

DIRECT MEASUREMENT AND FUNCTIONAL DEFINITION OF VOCAL HALLUCINATORY SYMPTOMS

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During the past eight years, we have used modifications of the method of free-operant conditioning to investigate the behavior of chronic psychotics (4, 6). In free-operant conditioning, responding is brought under the control of new stimuli by manipulating its consequences (reinforcing stimuli); whereas in classical or Pavlovian conditioning, responding is controlled by manipulating its antecedents (eliciting stimuli). This freedom from a dependence upon responses with known eliciting stimuli permits free-operant conditioners to work with a wider range of responses in the study of human behavior than classical conditioners. Also, since burdensome trials are unnecessary, free-operant methods can more closely approximate social settings to the extent that they allow the patients more experimental freedom than do classical conditioning methods.

Although free-operant methods show promise as therapeutic devices (*e.g.*, 1), we have primarily focused our research on developing new techniques for automatically evaluating within the behavior laboratory the types and severity of the psychoses. We have concentrated on evaluation not only

because psychiatry has a greater need for objective methods of evaluating existing therapies than it does for new therapies, but also because our exploratory attempts at free-operant therapy with chronic psychotic patients were too time-consuming to be practical and did not produce general or dramatic recoveries. Finding no suitable evaluation device sensitive enough to evaluate independently our own undramatic therapeutic results, we began to adapt the method to provide objective therapeutic evaluation rather than to perform therapy.

The high variability in behavior, both within and between psychotics, has demanded that we investigate the behavior of individual patients under a given experimental condition at least long enough to insure that any observed behavioral changes could not be due to intermittently recurring psychotic phases. Therefore, many experiments involve several years of daily observation. Also, the experimental conditions are arranged so that each patient serves as his own experimental and statistical control. To date we have collected over 30,000 hours of data from 80 adult chronic psychotics, with some patients entering their 1,200th experimental session. Such long experimental case histories are necessary in order to reveal lawful changes in the behavior of patients with intermittent psychotic phases and/or with extreme resistance to behavioral modification.

Characteristically, each patient is brought down from his ward to the laboratory, given a brief physiological examination by our research nurse, and taken to a small six-by-six foot experimental room containing a chair and on one wall a small plunger and delivery tray. The operation of this plunger (a free-operant response) can be made to

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deliver automatically various events (reinforcers) to the patient on different schedules of intermittent reinforcement (see 2). The nature of these reinforcing events (*e.g.*, food, candy, money, projected slide images, bursts of music) determines the class of motivation that is being investigated. The different rates of plunger pulling are recorded on cumulative response recorders and indicate the patient's current interest in and ability to work for the different reinforcers. In a sense, such an analysis is the only direct way to determine what a reinforcer "means" to a psychotic patient.

Differential reinforcement of responding in the presence of specific stimuli and alterations in the patterns of the reinforcement schedule are two ways in which discrimination can be experimentally analyzed. If two experimental rooms are joined by a window and the reinforcers delivered only when the patients in each room pull their plungers in some specified alternation, leadership in cooperation and competition can be experimentally generated and directly measured (7). Furthermore, the indestructible nature of the experimental rooms permits the behavior of all types of psychotics to be measured directly, without the use of tranquilizing medication even when patients are extremely disturbed. Finally, the independence of the method from verbal instructions and verbal recording makes it ideal for use in transcultural evaluation of mental disorders.

To date the method has been validated with psychiatric evaluations, psychological test results, behavior rating scales, hospital management criteria, and ability to work in hospital industry (8). Validation has also accrued from the high sensitivity of the method in recording subtle therapeutic responses in patients given psychoactive drugs, insulin coma, and psychotherapy treatment (6). In many cases the free-operant responding reveals a regular and significant therapeutic response at lower dosages and before recovery can be discerned by ward or psychiatric observation.

In our most recently developed and most sensitive evaluative device, both manual non-symptomatic responses and vocal symptomatic responses of overtly hallucinating patients are directly and simultaneously recorded (5, 6). The results and implications of experiments using this device will be briefly summarized in this paper.

Direct measurement of vocal hallucinatory symptoms: In addition to the plunger which records manual non-symptomatic responses, a microphone was installed behind a metal screen in the ceiling of an experimental room. This hidden microphone operated a voice key which was adjusted to emit a brief pulse whenever the sound level in the room rose above a pre-set intensity. Frequency filters which passed only the frequency range of human speech reduced the probability that the sounds of the patient moving about the room and pulling the plunger would operate the voice key. These pulses from the voice key, automatically recorded on a cumulative response recorder, represented grammatical stresses in the speech of a patient alone in the room. If singing and whistling are ruled out, a high frequency of vocalization by a psychotic patient who is alone in a room almost always indicates the presence of "auditory hallucinations."

Behavioral competition between symptoms and non-symptomatic responses: When the vocalizations of hallucinatory patients have never been reinforced experimentally, a high rate of vocal responses indicates their psychotic origin. These vocal symptoms occur in characteristic bursts varying from about one to forty minutes in duration. Each patient tends to have his own characteristic duration of hallucinogenic vocalization episodes. The local rate of vocalization within each burst appears to be relatively constant within each patient.

Even though these vocal responses can mechanically co-exist with manual non-symptomatic responding, the rate of plunger

pulling reinforced with candy and cigarettes on a variable-interval or fixed-ratio schedule of intermittent reinforcement is markedly reduced during the periods of symptom display. It is important to note, however, that even during these psychotic episodes, some normal or non-symptomatic operant behavior does seep through the veil of psychosis. The severity of the hallucinatory episode is more properly indicated by the degree to which the non-symptomatic responding is reduced during the episode rather than by the frequency or intensity of the vocalizations.

Singing and whistling of non-hallucinatory psychotics and drug-induced vocal hallucinatory symptoms in normals do not compete with their manual responding. Therefore, it appears that it is the *competition with the non-symptomatic behavior* which defines the psychotic origin of the vocal symptoms. This observation ties in with the old notion that schizophrenia is primarily a disorder of attention.

Use in determining therapeutic effects of drugs: Two-channel recording of both symptomatic and non-symptomatic responding shows great promise for use in experimentally analyzing the action of psychotherapeutic drugs. For example, the tranquilizers tend to decrease the rate of both symptomatic and non-symptomatic responding. Energizers tend to increase the rate of the non-symptomatic responding but also increase the rate of symptom display. Even more complicated effects appear in cases where amphetamine increases the rate of the response (either symptomatic or non-symptomatic) that is occurring at the time the drug takes its effect (15 to 20 minutes after oral ingestion).

If a drug which specifically decreased the rate of symptom display without also decreasing the rate of non-symptomatic responding could be located, it still would not be ideally therapeutic. Merely to remove the symptoms, without restoring the non-symptomatic responding during the psychotic

episodes, is in some ways no better than removing the patient's vocal cords or stuffing the attendant's ears with cotton. Since episodes of reduced non-symptomatic responding would still occur, one could well say that the patient was "listening to his voices but simply not talking to them." The ideal anti-hallucinatory drug would simultaneously eliminate the bursts of vocal symptoms and restore the rate of non-symptomatic responses to normal during these episodes. The continuous nature of the recordings allows the search for such compounds to be done with continuous records of single dosages in individual patients.

Increase in frequency of vocal symptoms in constant environment: Two hallucinatory patients have shown a gradual increase in the number of vocal symptoms per hour the more times they were in the experimental rooms. In one patient the symptoms increased from less than 100 to more than 1500 responses per hour in 250 experimental sessions. In another patient they increased from less than 100 to more than 4000 vocalizations per hour in 250 experimental sessions. We have not yet been able to determine whether this increase in symptom display is due to acclimation to the experimental room or to the light flashes which serve as feedback stimuli to permit the eventual reinforcement of vocal responding.

After-discharge of vocal symptoms to eliciting stimuli: In experimental attempts to discover appropriate eliciting stimuli for hallucinatory vocalizations, different types of auditory stimuli were presented through a hidden speaker to known hallucinators while they were responding manually for candy reinforcement in one of the experimental rooms. In general, the more similar the stimulus was to a human voice, the higher the probability that a given patient would "talk to it." When the patient did "talk to" the stimulus, the rate of manual responding was reduced, demonstrating the response competition characteristic of spontaneous symptom display. The content of

the experimentally stimulated vocalizations was in each case similar to the content of the patient's spontaneous vocal symptoms.

Only a brief stimulus presentation was usually necessary to initiate a long series of vocalizations, continuing for as long as thirty minutes after the termination of the stimulus. The more severely psychotic and more actively hallucinating patients required less similarity to a human voice for stimulation, had longer periods of after-discharge, and showed more competition with their non-symptomatic manual responding during their vocalizations. Normal individuals and non-hallucinatory psychotics did not respond to the hidden sounds and responded to their names being called over the hidden speaker with only an occasional "What?" or a comment such as "What are you trying to do, drive me crazy?"

Independence of symptoms from reinforcing stimuli: When the candy reinforcement was changed from the manual non-symptomatic responding to the previously never-reinforced vocal symptoms, the manual responses decreased in rate. This decrease in the rate of the manual responses during extinction demonstrated experimentally that the candy was truly a reinforcing stimulus. The "reinforced" vocal symptoms, however, did not increase in rate as expected, but *decreased* with the extinguished non-symptomatic responses.

When the reinforcement was again made contingent upon the manual non-symptomatic responses, they increased in rate, showing that our patient was not fatigued or satiated, that he had not gone into a deeply psychotic phase, and that the candy still functioned as a positive reinforcer. The now "extinguished" vocal symptoms, however, *increased* in rate with the reinforced manual responses (see 5).

The vocal responses of normals and of non-hallucinatory psychotics increased when positively reinforced and decreased when not reinforced in this experimental

setting (see also 3). Therefore, the independence of the vocal psychotic symptoms from direct positive reinforcement (experimentally defined as such on the same patient) appears to be due to their psychotic origin. These vocal symptoms appear to be altered in frequency by consequential events only indirectly by induction from non-symptomatic responses. The results of this experiment suggest that vocal psychotic symptoms are under some form of internal control that resists direct differential positive reinforcement. One might hypothesize that the vocal symptoms result from an afferent rather than efferent disorder and, even more tentatively, that they are truly "responses to voices."

Functional objective definition of a symptom: The results of the experiments summarized above have led me to define vocal hallucinatory symptoms (and possibly all psychotic symptoms) in terms of their functional rather than topographical or bizarre properties. Vocal symptoms appear to have the following functional properties: 1) an abnormally high degree of non-mechanical competition with strongly reinforced non-symptomatic behavior, 2) the ability to be elicited by hidden stimuli of incomplete topography in the appropriate modality, 3) an abnormally long after-discharge from such elicitation, and 4) independence from their environmental consequences or direct reinforcement.

Such a definition permits automatic laboratory measurement and definition of symptoms and frees the investigator from concern with hallucinatory content and bizarreness. It brings the hallucinatory symptom into the body of natural science in terms of the functional properties which differentiate it from other forms of skeletal behavior. It also suggests that similar experiments should be conducted on catatonic and other symptom topographies to determine whether they have similar functional properties and are therefore symptomatic of a single disease process despite their different topog-

raphies. The capability of elicitation and incapability of differential positive reinforcement suggests that vocal symptoms might be manipulated more easily by Pavlovian rather than free-operant conditioning. The generality of these statements awaits further research on a larger number of patients.

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