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BEHAVIORAL ENGINEERING: THE USE OF RESPONSE PRIMING TO IMPROVE PRESCRIBED SELF-MEDICATION[1]

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A major problem in outpatient treatment has been the extreme irregularity with which patients use medication prescribed for them. As a new approach to resolving this problem, a portable operant apparatus was developed based on response priming and escape reinforcement. The apparatus sounded a tone at the time that a pill was to be taken. When the user turned a knob to terminate the tone, the apparatus delivered the pill into the user's hand. The apparatus was evaluated with six normal adults using a medically inert pill. A greater proportion of the pills were taken by each subject when using the special apparatus as compared with the use of a portable alarm timer or the usual wristwatch. These results demonstrate a new approach for increasing the regularity of self-administration of medicines.

When a physician prescribes medicine, he generally assumes that the patient will take it and at the designated times. Several studies have shown, however, that a large proportion of patients receive inadequate treatment because of their failure to take the medication. Failures to take medication have ranged from 20 to 70% for tuberculous outpatients (Dixon, Stradling, and Wootton, 1957; Fox, 1958; Luntz and Austin, 1960; Simpson, 1956; Wynn-Williams and Arris, 1958), rheumatoid arthritis patients (Joyce, 1962), and psychiatric outpatients (Parkes, Brown, and Monck, 1962; Renton, Affleck, Carstairs, and Forrest, 1963; Willcox, Gillan, and Hare, 1965). In one study, "failure" of a drug to control epileptic seizures was attributed in all cases to the patients' failure to take the medication as prescribed (Kutt, Haynes, and McDowell, 1966). The problem seems to be general to most types of preventive medication.

The present study applied to this problem of self-medication the behavioral engineering approach outlined previously for the control of slouching (Azrin, Rubin, O'Brien, Ayllon, and Roll, 1968), cigarette smoking (Powell and Azrin, 1968) and stuttering (Azrin, Jones, and Flye, 1968). The specific steps in this approach as applied to the present problem were (1) to specify the target behavior and, (2) to construct a portable device that could selectively react to the target response and schedule an effective consequence for it. The principal difficulty in applying this behavioral engineering approach was the automatic measurement of the target response *i.e.*, swallowing a pill. The taking of a pill was analyzed as a behavioral sequence in which swallowing was the final response that was always preceded by the response of holding the pill and the pill container in one's hand. Holding the pill was selected as the response to be reinforced. The rationale was that the final response in a sequence would be more likely to occur if an earlier response in the sequence could be reinforced. This rationale and procedure has been called "response priming" and has proved useful for treating mental hospital patients (Ayllon and Azrin, 1968*a*; 1968*b*). A portable apparatus was developed which could eject a pill into the user's hand. The apparatus also sounded a tone at the time that a pill was to be taken. The termination of the tone could provide escape reinforcement. When a knob was turned, the tone terminated and the pill was ejected. Since the purpose of this study was to evaluate this general approach to the problem of self-medication, volunteer healthy adults were used as subjects in a situation that permitted more complete observation than seemed to be possible in a

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completely free clinical situation. This new procedure was compared with the alternative methods of relying on one's wristwatch or on a portable alarm timer.

METHOD

The subjects were six women, 20 to 33 yr old, who were employed at the Anna State Hospital and who volunteered for the study. Four of the subjects were not acquainted with either experimenter. The following written instructions were given.

> "We are conducting a study which is concerned with the consistency with which people take medication. The medication which will be used contains no active ingredients. However, for purposes of this study, you are to consider the medication as having been prescribed by a practicing physician for an existing pathological condition. On each day of the study, you are requested to take a pill every ½ hour. The beginning time for the first pill should be 8:45 a.m. Subsequent pills should thus be 9:15, 9:45, ... up to 4:15 p.m. which will be the time for the last pill each day. The pills being used in this study rapidly dissolve when placed in the mouth and, therefore, a liquid is not necessary to facilitate taking them. During the experiment you will be required to write down the time that you take each pill on a card provided to you for that purpose. In recording this time you are to use only your own wrist or pocket watch. In order to fully evaluate the results we will request that Miss_____ report information to us about the extent to which you are following the prescribed procedures."

Five of the six subjects were asked to designate a fellow employee with whom they were in continuous contact and who would observe the subjects as a "participant observer". This technique for obtaining independent records of behavior in a naturalistic setting has been described elsewhere (Powell and Azrin, 1968; Azrin and Powell, 1968). Each day, the participant observers were given a written schedule that designated about 10 occasions on which the observer should seek out the subject, observe her for about 2 min and record on the schedule card whether or not a pill was swallowed at that time. The observations were randomly chosen from the 16 occasions that the subject was to take a pill (one subject was scheduled for 13 pills). To prevent the observer's presence from becoming a signal to take a pill, the observers also made many observations at other times. At the start of the day, the wristwatches of the subject were synchronized to permit subsequent comparisons between their records.

Apparatus

The experimental apparatus measured 2.5 by 1.8 by 1.0 in. (6.2 by 4.5 by 2.5 cm) and could be carried in a purse or pocket. Its functions were, first, to provide a signal as to when to take a pill and, secondly, to reinforce the response of having the pill container and the pill in one's hand. When 30 min had passed since the last pill was taken, a 100 Hz tone sounded at an intensity of 50 db measured at a distance of 1 meter. Subjectively, the tone resembled a soft hum. The tone could be terminated only by turning a knob on the side of the apparatus. When the knob was fully turned, the tone terminated, a pill was ejected from an opening in the case into the subject's hand, and the time was reset. By turning the knob slightly ahead of time, the subject obtained a pill without having to be prompted by the tone. A cylinder within the apparatus contained the 16 pills that were "prescribed" for the 8-hr working day. The timer used was the major component in a portable alarm timer obtainable as catalog number 63-649 from Radio Shack Corporation, Waltham, Massachusetts. The tone was generated by a solid state oscillator circuit, described in Fig. 15. 6 of the G. E. Transistor Handbook, operating into a hearing aid speaker (Audiovox, Model 8AA). This same tone had previously been found to be aversive when used as a consequence for slouching (Azrin *et al.*, 1968).

Two other devices were used for comparison, both of which were of the same size and appearance as the pill-ejector apparatus. One was a simple pill container used in conjunction with the subject's wristwatch. Access to the pills in the container was by a sliding door on the container. The other apparatus contained the same mechanical timer as did the pill-ejector apparatus and gave a fixed dura-

tion 3-sec signal at the end of the interval. The simple pill case was included for comparison because it is the usual type of procedure for taking pills. The alarm timer case was included for comparison because it was an alternative, albeit less frequently used, procedure for taking pills and it also provided a control for the purely informational value of the alarm signal in the pill-ejector apparatus. Each subject used each of the three procedures for four days in a sequence that varied between subjects for a total of 12 days for each subject.

RESULTS

Table 1 shows that each subject missed fewer pills when she used the experimental dispenser than when she used either the simple pill container or the alarm apparatus. The Wilcoxin non-parametric test for paired comparison (Siegel, 1956) showed that the differences between the experimental dispenser and each of the alternatives were statistically significant ($P < 0.02$). The mean percentage of pills missed was 3% for the experimental dispenser, but 11% for the alarm apparatus and 16% for the simple container. Two subjects did not miss any pills when using the experimental apparatus.

Table 1

Percentage of Pills Missed

Subject	*Simple Pill Container*	*Alarm Apparatus*	*Behaviorally Engineered Dispenser*
S-1	44%	30%	8%
S-2	21	8	4
S-3	16	16	2
S-4	8	4	0
S-5	4	4	2
S-6	2	6	0
Mean	16%	11%	3%

The written records kept by the subjects were in almost perfect agreement with those of the participant observers. Instances of disagreement seemed to be attributable to incomplete synchronization between the subject's and the observer's wristwatch. The observers made 291 reports, 181 of which occurred while the subject was taking a pill; the records of the subjects were in agreement with 285 (98%) of the 291 written reports of the observers. Occasional counts of the number of pills in the containers at the beginning and end of the day were also in almost perfect agreement with the number reported in the subject's written record. In no instance did the observers report that a pill was taken from the container but not swallowed.

At the completion of the study, the six subjects were asked to comment on the different apparatuses. Five subjects stated that the experimental apparatus was preferred. The failures to take a pill were reported as caused primarily by preoccupation with other activities and by not having the pill container on their person at the scheduled time.

DISCUSSION

The results showed that the behaviorally engineered dispenser assured that almost all pills (97%) were taken and at the scheduled time. In contrast, the more usual method of relying on one's wristwatch resulted in 16% of the pills being omitted; the alarm timer was only slightly better. Of course, the final clinical value of the present findings must await direct comparisons in a natural setting with patients for whom regularity of medication is a problem.

The behaviorally engineered dispenser not only provided a signal at the time scheduled for the medication, but also reinforced the response of holding the dispenser in the hand and it automatically ejected the pill. Although the subject did not have to swallow the pill, the observers' records showed that all ejected pills were taken into the mouth. These results support previous findings regarding response priming (Ayllon and Azrin, 1968*a*; 1968*b*) that the terminal response in a sequence is more likely to be made if earlier component responses can be produced. This finding is especially relevant to the behavioral engineering approach since it provides a means of modifying target behaviors that are too difficult to record and control directly.

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