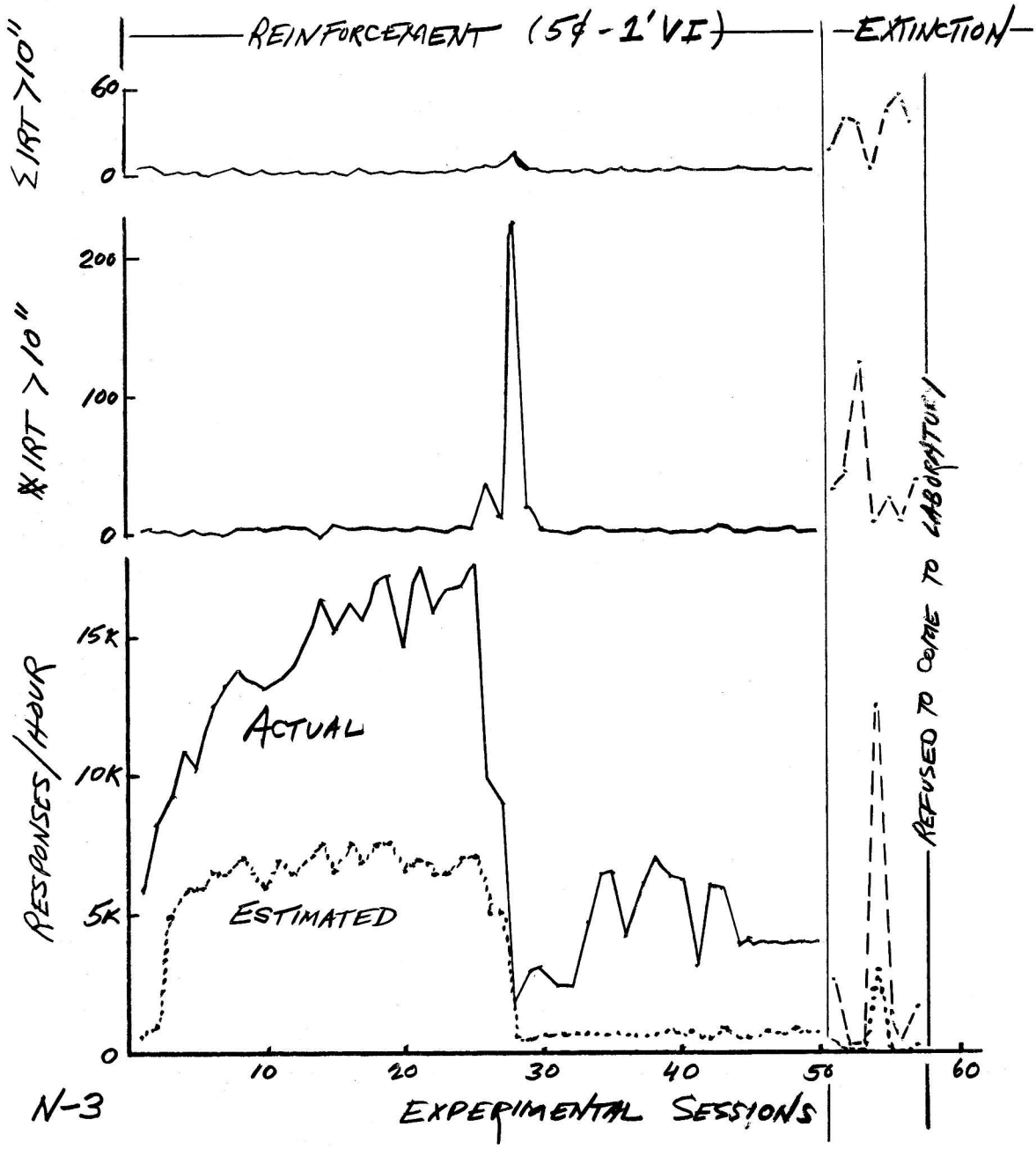

FIGURE 1

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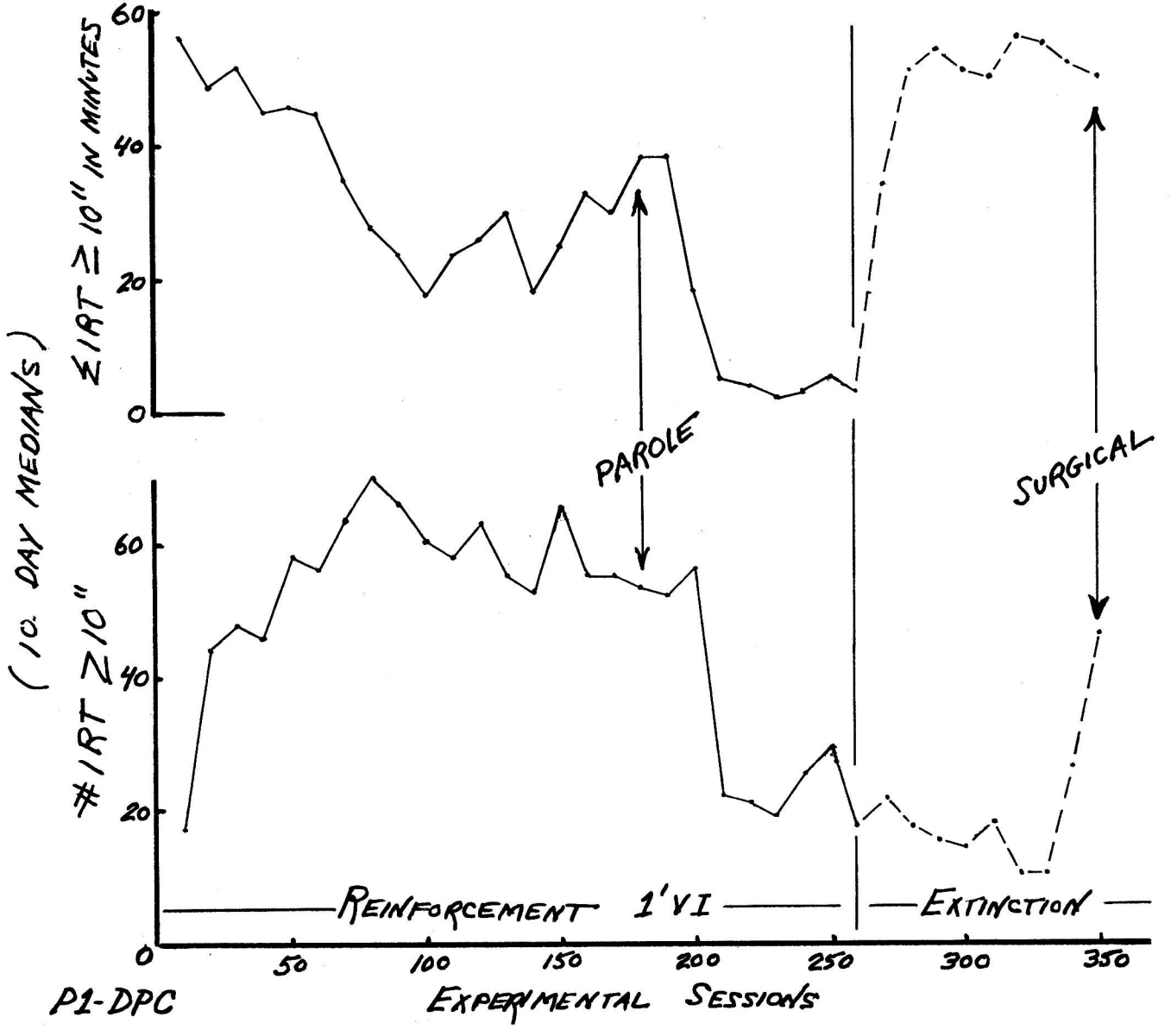
(10 DAY MEDIANS)
ΣIRT ≥ 10" IN MINUTES
#IRT ≥ 10"
60
40
20
0
PAROLE
SURGICAL
REINFORCEMENT 1'VI
EXTINCTION
50
100
150
200
250
300
350
P1-DPC
EXPERIMENTAL SESSIONS

FIGURE 2

times (#IRT>10"). Therefore extinction increased the duration of the long inter-response times rather than their frequency.

In summary, the superiority of the Σ IRT>10" over the Responses/Hr., the #IRT>10", and the M IRT>10" as a measure of the degree of "psychotic distraction" within a record of operant behavior was demonstrated. The validity of the Σ IRT>10" as a measure of the severity of the psychosis was determined using three independent clinical measures. Also the empirical independence of the Σ IRT>10" from the #IRT>10" as well as the sensitivity of both measures to certain experimental changes was shown. For these reasons we will continue to record both the Σ IRT>10" and the #IRT>10" in addition to the number of responses per hour.

1.3 Quantification of "Fixed-Ratio Pauses":

Two schedules of intermittent reinforcement that we have used extensively are the "variable-interval" schedule and the "fixed-ratio" schedule. On the one-minute variable-interval schedule the magazine circuit is primed after periods of time varying from 10 seconds to 2 minutes from the last reinforcement (on the average, once every minute). One priming is sufficient to deliver a reinforcement when a response is made at any time after the priming. Only one reinforcement is delivered, regardless of the number of primings, so that extra primings are, in a sense, wasted. In order to obtain all potential reinforcements, the patients must respond at a rate high enough to ensure a response between the closest primings (an even rate of one response at least every 10 seconds). This schedule produces a low, even rate of response from most normal subjects. On the fixed-ratio schedule, reinforcements are delivered after a fixed number of responses have been made since the last reinforcement. On a fixed-ratio twenty schedule, every twentieth response is reinforced.

The fixed-ratio schedule has two different effects when compared to the variable-interval schedule. 1) The rate of response is increased over the variable-interval rate (usually both the number of responses per hour as well as the "local rate" immediately before reinforcement are increased). 2) Pauses in responding tend to occur immediately after each reinforcement. We have previously found[4] that approximately 1/3 of the adult patients showed both of

4. Status Report IV, ONR Contract N5-ori-07662, Behavior Research Laboratory, Harvard Medical School, August 1955.