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**Characteristics of the Behavior of Chronic Psychotics as  
Revealed by Free-Operant Conditioning Methods**

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During the last sixty years experimental psychology has made great progress in objective behavioral measurement. The most sensitive, objective, and sophisticated of these methodological developments are those of B. F. Skinner and his associates.<sup>3,12,15</sup> These methods are generally described under the term "free-operant conditioning." The purpose of this research is to attempt to modify and make clinically relevant the methods of free-operant conditioning in order to produce medically useful, objective laboratory measures of the psychoses.

## *Behavioristic Approach to Psychosis*

The general approach to the analysis of psychosis that we are using is behavioristic. Naturalistic or behavioristic approaches to mental illness are rare in psychiatry today, even though the word "behavioral" occurs in many titles and programs. The behaviorist uses behavior as the final criterion of behavior and does not resort to mentalism or physiologism as his final criterion of knowledge or relevance.

At earlier times, naturalistic approaches<sup>2</sup> were briefly tried by men like Kraepelin,<sup>5</sup> Pavlov,<sup>10</sup> and even earlier by our own Benjamin Rush.<sup>11</sup> It is my conviction that early attempts at a behavioristic approach to psychiatry suffered from a lack of popular appeal and sound laboratory techniques of behavioral measurement. I am also convinced that today, even though the approach still suffers from popular appeal, methods which demonstrate its superiority over introspective approaches are available.

Skinner<sup>13,14</sup> and Ferster<sup>4</sup> have discussed some of the implications of a behavioral approach to psychiatric problems. However, without objective data such discussions are at best scientific extrapolations, plans or philosophies. The proof of the pudding is not the logical nature of the plans, but the knowledge and control of behavioral deviation produced by research based upon such plans.

To a behaviorist a psychotic is a person in a mental hospital. If psychosis is what makes, or has made this person psychotic, then psychosis is the behavioral deviation that caused this person to be hospitalized, or that is keeping him hospitalized. Looked at from this point of view,

very few psychotics are at this moment behaving psychotically. Neither is there any assurance that they will behave psychotically when we wish to evaluate or to sample their behavior in a brief test conducted at irregular intervals. In fact psychosis, defined in terms of the behavior that hospitalizes a person, is most often highly infrequent.

Most patients are hospitalized because the time of occurrence of their infrequent psychotic episodes cannot be predicted. Since the occurrence of these episodes cannot be predicted, the patient must be continuously hospitalized to insure that such episodes do not occur outside of the hospital. Also, many currently hospitalized patients behave psychotically only when they go home. Even though relatively normal in the hospital, they continue to be hospitalized because there is no safe place to send them. There are other patients who once behaved psychotically, but have become institutionalized and do not wish to leave the hospital, and still others who have no home to return to. For these reasons we should not expect all the patients in a mental hospital to exhibit psychotic behavior at any given moment.

Therefore, a few patients should behave relatively normally on all behavioral tasks. In fact, any behavioral measure that clearly separates all hospitalized psychotics from all unhospitalized individuals is merely a correlate of hospitalization and no better a measure of psychosis than the absence of hospital keys, neckties, or some other side effect of the way we care for psychotics.

If we wish to maximize our chances of measuring psychosis, we should evaluate the behavior of patients at the time they are actually doing what they are hospitalized for occasionally doing. This means that we should study our patients long enough to capture a psychotic episode in one of our experimental observation sessions. For, at that moment we would be surely measuring the behavior of a psychotic at the time he is behaving psychotically. This demands that our experimental rooms and recording devices must be indestructible, so that they will not be rendered inoperative by the bizarre behavior of any patient when he has a psychotic episode. Very few of the previously used measurement devices are capable of measuring the behavior of patients while they are behaving maximally psy-

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chotic. In this sense the earlier devices are extremely limited.

#### *Selection of Patients and Habitat*

If we wish to investigate a new phenomenon we should select the ideal conditions for observing it. We should maximize its amplitude and frequency of occurrence and minimize any changes in these properties, whether spontaneous or caused by agents other than those we can manipulate for investigational purposes. This means that the acutely ill psychotic is a poor research risk. For there is a high probability that his psychosis will change in degree or type while we are endeavoring to analyze it. Also, the natural habitat of the acute psychotic is a dynamic environment in which therapy is maximized and research design usually destroyed. The admissions unit is a model of confounded, rather than isolated and controlled behavioral variables.

However, the chronic psychotic has a maximized form of psychosis and the lowest probability of spontaneously changing during the course of study. Also, the chronic psychotic's natural habitat (the back wards of large state hospitals), although far from the research ideal of full experimental control, more closely approximates this research ideal of full control than does an admissions ward. Moving chronic patients to admissions units or research wards, takes them from their natural habitat which reduces the probability that their psychosis will remain stable, and places them in an environment full of uncontrolled behavioral variables.

Therefore, in order to maximize our phenomenon and its stability we selected a group of approximately 50 chronic psychotics for intensive investigation, who would continue to live on the back wards in their natural habitat. They were hospitalized a median of 18 years, insuring that their behavioral deviations were maximum and stable. Males were selected to eliminate any behavioral fluctuations that might be correlated with menstrual cycles. Patients were selected independently of psychiatric diagnosis in order to eliminate any theoretical bias, and to approach our subject matter with a maximized degree of freedom, limited only by our methods of observation and creative ability in adopting the methods to the measurement of clinically relevant behaviors. The clinical relevance was sought in clinical practice and experience, rather than in formal theory or diagnosis.

#### *Research Design*

The research design is frankly Darwinian rather than Newtonian. It is our feeling that there is not enough experimental data on the behavior

of psychotics in finely controlled situations to draw exact and meaningful generalizations at this time. Since the behavioral properties of psychosis are highly individual, each experiment must be conducted in such a fashion that each patient serves as his own control. We must not have to resort to the behavior of any other individual in order to determine the significance of the effects of any agent upon the behavior of our experimental subject.

The experimental observations are conducted in continuous experimental sessions of one or more hours duration each week-day, until we have exhausted our ability to obtain further important experimental information concerning the behavioral abilities and symptoms in a given patient. Although psychosis is clinically known as an oscillating, dynamic process, and patients are clinically known to be timid, afraid and nervous in novel situations, the majority of previous experimental studies of psychosis have investigated psychotics in novel situations. It is important to remember that we often evaluate a psychotic in 15 minutes, a secretary in one month, and an executive in one year. It seems to me that we might do better by reversing this order—at least until we develop reliable and exact methods of evaluation.

In our own research, we have found that the behavior of many psychotics is modifiable by manipulating properties of the immediate physical environment. However, their behavior is so slowly modified that experimental manipulation and observation must be continued over a period of years in order to disclose such slowly developing laws of psychotic behavior. Shorter periods of observation would show no lawful modification in the patient's behavior, and lead us to conclude that it was not modifiable, and the law of psychotic behavior would remain hidden.

Intensive investigation of single psychotics is the only way that a number of different behavioral deficits may be catalogued with respect to individual psychotics in attempts to locate and define syndromes of behavioral deficits which could define sub-types of psychosis.

Then again the currently used therapeutic variables (tranquilizing drugs, insulin, and psychotherapy) appear to take weeks, months and even years to reach their maximum effect. Experiments must be conducted over a period of years in order to provide a continuous measure of the effects of such variables on the behavior of individual patients. This intensive and continuous study of single individuals also permits a comparison of the effects of several different therapeutic agents upon the same individual as the experimental case history grows. I know of no

other way to adequately control for placebo effects without confounding the results with individual variability in reaction.

#### *Apparatus and Techniques*

The theoretical and historical background and the modifications of the method of free-operant conditioning for use with chronic psychotics, including its advantages and disadvantages have been discussed elsewhere.<sup>6,16</sup> In brief, a volunteer patient is conducted, or conditioned to approach a small (six feet square) experimental room. Such a room is shown in Figure 1. In this room there are only a chair and a manipulandum panel on one wall. On the panel are a plunger that can be pulled and a small aperture through which small objects can be automatically presented. Such a controlled environment can be used to measure the simplest operant or "volitional" behavior known—pulling a plunger for an unconditioned reinforcement or reward.

However, by manipulating the objects or events used as reinforcers, a wide variety of different motivations or "interests" can be studied.<sup>7</sup> By manipulating the contingencies of these reinforcers upon the plunger-pulling responses, a wide variety of discriminations and other behavioral processes can be studied. For example, with such a simple experimental environment, motivations ranging from food to social altruism, and discriminations ranging from simple visual to time estimation and complicated concept formation can be studied.<sup>8</sup>

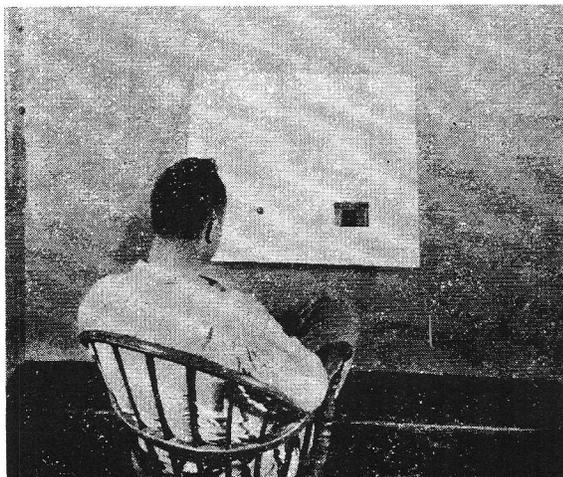
By permitting visual communication between such rooms (opening windows as shown at the sides of the room in Figure 1), social interaction from the most primitive facilitation and imitation to complicated leader-follower relationships in cooperation and competition teams can be controlled and objectively measured.<sup>1</sup>

By changing the form of the manipulandum or plunger, a wide variety of different response topographies ranging from simple manual to complex vocal responses can be studied. If the manipulandum is carefully designed, peripheral response properties (fatigue, frequency limitation, etc.) can be overcome and will not confound the interpretation of the data.

By making intelligent and creative changes of the types described above, and making these one at a time so that variables are not confounded, the method of free-operant conditioning can be modified to the objective and exact measurement of behaviors as clinically relevant as vocal hallucinatory symptoms in chronic psychotics.

#### *Behavioral Records*

Since the response recorded by the operation of the manipulandum is free to occur at any mo-



*Figure 1.* An experimental enclosure for the free-operant conditioning of chronic psychotics. The room is indestructible and designed to measure the behavior of even extremely disturbed patients while they are engaging in psychotic episodes. Any small physical object can be automatically presented through the aperture on the right as a reinforcement for pulling the carefully designed plunger on the left. The windows at the side can be made transparent for the study of social interaction with patients in adjoining rooms.

ment during the experimental session, maximum information is obtained if responses are recorded as they occur in time. Graphs of the distribution of the responses in time are automatically made on cumulative response recorders. The operation of such a recorder is schematically shown in Figure 2. The paper is driven under the pen at a constant rate. The pen makes one small movement up the paper when each response is made. In this way a graph of cumulated responses plotted against time is automatically produced. The slope of the pen tracing gives an index of the rate of response. If the slope is almost vertical, the rate is high and even. If the slope is horizontal, no responses were made. Events, such as the presentation of reinforcements can be marked on the record by a downward deflection of the pen. After 500 responses have been made, the pen is automatically reset from the top to the bottom of the paper where it is ready to draw another segment of a cumulative response record.

Clinical records of the patients' behavior on the wards and in psychiatric and psychological evaluations are periodically made in the usual manner. Also, the patients can be observed within the experimental rooms through a hidden periscopic system. Important changes in their symptoms and other demeanor are written down and used for correlation with the operant response records. The non-operant records are useful in making plans for developing new mani-

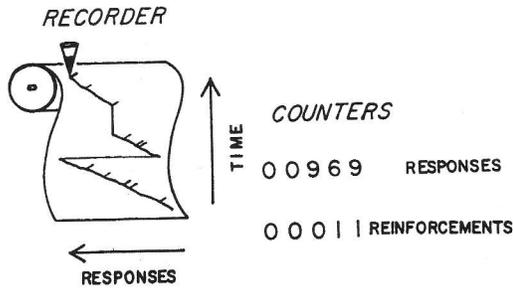


Figure 2. Schematic diagram of operation of a cumulative response recorder. Described in text.

pulanda to bring clinically relevant response topographies out on an electrical switch for automatic recording and programming. The non-operant records are also useful for correlation with the operant records in demonstrations of the validity and meaning of the operant data.

#### Characteristics of the Operant Behavior of Chronic Psychotics

The first and most striking characteristic of the free-operant behavior of chronic psychotics is the extreme degree of behavioral debilitation found in the majority of patients. For example, approximately 90% of the patients are unable to respond normally in the simple situation shown in Figure 1. Also surprising is the unpredictability of the patients' operant ability from observations of the patients' ward behavior and general appearance. Remember, that we are talking here of dynamic behavioral ability—the ability to develop and to maintain new behavioral repertoires, as distinguished from the behavioral repertoire that a patient may have acquired before he became ill.

For example, Patient No. 48, shown in Figure 3 has a much greater current behavioral repertoire, but a much lower current behavioral modifiability than Patient No. 46, shown in Figure 4. The first patient was an acute depressive and now is a chronic schizophrenic with an operant response rate (candy reinforcement on a 1'VI schedule) of zero responses per hour. The second patient has always been a psychotic idiot, but he now has an operant response rate of over 1,000 responses per hour and he can form primitive counting discriminations. Both patients are currently untestable by psychometric procedures.

#### I. Low, Erratic Operant Response Rates

Normal humans and lower organisms respond at moderately high (above 800 responses per hour) and remarkably even rates of response on variable-interval schedules of reinforcement. Figure 5 shows six records of normal humans responding on that schedule for five-cent coins as

reinforcers. Note that although reliable individual differences in rate of response exist, all the rates are above 800 responses per hour and

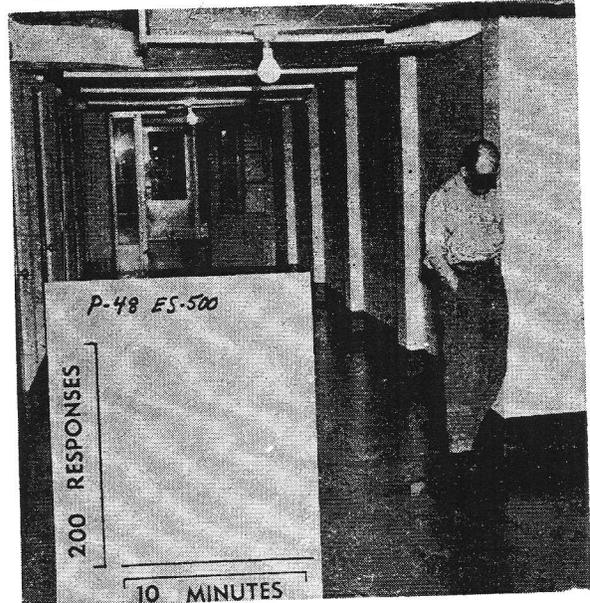


Figure 3. Patient No. 48, an acute depressive, who has recently been rediagnosed schizophrenic. He has been hospitalized during the last six of his 42 years and is currently untestable by psychometric techniques. His operant response rate is zero, but his repertoire of personal and social behavior is relatively high.

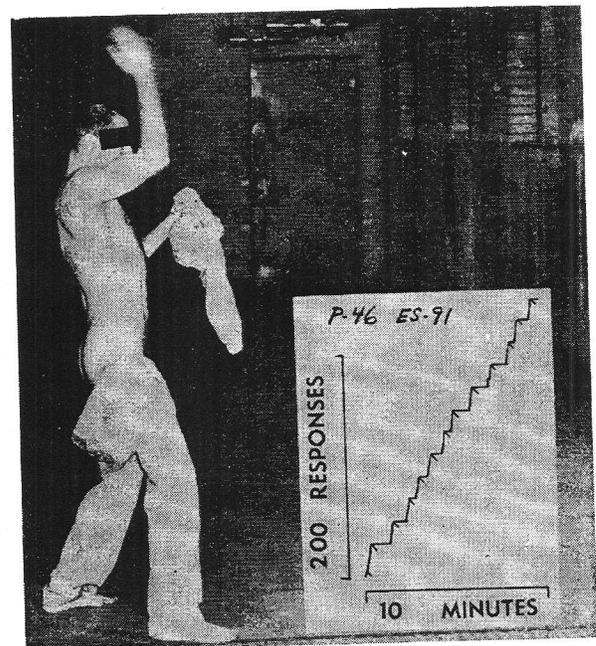


Figure 4. Patient No. 46, a psychotic idiot, who has been hospitalized for 24 of his 29 years. He is currently untestable by psychometric methods, but has an operant response rate of 1,000 responses per hour and primitive ability to form simple discriminations. He has almost no socially appropriate behavior.

are relatively even. These reliable individual differences in rate of response have not been extensively studied, and could probably be related to personality differences in preferences for certain work tempos. Perhaps they might even be related to accident proneness, with the high rate person going through doors before he opened them, and the low rate person going through doors after he had closed them.

Figure 6 shows six records of chronic psychotics responding on the variable-interval schedule for candy reinforcement. Note that the majority of the patients respond intermittently. Approximately 50% of those patients with a normally high number of responses per hour show an abnormally high number of pauses in responding greater than ten seconds. During these pauses patients that have readily observable psychotic symptoms can be observed displaying these symptoms.

Summarizing the debilities in simple operant responding on a one-minute variable interval schedule of intermittent reinforcement with candy, we find that only 20% of our unselected group of 50 chronic psychotics are capable of responding at the normal rates above 800 responses per hour; 50% of these, or only 10% of the total group of patients responded at normally high and even rates of response, with no pauses in their responding greater than 10 seconds in duration.

## II. Psychotic Incidents

We have termed these small pauses in responding on a schedule of reinforcement which pro-

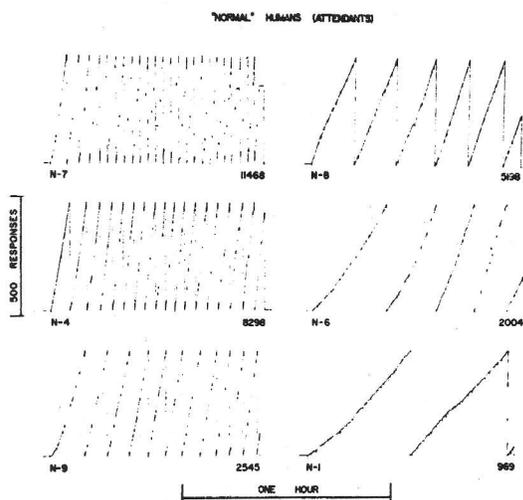


Figure 5. Cumulative response records for six unhospitalized normal adults, responding on a one-minute variable-interval schedule of intermittent reinforcement with five-cent coins. Each record is of the fifth hour of responding on this schedule. Under each record is printed the number of the subject on the left, and on the right the number of responses made during the hour.

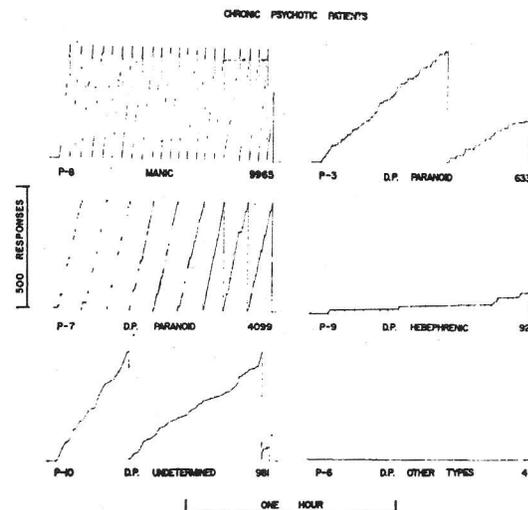


Figure 6. Cumulative response records for six hospitalized adult chronic psychotics, responding on a one-minute variable-interval schedule of intermittent reinforcement for small assorted pieces of candy. Each record is of the fifth hour of responding on this schedule. Under each record is printed the number of each patient to the left, the most recent psychiatric diagnosis, and to the right the number of responses made during the hour.

duces even responding in normals, "psychotic incidents." They have been successfully quantified by using, 1) automatic counters which record the total number of inter-response times greater than ten seconds that occur in each experimental session, and 2) automatic time indicators which record the total amount of time spent in inter-response times greater than ten seconds. These two quantities give a record of the number and total duration of psychotic incidents within a given experimental session. The average duration can be computed from the two. These measures correlate highly with clinical measures of ward behavior, and ward assignment, and with the ability to work in hospital industry.<sup>9</sup> However, they do not correlate with psychiatric diagnosis nor with years of hospitalization. Therefore they indicate the general degree of psychosis or psychotic debilitation rather than the presence of a particular form of psychosis from which a given patient suffers. In other words, these measures have the disadvantage of being non-specific measures of the different types of psychosis, but the distinct advantage of permitting a direct comparison of the effects of a given therapy on the severity of psychosis in several different patients with different types of psychosis. Therefore, the measures are useful in the evaluation of therapies on patients with different types of psychosis, once non-psychotic causes of intermittent responding have been ruled out.

Since low, erratic rates of response on vari-

able-interval schedules occur in non-psychotic individuals under certain unusual conditions, erratic response rates do not indicate psychosis unless these other potential causes are ruled out. Low, erratic response rates occur in normal individuals when: 1) inappropriate reinforcement is used, 2) before the response is fully acquired and the experimental situation is still novel, 3) when a competing response system is present, and 4) in acute physiological illness or under the action of certain drugs. These are a difficult, but not impossible, set of variables to rule out in order to make our measures specific to the psychoses.

In order to further investigate and to rule out the possibility of inappropriate reinforcement, several different reinforcing stimuli were tried with a large number of patients.<sup>7</sup> Reinforcers used were: money, food, candy, cigarettes, male and female nude pictures, bursts of music, tokens, escape from loud noise, and escape from a dark room. Although significant differences in rate of response for these different reinforcers were found in most of the patients, no patient was restored to a normal rate of responding by any of these reinforcers. The different reinforcers could be used to develop motivation profiles for diagnostic use, but were not useful in providing high, even rates of response for the maintenance of behavior for further investigation. Therefore, the low rates of response did not appear to be due to inappropriate reinforcement.

To investigate the possibility of slow acquisition causing the low, erratic rates of response, patients with extremely low rates were held on the variable-interval schedule with candy reinforcement for over a year of one hour experimental sessions each week-day. Only three of these patients (approximately 10%) showed a gradual increase in rate of response. The experimental history of one of these patients is shown in Figure 7. Responses per hour are plotted in thousands (10-day medians) against experimental sessions on the abscissa. The rate of response gradually increased from less than 10 responses per hour to over 6,000 responses per hour in 260 hours, or 14 months. When the response was no longer reinforced (extinguished), it slowly declined in rate to less than 10 responses per hour within 140 experimental hours, or 8 months of calendar time. This decrease in rate during extinction shows that the rate increase during reinforcement was produced and maintained by the candy reinforcement, and not by the patient's activation, visits to the laboratory, or personal attention in the waiting room

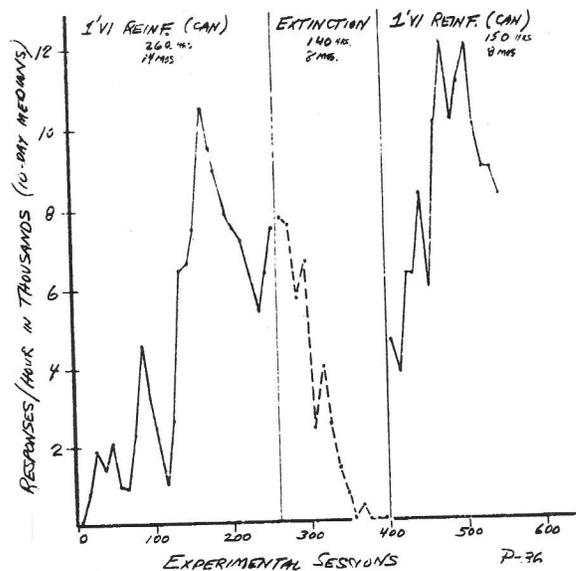


Figure 7. Slow acquisition, slow extinction, and immediate re-acquisition of a high rate of plunger-pulling reinforced with candy on a 1' VI schedule in a chronic psychotic. Patient No. 36.

and during the daily physical examination. When the responses were again reinforced, the rate immediately increased to over 4,000 responses per hour. This immediate re-acquisition showed that a permanent change had been made in the patients' behavior, and that he did not have to go through another long drawn-out re-acquisition process.

However, the patients that showed this slow acquisition did not develop completely normal rates of response. Even though their rates of response were well above the lowest normal rate of 800 responses per hour, their responding was still erratic with an abnormally high number of pauses greater than ten seconds in duration. These three patients differed from the majority of the patients that did not show slow acquisition because the manual plunger-pulling response mechanically competed with their psychotic symptoms which were primarily manual in nature. In other words, these data suggest that slow acquisition of a high rate of response is possible in some patients with candy reinforcement, if a non-symptomatic response is reinforced which mechanically competes with the patient's most characteristic motor symptom.

Since slow acquisition only occurs with a very small number of patients, it is more probably a form of restricted occupational therapy, rather than a general property of the behavior of chronic psychotics. Therefore, the possibility that the low rates of response of the majority of the patients were due to slow acquisition was ruled out.

Since each patient was in a finely controlled environment during each experimental session, the possibility of a competing response system as normally conceived can be ruled out as a cause of the pauses in responding or psychotic incidents. The records of the non-psychotic individuals shown in Figure 5, attest to the fact that no stimuli were present in the rooms which would produce competing responses in non-psychotic individuals. However, our more recent analyses strongly suggest that many forms of psychosis act as a competing response system does on the free-operant behavior of non-psychotics. In other words, many psychotics behave similarly to non-psychotics who are being intermittently bombarded with behavioral stimuli.

Our physiological controls (the daily physical and weekly laboratory examinations) and therapeutic controls adequately rule out the possibility that acute physiological illness and drug action caused the pauses in responding. It is important to note that in careful behavioral investigation such physiological controls are absolutely necessary in order to attribute any recorded behavioral deviations to other causes.

### III. Psychotic Episodes

Occasionally certain patients who usually respond at higher, more even rates of response, will have a period of very low, erratic responding which lasts for a period of 20 or 30 minutes up to several hours. During these periods of lowered response rate, they can be observed displaying hallucinatory, disturbed, destructive, or other more extremely psychotic symptoms than they

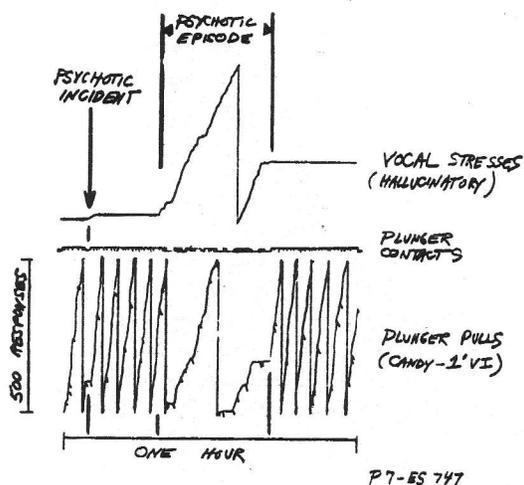


Figure 8. A psychotic incident and episode appearing in simultaneous cumulative response records of vocal stresses with psychotic or hallucinatory origin and manual plunger-pulls reinforced with candy on a 1' VI schedule. Manual contacts with the plunger are recorded on the event marker between the cumulative records.

usually display. Psychiatric aides usually say a patient "went high" when such episodes occur on the wards. It is the unpredictable occurrence of such episodes that keeps many chronic patients in the hospital, off parole, or on the disturbed ward.

Such periods of temporarily lowered response rate, and increased duration and/or frequency of psychotic incidents, we have termed *psychotic episodes*. Cumulative response records of a single psychotic incident, and a psychotic episode in the behavior of patient No. 7 are shown in Figure 8. This figure will be described in more detail in a later section of this paper. Here, we wish only to point out that such psychotic episodes occur, and that they are the truly psychotic behavior which keeps many patients hospitalized, and that they can be automatically and objectively recorded. Some drugs, for example Benactyzine at high dosages, increase the frequency and duration of psychotic incidents and produce one of these psychotic episodes in many patients.

### IV. Psychotic Phases

In the intensive, longitudinal studies several of the patients showed marked rhythms in their rate of response. These rhythms characteristically occur over relatively long periods of time. For a few weeks the rate of response will be consistently high. Then, for a few weeks or months the rate will be consistently low. Then the rhythm will repeat. We have called these periods of low response rate *psychotic phases*. They are not related to temperature, humidity, phases of the moon, home visits, or changes in

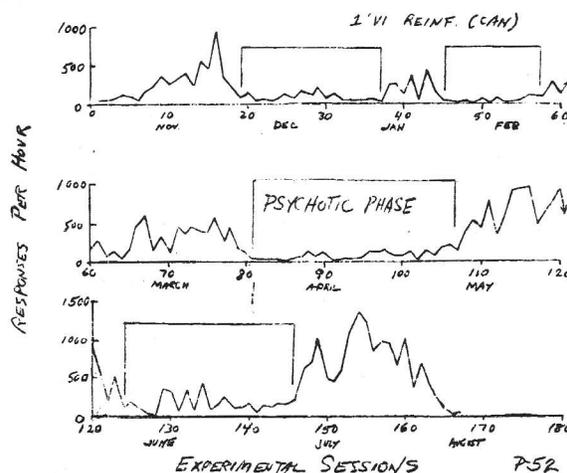


Figure 9. Psychotic phases or rhythms in rate of response of a chronic psychotic responding on a 1' VI schedule of candy reinforcement. Each experimental session lasted one hour and was conducted on successive week-days. The months of the year are printed below the experimental session closest to the first of each month to indicate calendar time. Patient No. 52.

ward assignments or hospital social environment. They are related to ratings of the patients' ward behavior until the behavior rating scales lose their sensitivity as a result of repeated administration.

An example of these psychotic phases is shown in Figure 9. At the start of the experiment the patient was hospitalized for 20 years and was 52 years old. He was first hospitalized at the age of 18 and diagnosed as a manic-depressive. The diagnosis at admission for his current period of hospitalization was dementia praecox, hebephrenic type. His last hospital diagnosis (in 1951) was schizophrenia, paranoid type. A current "blind" diagnosis was organic psychosis.

It is easy to see how long-term hospitalization and the loss of social reinforcement could suppress the socially observable behavior of a patient to such a low level that such behavioral rhythms, which were originally easily observed without instrumentation and used to diagnose a manic-depressive psychosis, could later only be recorded by sensitive, and highly quantified behavioral recording devices.

It is important to note the havoc that can be wrought by including such a patient in a drug evaluation study of the type that would run a 30-day placebo control while the patient happened to be in a psychotic phase, and a 30-day drug run when the patient was in his following more normal phase. The drug would be interpreted as therapeutic. It is also important to note that such patients could be of great value in attempts to show physiological or biochemical correlates of psychosis. For, here in a single physiological system we have a naturally oscillating amount of psychosis, which could be correlated with samples of biochemical materials in order to determine correlations without confounding the data with inter-patient differences in behavior or chemical quantity.

#### *Practical Use of Free-Operant Rate of Response in Therapeutic Evaluations*

Although the simple free-operant rate of response on a variable-interval schedule is a non-specific laboratory measure of the degree of psychotic disability, nevertheless, it is more reliable and more sensitive to most therapeutic variables than other existing evaluative techniques. Here I shall present only a few examples of therapeutic evaluation. We have collected a large number of similar evaluations, which clearly demonstrate the practical utility of the method in its current form in this application.

Since we are methodologists, we will continue to refine and to develop more complicated and more exact measures of the psychoses. It is more

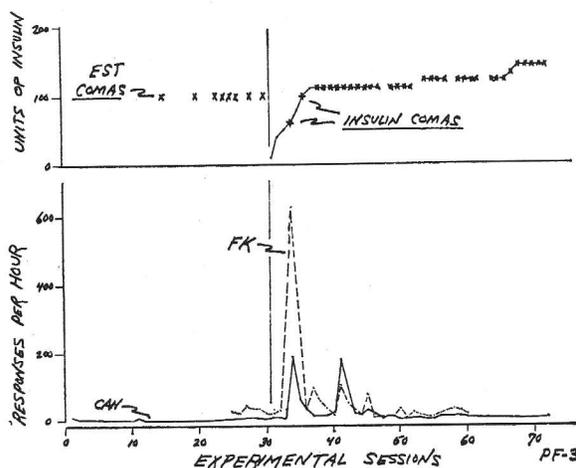


Figure 10. Effect of Electroshock and Insulin Comas on rate of response of an acute psychotic responding on a variable-interval schedule for candy (solid line) and for succor (feeding milk to a hungry kitten—dashed line). The electroshocks had no effect, and the insulin produced increases in the rate of response at the time of the first insulin reactions and comas. Patient No. PF-3.

efficient if large scale therapeutic evaluations using our currently available measures are undertaken by those trained and equipped for therapeutic evaluation. Like the lens maker in microscopy, we wish to hand our latest lens over to the histologist, and get back to our business of designing and polishing more powerful lenses.

#### *I. Electroshock and Insulin Coma*

In Figure 10, the rates of response on a one-minute variable-interval schedule of reinforcement with candy (solid line) and feeding a kitten, or succor (dashed line) reinforcement are plotted against experimental sessions. The patient was in an acute psychotic depression and undergoing electroshock and insulin coma therapy. At the top of the graph the crosses mark the days in which EST was given in the morning before the afternoon experimental session. Note that the extremely low rate of response was not increased during the EST series.

At the vertical line, on the 32nd experimental session, the insulin treatment was begun. The number of units of crystalline insulin that were injected each day are plotted in the black curve at the top of the graph. Note that there was no increase in the operant response rate until the first coma occurred when the therapist levelled off the dosage of insulin. Note also, that the rate of response reinforced by feeding the kitten was increased much more than the rate reinforced with candy. This shows that the rate increase was not caused by a need for sugar increased by hypoglycemia, unless succor is also increased by hypoglycemia. The major therapeutic effect was

produced by the first coma. The rate was also increased after the next ten insulin comas, but returned to the pretherapy level for the remainder of the treatment.

Monitoring courses of insulin therapy with operant response rates might prove to be useful in individualizing insulin treatment by providing an exact measure of the degree of therapy produced by each coma. The therapist would then have the information necessary to give the comas at intervals designed to produce the maximum therapeutic effect in each patient.

## II. Iproniazid

In Figure 11, the rates of response on a one-minute variable-interval schedule of reinforcement are plotted against experimental sessions for a regressed chronic psychotic, patient No. 4; 700 daily hour-long experimental sessions are shown in the graph. During the first 200 sessions, female nude pictures, feeding a kitten, five-cent coins and candy were used in attempts to determine the most appropriate reinforcer for this patient. From the 200th session on, candy was used as the reinforcer. Note periods of "spontaneous" increases in rate of response around the 250th, 280th, 310th, 340th, and 460th sessions.

On the 535th session 50 mg. t.i.d. of iproniazid (Marsilid) was administered for four weeks with no therapeutic effect. On the 545th session, the dosage was increased to 100 mg. t.i.d. and a slight rate increase was produced and sustained for a few days. However this increase was of no greater amplitude than the previously recorded "spontaneous" increases. About three weeks after the rate had declined, there was another temporary rate increase of a much greater magnitude than was found in any previous "spontaneous" increase. After six weeks of 100 mg. t.i.d. iproniazid administration liver damage began to develop and the medication was terminated.

From about the 640th through the 660th session another "spontaneous" rate increase occurred in which the rate went up to 1,500 responses per hour.

In summary, the iproniazid given in the heaviest dosages that were medically feasible, appeared to produce only two "recovery cycles" in this chronic patient. The recovery cycles are only significant because of their timing with respect to the change in dosage of the drug. In terms of therapeutic significance, the "recovery" is not significant, for it was not maintained during or after the drug administration, and it was of no greater magnitude than the several "spontaneous" improvement periods in the patient's experimental history.

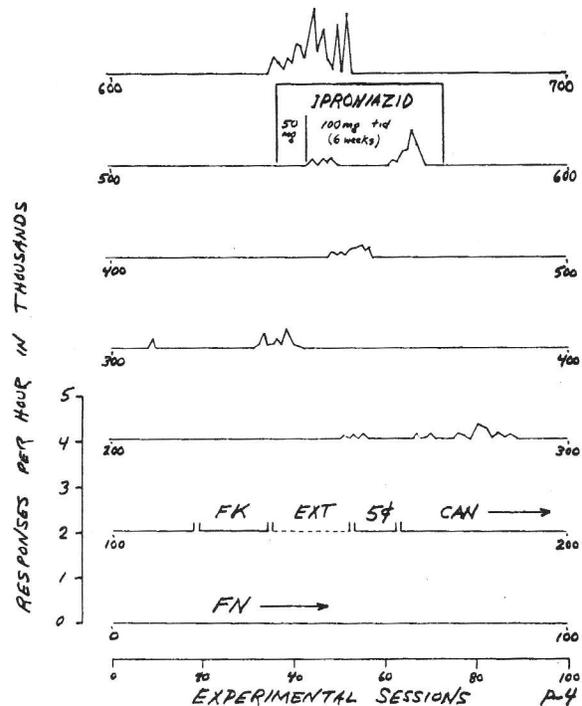


Figure 11. Experimental history of a chronic psychotic responding on a variable-interval schedule for various reinforcers (FN—Female Nude Pictures, FK—Feeding a Hungry Kitten, EXT—Extinction, 5c—five cent coins, and CAN—penny pieces of candy). The history covers a period of five years and seven months of almost daily experimentation and reveals severely depressed operant behavior with several "spontaneous" recovery phases of extremely low magnitude in addition to an initial, but not sustained, therapeutic effect of iproniazid medication. Patient No. P-4.

taneous" improvement periods in the patient's experimental history.

## III. Student-Nurse Psychotherapy

In Figure 12, the experimental case history of patient No. 4 is continued. At the first arrow, psychotherapy sessions with a student nurse were begun. Psychotherapy sessions lasted one hour and they were held on Mondays, Wednesdays and Fridays. At the second arrow, the patient stopped swearing during the therapy sessions. The nurse became a little irritated because the patient was inattentive and mumbled a lot during the therapy sessions. At the third arrow she told the patient to stop listening to his voices. "They are only part of your illness and you should not pay attention to them." By the third experimental session immediately following this therapeutic session the rate of response had climbed to over 2,000 responses per hour. Responding was maintained at this high rate, even on the two days of each week that the nurse did not see the patient.

At the fourth arrow, the nurse told the patient

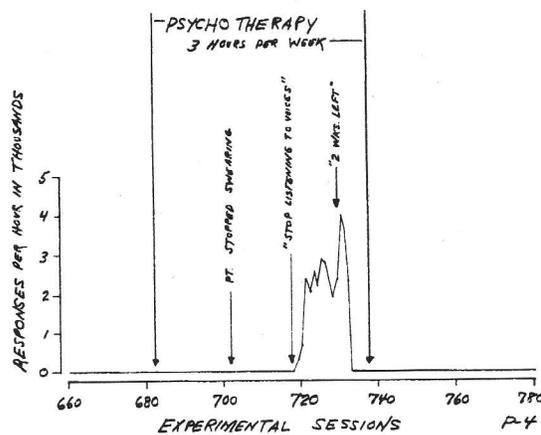


Figure 12. Effect of psychotherapy sessions on operant rate of response of a chronic psychotic. The graph is a continuation of experimental history shown in Figure 11, using same size ordinate and abscissa scales. A student nurse conducted the one-hour therapy sessions three times a week. The effect of the psychotherapy was six times greater than that produced by 100 mg. t.i.d. of iproniazid given for six weeks, and three times greater than the highest "spontaneous" improvement cycle in the patient's six-year experimental history. Patient No. P-4.

that after two weeks she could no longer see him. The rate of response jumped up about another 2,000 responses per hour immediately after this information was given the patient, and then abruptly fell to zero responses per hour. At the fifth arrow the nurse left the hospital and the therapy was terminated.

The rate increase which occurred during the psychotherapy was abrupt in onset and termination, in contrast to the gradually onsetting rate increases which were "spontaneously" and drug produced. This fact taken together with the close timing of the recovery with relevant psychotherapeutic variables, leaves little doubt that the recovery was produced by the nurse's visits. This was the highest rate of response emitted by the patient in over four years of daily experimental observation. Therefore, the effect has high statistical significance and cannot be attributed to chance. However, since the patient was by no means "normalized," and since the recovery was not maintained after termination of the therapy, the psychotherapeutic sessions had only a relatively weak and supportive effect. In this respect their therapeutic significance was relatively low, even though greater than that produced by iproniazid.

Nevertheless, quantified, objective measures of the effect of single psychotherapeutic sessions on the behavior of chronic psychotics are scarce, and this effect is highly significant from that point of view. In cooperation with Dr. Jack R. Ewalt we have plans to continue the investigations of

psychotherapeutic effects using more highly trained therapists. The method shows promise as a device for accurately calibrating the effect of single therapeutic sessions. Such sensitive calibrations of the effects of single therapeutic sessions will permit the therapist to determine, by single manipulation which variables in the sessions were active. In this way a true experimental analysis of psychotherapy can be undertaken, and the functional aspects of psychotherapy can be proven by the methods of natural science in the laboratory.

In summary, three hours per week of psychotherapy conducted by a student nurse produced an increase in the rate of operant responding of this chronic psychotic that was three times that of any "spontaneous" improvement recorded in over three years of daily behavioral measurement, and that was six times the improvement produced by 100 mg. t.i.d. of iproniazid administered for six weeks.

#### *Specific Characteristics of Psychotic Behavior*

More complicated behavioral processes are debilitated by fewer agents than the rate of a simple operant response. For this reason debilities in these more complicated behaviors more specifically indicate the presence of psychosis and the type of psychosis than do debilities in the simple rate of response. However, in order to determine debilities in more complicated behavior, the scientist needs enough behavior to study. Only about 50% of the chronic patients have useful rates of response above 100 responses per hour, so specific debilities cannot be determined in the other 50% of the patients who are extremely debilitated.

Due to our lack of time, I will only briefly summarize the more complicated, and hence more specific behavioral characteristics of the psychoses that we have located to date. The majority of the patients have extremely slow extinction processes. We have located one patient in which there appears to be a complete lack of extinction. In counting discriminations as measured on fixed-ratio schedules of reinforcement, approximately 50% of the patients have deficits. In more complicated discriminations based upon differential responding to two manipulanda and two lights, 90% of the patients show deficits. These discriminatory deficits have diagnostic utility in separating seniles and true mental defectives from the social mental defectives.

#### *Simultaneous Recording of Vocal Symptoms and Non-Symptomatic Responses*

Visual observation of patients through the hidden periscopic viewing system has shown that

most patients with abnormally long pauses in their operant responding engage in their particular individualistic symptoms during these pauses. The development of keys or switches to automatically and electrically record the occurrence of these symptoms would facilitate their further analysis.

Simultaneously recorded cumulative records of both the psychotic symptoms and the reinforced operant responses would permit an exact and objective analysis of their competition. Such simultaneous records would also permit an objective search for sympto-specific drugs which should decrease the frequency of symptoms without decreasing the frequency of reinforced operant, normal, or non-symptomatic behavior.

Also, the symptom key could be used to automatically schedule the presentation of environmental stimuli contingent upon the psychotic symptoms. The differential reinforcement of symptomatic responses would show whether they are or are not affected by environmental changes in the same way as are non-symptomatic responses.

In Figure 8 simultaneously recorded cumulative records of vocal stresses and manual plunger-pulls are shown for the 747th experimental session with a chronic psychotic patient. The vocal responses were never experimentally reinforced and can be considered to have a psychotic origin. Their content was identical with that in the vocal behavior of the patient whenever he "went high" on the wards.

Patient No. 7 is male, 58 years old and he has been continuously hospitalized for 29 years. His experimental behavior has been under study for five years. Admitted in 1930 at the age of 29 he was diagnosed dementia praecox, paranoid type. The recent "blind" diagnoses were simple schizophrenia (by the clinical psychologist), and schizophrenia, mixed (by the psychiatrist). His recent Wechsler-Bellevue I.Q. was 60 and he scored in the 3rd percentile on the Hospital Adjustment Scale and lives on a locked ward. His personality picture is "that of a withdrawn, colorless patient who shows little evidence of acting-out and whose general defense is that of compulsivity in terms of wanting a fixed routine, his own things, and to be left alone." He is very untidy, but not incontinent. He collects worthless objects and eats cigarette butts. He cleans the hospital basement floors but needs almost constant supervision. He is a good worker unless provoked, when he has tantrums and runs about, yelling, biting his fists, and pounding the walls. He behaved in this fashion during the psychotic episode shown in Figure 8, and it is this behavior which keeps him on a locked ward.

Consider Figure 8 and note the exact nature of the functional competition between the patient's vocal symptoms and his manual operant responses. The manual responses were reinforced on a 1' VI schedule with candy. The rate of reinforced manual non-symptomatic responses was reduced about 75% for two periods by competition from a moderate rate of never-reinforced vocal symptomatic responses.

The first period of symptom display and reduced rate of normal or non-symptomatic behavior lasted only about one minute and might be properly called a "psychotic incident." The second period lasted about 20 minutes and appears to be composed of a long series of psychotic incidents. Such sustained periods of psychotic display are often called "psychotic episodes."

Note that in the psychotic episode the vocal symptoms began about two minutes before the manual response rate dropped. This delay in the reduction of the non-symptomatic responding by the symptomatic responding shows that the competitive effect of the symptoms takes a minute or two to build up. The delay also demonstrates the physical independence of the two responses and their recording systems.

Note also that at the end of the episode there was a period of about two minutes with no vocal responding before the non-symptomatic responses returned to their pre-incident rate. This delay in the recovery of the non-symptomatic responding shows that the competitive effect of the symptoms lasts longer than their display. These delays in onset and recovery of the competitive effect of the symptoms suggest that the competition is a higher-order behavioral effect than the symptom. The delays also show that symptoms can occur without the competition.

Note also that a relatively even rate of vocal symptoms and manual responses was maintained throughout the episode. These even episodic rates indicated that the severity of the psychotic episode and its competition with the normal behavior was maintained at about the same intensity throughout.

Also shown in Figure 8 is a record of the time that the patient's hand was in contact with the manipulandum (plunger contacts). The contacts were recorded by a capacitative relay circuit. The event pen on one recorder was in the "up" position whenever the patient's hand was on the manipulandum. Note that the patient usually took his hand off the manipulandum when a reinforcement was delivered. At this time he placed the candy in a paper bag that he carried. But also note that his hand was off the manipulandum during the psychotic incident and much of

the time during the psychotic episode. This record of contacts shows that the symptomatic vocalizations not only compete with the recorded manual responding, but also compete with non-recorded responses necessary to the performance of the recorded responses.

In summary, a voice key to automatically record the competition between symptomatic vocalizations and the normal non-symptomatic behavior of patients within an experimental setting was developed. Its use has clearly shown that the pauses in the operant responding of patients with vocal hallucinatory symptoms are due to functional competition from these symptoms. The opportunity to record the exact nature of this competition will be useful in further research into the basic nature of psychosis. Objective recording of these vocal symptoms and their competitive effect will also be useful in the evaluation of therapeutic agents. Such a high degree of exactitude in the observation of the competition between the psychotic symptoms and normal behavior of a patient can be obtained by no other currently available psychiatric research device.

#### *Functional Definition of a Psychosis*

In order to show that Darwinian, naturalistic observations can lead to what might be called theories, lastly I shall present a way of defining a certain type of psychosis. This definition is functional because it describes the psychosis in terms of its effects on and interaction with non-psychotic behavior.

This notion is a direct outgrowth of the simultaneous measurement of symptomatic and non-symptomatic behavior described in the last section. When normal individuals are placed in this two-channel recording situation the only vocal responses they emit, when alone and being reinforced for their manual responses, are occasional bursts of singing and whistling. This singing and whistling can be readily separated from most psychotic hallucinating by the pattern of response emission which is regular for singing and whistling, and irregular for one-sided conversations with no one. Also, the singing and whistling does not compete with, but rather seems to "pace" along with the plunger-pulling responses.

However, if non-psychotic individuals are given an hallucinogenic drug (i.e., Benactyzine in high dosages) and their name is called over a hidden microphone, they will carry on a "psychotic-like" one sided conversation with no one. When questioned afterwards they report having had auditory hallucinations. The interesting fact is that

the drug-induced vocal hallucinatory symptoms in the non-psychotics do not compete with their plunger-pulling responses. The non-psychotics pull the plunger for nickels without reduction in rate through their hallucinatory episode.

Also, the non-psychotics do not hallucinate for as long a period after their name is called over the hidden speaker as do the psychotics. The after-discharge of the drug-induced and experimentally stimulated hallucinatory episodes in the non-psychotic is much shorter than the after-discharge of the "spontaneous," or experimentally stimulated hallucinatory episodes in the psychotic.

To date we have run very few psychotic and non-psychotic subjects under these conditions, but the data collected are amazingly uniform. Therefore we tentatively venture the hypothesis that one property of one form of psychosis is that its symptoms have an abnormally long after-discharge and an abnormally high degree of competition with strongly reinforced non-symptomatic behavior. In other words, it is not the symptom (talking to no one) that defines this form of psychosis. Neither is it the stimulus that produced the symptom ("hearing" your name called when no one is there) that defines the psychosis. Rather, it is having the symptomatic response (talking to no one) last long after a non-psychotic would stop, and more importantly being unable to do anything else demanded of him while this talking is going on, that defines the psychotic.

I think this definition of psychotic symptoms has a lot of clinical relevance. We are all familiar with the old lady walking down the street, obeying traffic signals, nodding and occasionally speaking to friends along the way. She is not hospitalized as a psychotic, because she is walking down the street and only talks to no one when there is nothing else to do with her mouth. She just "talks to herself."

And again, if a person goes to a psychiatrist and says, "I worry all the time, I think I am going to die, please help me." The psychiatrist will probably ask, "Do you sleep well? Do you eat well? Are you getting your work done?" If the answers to all of these questions are honestly in the affirmative, the patient is not diagnosed as psychotic and hospitalized. Rather he is classified as an interesting and compensated neurotic. On the other hand, if a man is located who has been talking to no one in a closet for three days, and has done nothing else, he stands a high probability of being immediately hospitalized if he won't even stop talking to his "friend" for the police.

## Summary

Much of what we have learned from our carefully controlled experiments appears in retrospect to be composed of things that skilled, experienced clinicians "knew" all the time. But, that is as it should be, for the business of science is to separate the wisdom of casual and field observation from its superstition, and then to quantify and to make this wisdom practically useful. For the first time we have brought a few facts of psychosis into the body of natural science. In so doing much of what we have brought in looks just as the clinicians always said it did. But remember that we now have the advantage of measuring these things automatically in the laboratory. And also remember that we have left many things that clinicians say in the clinic.

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The initial help and guidance of Dr. B. F. Skinner speaks for itself in the nature of the method and the content of the reference list.

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