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BEHAVIORAL ENGINEERING: THE REDUCTION OF SMOKING BEHAVIOR BY A CONDITIONING APPARATUS AND PROCEDURE[1]

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Recent findings from animal conditioning studies have revealed methods of reducing responses to a very low level with a minimum of aversive by-products. These findings were incorporated into the design of a cigarette case that automatically locked itself for a period of time after a cigarette was removed from it. The next cigarette could be taken at the end of the interval, which was signalled by distinctive stimuli. Five heavy smokers were allowed to become accustomed to using the case. Then, the duration for which the case was locked was gradually increased over a period of weeks to about 1 hr. Smoking gradually decreased to the target level of about one-half of a package of cigarettes per day. Control procedures showed that specific features of the apparatus were responsible for the reduction of smoking. The results indicated that this apparatus was sufficiently effective, convenient, and acceptable to smokers to constitute a practical procedure for reducing smoking to the level considered medically safe. The procedure may also have potential for reducing other habit-forming or addictive behaviors.

The present study attempted to apply principles of operant conditioning to the problem of addictive or habit-forming practices. Cigarette smoking was selected as a convenient habit-forming practice that is easily studied because of its extensive occurrence. The specific approach was that of behavioral engineering as outlined elsewhere (Azrin, Rubin, O'Brien, Ayllon, and Roll, 1968). Briefly, this approach uses a portable apparatus to arrange operant consequences for an undesired behavior in the individual's natural environment. In a previous application of this behavioral engineering approach to the problem of cigarette smoking (Powell and Azrin, 1968), the subject received a shock upon opening a specially designed cigarette case (Whaley, Rosenkranz, and Knowles, in press). A major problem with using shock as a consequence was that very few smokers would wear the shock apparatus; those who did tended to abandon it as shock intensity was increased to the levels needed for suppression (Powell and Azrin, 1968). It seemed necessary to find some other controlling event that would be effective and yet sufficiently non-aversive to permit usage by more smokers.

Extinction reduces responding, but, unfortunately, it also seems to possess aversive properties, as evidenced by the findings of Ferster (1958), Baer (1962), Holz, Azrin, and Ayllon (1963), Azrin, Hutchinson, and Hake (1966), and the frequent characterization of extinction as a frustrating (Dollard, Doob, Miller, Mowrer, and Sears, 1939; Amsel and Roussel, 1952), or emotional state (Skinner, 1953; and see the recent review by Leitenberg, 1965). Terrace (1963) discovered a method of employing extinction that did not appear to possess these aversive properties (Terrace, 1963; and see review by Terrace, 1966). Terrace used the darkening of a response panel as the stimulus that signified extinction. This extinction stimulus was presented only when the subject, a pigeon, was in a location that precluded the possibility of a response. The stimulus was thereby associated selectively with periods of non-responding. Then, the stimulus was gradually lengthened. This gradual increase of the stimulus duration resulted in fewer conditioned responses and fewer of the general emotional reactions during the stimulus than did a stimulus that was not intro-

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duced gradually. More recent findings, also with pigeons, suggested that a feasible method of introducing this nonaversive extinction was to schedule it immediately upon each response. Hake and Azrin (1968) found that when a brief stimulus was arranged to follow each response, responses were absent during that stimulus and continued to be absent when that stimulus was gradually increased in duration.

The present study attempted to reduce cigarette smoking to the medically safe level of about one-half of a package per day (Surgeon General's Report, 1964) by the above mentioned stimulus-control procedure. The response of taking a cigarette from a specially designed cigarette case caused the case to be locked for a period of time. The rationale was that approach responses, such as reaching for the case and pushing the case lid, would be extinguished by the unavailability of the cigarettes during that period. The initial duration for which it was locked was less than the minimum duration that normally elapsed between responses. Distinctive stimuli (extinction stimuli) were presented for the duration that the case was locked. The duration for which the case was locked was then gradually increased. The questions posed by this study were (1) whether smokers would be willing to undergo this procedure, (2) would the procedure be sufficiently nonaversive (unlike pain-shock) that smokers would not discontinue its use, and (3) would the procedure reduce the number of cigarettes smoked?

METHOD

For a three-day period one experimenter listed all individuals he met who fulfilled the combined criteria of having a speaking acquaintance and occasional direct contact with the experimenter and who smoked cigarettes in his presence. Seventeen persons met the three criteria and were the initial subjects. All were employees at Anna State Hospital or students or employees at Southern Illinois University. The subjects read and filled out the following written form:

> We are soliciting volunteers for a study designed to reduce smoking. The essential feature of this study is a specially designed cigarette case which remains locked for a specified time whenever a cigarette is removed from it. A minimum time of three weeks is necessary to complete the study. If selected for the experiment, you will be expected to only smoke cigarettes obtained from the case. Individuals with whom you are in daily contact will be requested to observe whether you are using the cigarette case and to report the results of these observations to the experimenter. The cigarette case can be locked for any of the three following periods of time: 7 minutes, 30 minutes, 55 minutes. Would you be willing to participate in the experiment if the initial time the case remained locked was:
>
> (1) 30 min. Yes_____ No_____
> (2) 55 min. Yes_____ No_____
> (3) 7 min. Yes_____ No_____

The sequence in which the time values were listed differed between subjects. All 17 agreed to participate if the initial value was 7 min, eight agreed to 30 min, and only five to 55 min. Seven persons were selected to use the apparatus; all had stated on the written form that they would not use the apparatus if it were initially locked for more than 30 min. Two of the seven subjects were discontinued within the first 10 days of the study. One of these two subjects was belatedly discovered to have made travel arrangements that involved a long absence. The second subject had difficulty in carrying the cigarette case because of his unusually small shirt pockets. The other five subjects were able to carry the case either in their shirt pockets, or for the females, in their purses. None made travel arrangements that absented them for more than three days. Of the final five subjects, three were females and two were males; all were over 21 years of age. The five subjects reported that they had been smoking for 6, 7, 12, 12, and 20 yr respectively. They reported smoking between 30 and 50 cigarettes per day during the period preceding the study.

Apparatus

A special cigarette case was designed so that it automatically locked shut for a period of time after a cigarette was removed from it; the interval was measured from the closing of the

lid. The maximum duration for which the case could be locked was about 65 min and was determined by a timer within the case. (The timer was the major component of a portable alarm timer obtainable as catalog number 63-649 from Radio Shack Corp., Waltham, Mass.) Distinctive stimuli signaled when the case was unlocked; at the moment the case could be opened, a clicker ratchet-type noise sounded for about 0.5 sec and a narrow rod projected about 0.25 in. from the top of the case. Additionally, a clock dial face on the side of the case showed how many minutes remained, if any, before the lid would be unlocked. In one of the two models of the apparatus used, the desired duration was set by the experimenter and required disassembling of the case. In the other model, used by two subjects, the duration could be advanced at any time by the subject by means of a thin stylus provided with the case. This duration then remained in effect until it was increased again; the duration could not be decreased.

The outer dimensions of the case were 5.375 by 2.625 by 1.25 in. This size was 2.125 in. longer, 0.5 in. wider, and 0.25 in. thicker than the package of cigarettes it contained. The lid was connected internally to the timer, so that a fractional opening of the lid reset the spring-wound timer. The other characteristics of the case have been described previously (Powell and Azrin, 1968). The case lid was under sufficient tension to snap shut and lock when the subject released the lid. An elevator arrangement forced the package of cigarettes up 0.5 in. when the case was opened, thereby facilitating removal of a cigarette. A non-resettable counter within the case recorded the number of times the lid was opened.

Procedure

For about one week (4 to 10 days for different subjects) the special cigarette case was locked for only 6 min after each opening of the lid. Since this duration was about equal to that needed to smoke a cigarette, this period allowed the subject to become accustomed to the case and its associated stimuli without interference with his smoking. Subsequently, the duration for which the case remained locked was increased. The experimenter contacted the subject every three days by phone or in person and asked whether the subject wished the duration increased. The change, if desired, was made on the same day that the subject requested it. Except in two instances, each increase was limited to 5 min and was made no less than three days since the last change. The duration was increased in this manner to the maximum value of the timer. From the seventh to the twelfth week, S-2 used that model of the apparatus which permitted her to advance the duration herself; S-3 used it for her entire period of study. The subjects spent 1 to 3 weeks at maximum duration. Then, redeterminations were obtained by decreasing the duration to 6 min for four subjects and to 30 min for the fifth subject.

After this part of the study was finished, the subjects filled out a written questionnaire that asked about any annoyance in using the case and the extent to which the various signals were used.

A control procedure was used with two subjects to evaluate the present method by comparing it with a commercially available device (Memosmoke available from Lebovits Associates International, Los Angeles, California) also designed for controlling smoking. That device can also be locked after each cigarette is removed but the smoker must set the duration himself each time he closes the case. Consequently, no gradual lengthening of the interval is programmed. Also, the device does not provide auditory or tactual extinction stimuli. One subject used the device for four weeks, the other subject used it for six weeks under the same recording conditions described below for the newly developed apparatus.

Recording. Two separate methods were used on each subject for recording the number of cigarettes smoked. The first method was the non-resettable counter within the cigarette case that counted the number of times the lid was opened to obtain a cigarette. (A counter was also added to the Memosmoke device.) The subjects had been instructed to open the lid only when a cigarette was to be taken. The counter numerals were visible through a small window on the case. An inconspicuous pocket on the back of the case contained small cards provided by the experimenter on which the subject recorded the time of day when the first and the last cigarette was taken and the counter readings at those times. The cards were collected by the experimenter every few days and without comment regarding their

contents. The experimenter did check the correspondence between the counter reading on the case and the last reading recorded on the card. The second recording method was the participant observer technique described elsewhere (Powell and Azrin, 1968). Each subject had designated one or more individuals in their living and working environment who could report on their smoking behavior. These participant observers were given envelopes, addressed to the experimenter, that contained a form on which they reported whether all the cigarettes smoked in their presence by the subjects were obtained only from the cigarette case. The observers were also instructed to report any other deviations from the prescribed procedure. These reports were obtained each day, usually by mail. One subject had a participant observer at work; the others had an observer at their home as well as at work.

RESULTS

Figure 1 presents the number of cigarettes smoked per day. Each data point is a seven-day average. The variability (average deviation) was less than 20% of the mean value for 44 of the 53 data points. Figure 1 shows that the number of cigarettes smoked per day decreased progressively for each subject during each succeeding week that the special cigarette case was used. The initial level of smoking, when the case was locked for only 6 min, varied from 20 to 44 cigarettes per day between subjects. Smoking decreased to about 12 cigarettes per day at the maximum delay of about 65 min. When the duration was then decreased to 6 min (see redetermined point) for S-1, S-3, S-4, and S-5, smoking increased to about the level seen at the start of the procedure; S-1 was 10 cigarettes lower on the first redetermination and one cigarette higher on the second redetermination, which was obtained four weeks later. The redetermined value of 30 min for S-2 resulted in a difference of only two cigarettes per day from the initial determination. After the initial adaptation week, the subjects required about one week to reach the 15-min duration, 3 to 4 weeks for the 30-min duration, 4 to 8 weeks for 45 min

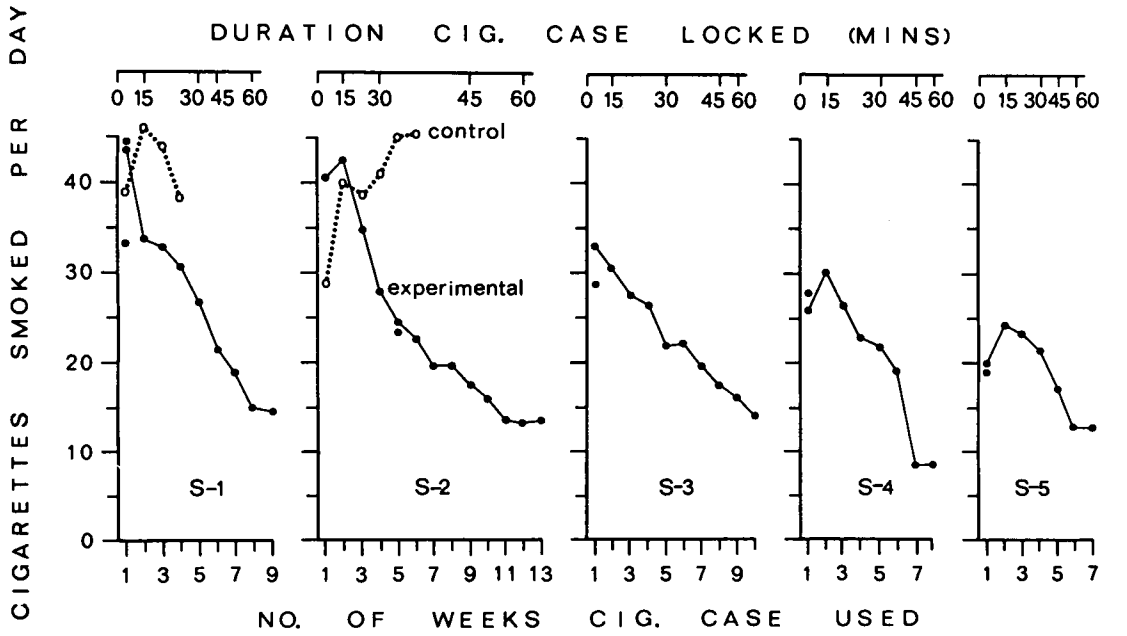

Fig. 1. The number of cigarettes smoked per day while using a special cigarette case (closed circles, solid line) that locked automatically for a specified duration after a cigarette was removed from it and a control apparatus (open circles, dotted line) which required the subject to preset the duration. Each data point is a seven-day average except for the initial points which included 4 to 10 days for different subjects. The lower horizontal axis shows the number of weeks each cigarette case was used; the upper horizontal axis shows the duration for which the special case was locked. The redetermined points are not connected by the curves. The lower of the two redetermined points for S-1 was the first redetermination; the upper one was made four weeks later.

and 6 to 12 weeks for the maximum duration of about 65 min. A slight increase in smoking is seen at the 15- to 20-min duration for three of the five subjects. These subjects reported that at these values the auditory signal seemed to prompt them to have a cigarette. Both models of the cigarette case were effective in reducing smoking as seen by the reduction of smoking for S-3 and after the seventh week for S-2, both of whom increased the delay interval themselves.

Of the 54 opportunities given to the subjects to increase the delay interval, they advanced it 22 times and postponed the advance on the other 32 occasions.

Smoking was not reduced during use of the control Memosmoke device as seen from the dotted curves in Fig. 1. After four weeks, S-1 showed no reduction; after six weeks, S-2 smoked more than initially. Both subjects reported that they usually set the interval at 5 min or less. Both subjects refused to continue using the device.

Figure 2 shows the latency of taking a cigarette measured as the time between the automatic unlocking of the case and the subject's response of opening the lid. This measure was calculated from the counter readings and from the data given on the daily self-reports as to when the first and last cigarettes were smoked. As the duration increased for which the case was locked, all five subjects showed a progressive decrease in the time that they allowed it to be unlocked before obtaining a cigarette. This average latency was as low as 3 min for S-1 and 5 to 10 min for the other four subjects. Both S-2 and S-4 showed an increase in latency when the case was locked for more than 45 min. Both subjects volunteered the report of a general decrease in their desire for cigarettes at those values.

Of 374 reports submitted by the participant observers, four reports noted that the subjects had obtained a cigarette from another person. In each of these four instances, the subject also had independently reported the deviation. One subject began smoking a pipe for one day which was also reported by one of his participant observers. All of the other 369 reports (99%) stated that the special cigarette case was being used as the only source of cigarettes and that only one cigarette was taken at a time.

On the written questionnaire given at the end of the study, all subjects reported that they used the signals that indicated whether the case was unlocked. All five subjects reported relying primarily on the click sound at the end of the interval. The dial face was reported as used some of the time by all five subjects, three of whom reported that they used it most often at the longer durations. Four of the five subjects reported relying on the projecting rod by touching it, especially in noisy or dark environments such as in an auto where the other signals could not be perceived. Annoyance with the physical characteristics of the case was reported by two subjects, the prob-

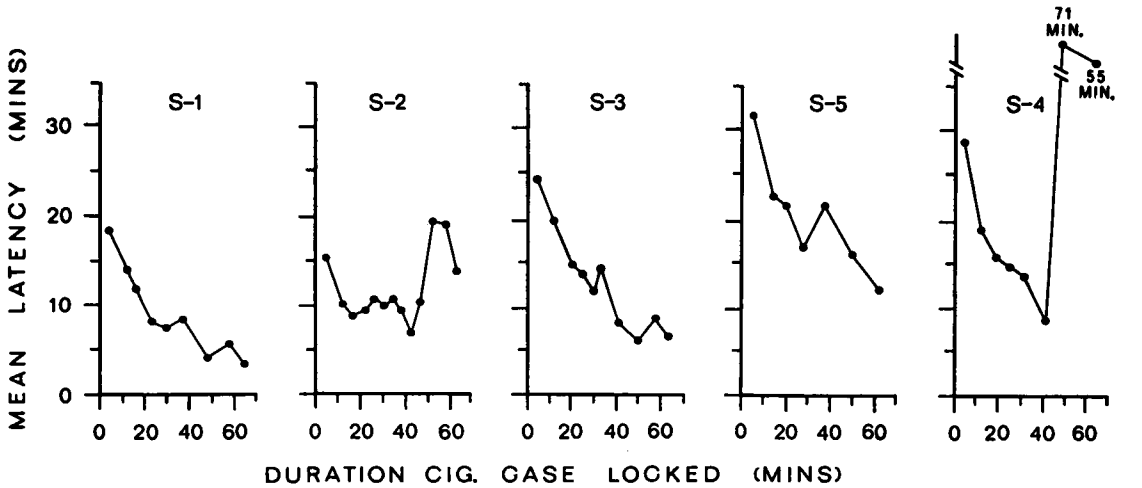

Fig. 2. The mean latency of taking a cigarette from the cigarette case as a function of the duration for which the case was locked. Each data point is a seven-day average except at the 6-min duration which was 4 to 10 days for different subjects.

lems being apparently the same as for any large cigarette case designed for very long cigarettes. Impatience was reported by four subjects in the form of attempts to open the case while it was still locked. For two subjects, these attempts were reported to have occurred primarily during the initial few weeks of the study. The other three subjects reported that these attempts occurred primarily at the time that the interval was increased or at the longer intervals. This impatience was reported by three subjects as being specific to stressful or party-like social situations.

DISCUSSION

The procedure reduced smoking for each of the subjects to one-half or less of the original rate and to the level of about 12 cigarettes per day that is considered medically safe (Surgeon General's Report, 1964). The number of cigarettes smoked was determined primarily by the duration for which the case was locked as evidenced by the short latency with which a cigarette was removed from the case. The need to increase the delay interval gradually was evidenced by the refusal of many subjects to use the cigarette case if the initial duration were long. Only five of the 17 subjects would use the experimental apparatus at starting delays of 55 min and only eight of the 17 at delays of 30 min. Also in using the case the subjects increased the delay interval very gradually and allowed the experimenter to increase it only infrequently. Since smoking returned to its original level immediately when the smoking delay was eliminated, the observed reduction of smoking could not have been caused by the simple passage of time. At a given delay interval, smoking was reduced for as many days as the delay was in effect. The subjects' statements indicated that a delay longer than 65 min could have been tolerated. The apparatus was not designed for longer intervals since the immediate objective was attainment of a medically safe level of smoking, not complete cessation. Presumably, longer delay intervals might be used to attain a near-zero level if that level is taken as the objective.

The possibility exists that the subjects continued to use the special cigarette case partly because of the continuous attention being shown by the participant observers as well as by the experimenter who advanced the delay interval periodically. The results showed that the influence of the experimenter was not critical since smoking was also reduced for the subjects who used that model of cigarette case that did not require the experimenter to advance the interval. The reports of the participant observers were valuable in providing assurance that the cigarette case was being used appropriately. The reduction of smoking cannot be attributed to the participant observers, however, nor to the novelty of the special cigarette case, or to the attention paid to the subject. Smoking was at a high level during the control periods at the beginning and end of the study when all of these factors were present but the cigarette case was locked for only a brief duration.

The ineffectiveness of the control device is especially relevant in demonstrating the importance of the specific features of the experimental apparatus. The control device and the experimental apparatus both had the same apparatus novelty, presumption of effectiveness, experimenter interaction, participant observer influence, details of record keeping, and general motivation of a subject. The experimental apparatus differed in two respects: it had a programmed and automatic increase of the delay interval and it associated auditory and tactile stimuli with the delay interval in addition to the visual stimulus which was present in both models. One or both of these differences appears to have been responsible for the reduction of smoking.

The present procedure seems to hold promise as a practical means of reducing smoking: complete evaluation will, of course, require its use with more subjects. First, it seems to be a method that individuals are willing to use. Survey results (Mausner, 1966; Cartwright, Martin, and Thompson, 1959) have shown that a large proportion of smokers state that they would like to stop smoking. These reports were in agreement with the present finding that all 17 individuals approached were willing to try the present procedure. It may be noted here that two of the final five subjects had refused to use an aversive conditioning procedure in a previous study (Powell and Azrin, 1968). Secondly, the present method seemed fairly convenient to use. The special cigarette case was described by three of the subjects as too large, but the size could be easily reduced by using a smaller timer.

Thirdly, the procedure did not seem to be aversive. None of the subjects gave any indication that they wished to discontinue use of the apparatus. Annoyance was reported principally at the time that the delay interval was increasing and during infrequent party-like occasions. A more gradual increase of the delay interval might be expected to reduce this slight annoyance further. Some disadvantages of the procedure were that the reduction of smoking required several weeks, the smoking returned to normal when the procedure was discontinued and the smoker was required to advance the delay. This last disadvantage has been eliminated in a later model of the cigarette case in which each opening of the case automatically increased the delay interval by a few seconds; for reasons of experimental design this model was not used in the present study but might be the best of the three models since it does not require the smoker to decide continuously what the delay should be, only that he use the case to hold his cigarettes. The overall usefulness of this procedure depends on the alternatives. Short-term aversion therapy, educational and therapeutic procedures, drugs, such as lobeline sulfate, all may require less time to perform. Unfortunately, these alternatives have not been demonstrated to be effective or have not been generally acceptable to most smokers (Bartlett and Whitehead, 1957; Horn, 1960; Lawton, 1962; Mausner, 1966; Franks, Fried, and Ashem, 1966; and see reviews by Keutzer, Lichtenstein, and Mees, 1968; and Surgeon General's Report, 1964).

The essential features of the procedure followed the behavioral engineering principles outlined previously (Azrin *et al.*, 1968) for designing a portable operant conditioning apparatus. (1) *The target behavior* was defined as cigarette smoking and this *response was defined by an apparatus* as opening a cigarette case. (2) Although smoking could theoretically take place by obtaining cigarettes from another source, such (3) *false negatives of this response definition* were found to be minimal, probably because of the nonaversive features of the procedure. False positives seemed to offer no problem since the subject had nothing to gain by opening the case except to obtain a cigarette, and (4) *the controlling behavioral event* was extinction, which was achieved by the locking of the case. Since the period of extinction was associated with distinctive stimuli, the duration for which these stimuli were present constituted a period of discriminated extinction. The nonaversiveness of this extinction stimulus control seems to have been successfully achieved by lengthening the stimulus gradually, as suggested by the temporal shaping procedure used by Terrace (1963) and Hake and Azrin (1968), to produce long periods of time during which the smoker would not attempt to open the case to obtain cigarettes and would not discard the cigarette case. These signals and response-delay arrangements were incorporated into (5) *an apparatus that was convenient and portable* so that the procedures could act on the subject in his natural environment.

All five subjects reported a long history (6 to 20 yr) of fairly uninterrupted smoking at a high level in spite of their reported desire to discontinue smoking. For these and similar subjects, smoking seems similar to addictive behaviors with respect to the extreme behavioral dependence on the drug and probable physiological withdrawal symptoms (Knapp, Bliss, and Wells, 1963). This technique also might be effective in assisting addicts to withdraw gradually from their addictive drug in an outpatient situation as an alternative to the institutionalization that is customarily employed (Jaffe, 1965).

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