OPERANT CONDITIONING OF HUMAN ANAL SPHINCTER PRESSURE¹

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Anal sphincter pressure in a 13-yr-old encopretic boy was modified by reinforcing increases in pressure exerted on a fluid-filled balloon inserted into the rectum. It was found that pressure changes were a function of the reinforcement schedule and that baseline levels (resting pressure) during extinction conditions tended to increase throughout the experiment.

The control of anal sphincter pressure is a prime concern in the rearing of children. From an operant viewpoint, parents arrange the delivery of reinforcement and punishment such that most children gain adequate bowel control at 2 to 3 yr of age. In some cases, however, the training is not completely successful or other conditions intervene which then result in a broadly defined clinical disorder termed "encopresis". Encopresis always involves fecal soiling and the absence of regular bowel movements.

For the purposes of this paper, encopresis can be differentiated into two syndromes. The first involves a sequence that starts by withholding stool which in turn becomes a large, compacted mass. This mass eventually forces the anal sphincter open which then allows the continuous discharge of a mucous substance. This discharge, in turn, is responsible for the encopretic soiling and odor. Several investigators have reported treating this type of encopresis with operant techniques (Ferinden and Handel, 1970; Gelber and Mayer, 1965; Keehn, 1965; Neale, 1969). In general, these approaches involve reinforce-

ment of regular elimination responses and punishment of withholding.

The second type of encopresis does not involve withholding or the accumulation of a large compacted mass. Instead, soiling is caused by a dilated sphincter which allows a constant fecal discharge. Since there is no accumulation of stool, there is no operant level of normal elimination behavior.

In the absence of organic antecedents, the treatment of this second type of encopresis requires continuous measure of anal sphincter pressure. This paper is concerned with the measurement of anal sphincter pressure and the treatment of a child who exhibited the second type of encopresis.

Subject

A 13-yr-old boy reported by his parents to be a continuous soiler throughout his life, served as subject. Since 6 yr of age, several physicians had suggested that inadequate anal sphincter tone was responsible for the encopresis. One and a half years before the present study, he had been unsuccessfully surgically treated for Hirschsprungs disease, a congenitally dilated colon. The surgical procedure involved removal of a section of the colon. At the time of this study, the subject was an in-patient on the pediatric wing of a hospital where he was being considered for a colostomy which would create a new opening of the colon on the surface of

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the body. Since digital examination of the rectum was reported to indicate inadequate sphincter tone, and because colostomy is considered to be physically and psychologically traumatic, an operant approach to modifying anal sphincter tone was attempted.

Apparatus

A necessary condition for setting up an operant contingency is a reliable and continuous measure of the response of the subject. A precise measure of sphincter tone is the Resting Yield Pressure (Harris, Winans, and Pope, 1966), which indicates the amount of pressure required to force fluid escape through an aperture held against the sphincter surface. The aperture is on a cylinder, which is inserted into the rectum. This measure was not suitable for the purpose of this study because measurement of anal sphincter pressure could be sampled only at intervals of several minutes and not continuously. The Resting Yield Pressure apparatus was used, however, for ancillary pre- and post-treatment measurement of anal sphincter pressure.

An apparatus was constructed that would allow direct continuous measurement of pressure in the anal sphincter area. A 16F plastic Levine tube was sealed at one end with tetrahydrofuran and two openings cut in the first 3-cm segment. Over this segment, a Miller-Abbott balloon (capacity approximately 30 cc) was tied. A small clear polyvinyl tube 2.5 mm O.D. was cemented into the other end of the Levine tube. In use, the apparatus was filled with red tinted water and the smaller polyvinyl tube placed in a vertical position next to a scale. The balloon assembly was made to be inserted in the rectum so that the balloon crossed the area of the anal sphincter. The height of the water column in the small polyvinyl tube then could serve to measure relative changes in pressure exerted in the anal sphincter area.

Other apparatus used in this study consisted of Davis Scientific programming and timing equipment, an Esterline Angus event recorder, and a time-lapse movie camera.

Response Definition and Recording

Data were continuously recorded by a time-lapse movie camera that photographed the water column every 1 sec. In addition, the operation of timers used in arranging contingencies was recorded on the event recorder. All contingency and data reporting were based on the water column height, which exceeded the criteria of 22.5 in. above the rectal balloon. This criterion was used throughout the experiment having been selected on the basis of preliminary observations that indicated that it was exceeded only briefly and relatively infrequently.

General Procedure

After pre-treatment measures of Resting Yield pressure were obtained, 15 experimental sessions of approximately 1 hr duration were conducted over a five-day period. All experimental sessions took place in a private room on the ward with the subject lying in bed in a position such that he could observe the height of the water column, as shown in Figure 1. There

Fig. 1. The arrangement of bed, water column indicating pressure, movable sheet to block subject's view of pressure indicator, time-lapse camera, and reinforcement jar.

were always two other people in the experimental room, a nurse who inserted the rectal balloon and assisted in experimental procedures, and the author, who operated the recording and timing equipment. The procedure was modified in succeeding sessions based upon the results of the preceding sessions. The 15 experimental sessions were, for the purposes of this report, divided into three distinct experimental phases.

Phase 1. Procedure

Phase 1 consisted of one experimental session. This, the first session, began with 15 min of baseline condition during which the water column was closed to the subject's view by a curtain. The second 15-min segment consisted of exposing the water column to the subject's view and explaining that keeping the water level high

meant that his anal sphincter was working and that surgery would not have to be performed because the problem was cured. This sequence was repeated over the next two 15-min segments of the first experimental session.

Phase 1. Results

The cumulative number of seconds during which the water column exceeded the 22.5-in. criterion is shown in Figure 2. Visual feedback alone (segments b and d) had little apparent effect on anal sphincter pressure, and this led to the institution of Phase 2 procedures.

Phase 2. Procedure

The next three experimental sessions consisted of alternating 15-min segments of no contingency (extinction) and monetary reinforcement. The

Fig. 2. Cumulative records of time that pressure exceeded criterion during the first session (curve is horizontal when pressure is below criterion and inclined when pressure exceeds criterion). Session consisted of 15-min segments of (a) no-feedback (b) feedback (c) no-feedback (d) feedback.

reinforcer was nickels dropped in a glass jar in the subject's field of vision and was used throughout the remainder of the experiment. The contingency was as follows: every 10 sec, the experimenter looked at the water column. The 10-sec interval was signalled by a recycling timer. If at that time the water column exceeded criterion, the reinforcer was delivered.

Phase 2. Results

The total amount of time that the water column exceeded criterion is shown in Figure 3, together with comparable times for the other phases of the experiment. The contingency resulted in an increase in anal sphincter pressure over the values obtained during Session 1.

A portion of the last experimental session with Phase 2 contingencies is shown in Figure 4. Inspection of this figure demonstrates that, except for the first burst in segment d, the duration of any one response was less than 15 sec. The clinical implications of this short duration response were not favorable because the target response was a relatively long duration of increased sphincter tone. There was also a tendency for pressure to increase towards the end of the 10-sec interval and to decrease shortly after delivery of the reinforcer. This performance is similar to that observed on fixed-interval schedules with limited hold (Ferster and Skinner, 1957); thus, the data indicated that the behavior under study is similar to other operants in

Fig. 3. Total time during each session that pressure exceeded criterion for reinforcement and extinction conditions. Phase 1 procedures were used during Session 1, Phase 2 procedures were initiated at (A), and Phase 3 procedures at (B).

Fig. 4. Cumulative record of time that pressure exceeds criterion for portions of the fourth session during which a fixed-interval schedule of reinforcement was employed. Hatch marks indicate delivery of reinforcement (nickels). The final 3.33-min portions of successive 15-min segments are shown (a) extinction (b) reinforcement (c) extinction, and (d) reinforcement.

that the temporal pattern of the response appeared to be a function of the temporal characteristics of reinforcement schedule. On the basis of the above data, Phase 3 procedures were instituted.

Phase 3. Procedure

Since it was found in Phase 2 that the schedule or manner in which contingent reinforcement was delivered seemed to control the topography of the response, it was decided to arrange conditions that would favor increasing durations of height and pressure. The following procedure was used in the remaining experimental sessions, except Session 7, during which data were not recorded and the contingency was given on the basis of an estimate of session performance. The water column was continuously observed by the experimenter, and whenever

pressure exceeded criterion, a button was depressed that activated two timers. After the first timer had timed out its interval (T_1), a second timer would begin timing and, if the button remained depressed, would recycle at intervals (T_2). If at any time the pressure dropped below criterion, the button was released, electrical contact was broken, and a new response was required to initiate activation of timer 1. Reinforcement was delivered each time timer 2 recycled. T_1 was relatively long as compared to T_2 , initially, T_1 was 10 sec and T_2 was 4 sec. At the end of training, T_1 was 38 sec and T_2 was 20 sec.

Phase 3. Results

Overall performance for this phase is shown in Figure 3 and a more detailed record is shown in Figure 5. Figure 5 shows data obtained dur-

Fig. 5. Cumulative record of time that pressure exceeds criterion during the tenth session during which long durations were reinforced. The session consisted of successive 15-min segments of (a) extinction (b) reinforcement (c) extinction, and (d) reinforcement.

ing the tenth experimental session, which is typical of the results obtained during the last six sessions. Both Figures 3 and 5 indicate that during the reinforcement condition, sphincter pressure exceeded criterion for longer durations than under extinction conditions. The duration of the response was greatly increased, and as shown in Figure 5, one response exceeded 14 min during the second 15-min reinforcement segment. It is also interesting to note that the cumulative level of pressure occurring during extinction is considerably greater than the levels observed in Figures 2 and 4. This trend occurred throughout training and is shown in Figure 3.

Resting Yield Pressure Measurement

The apparatus for measuring Resting Yield Pressure was located at a different hospital (Hospital B) than the one in which the subject was a patient (Hospital A). As part of the clinical diagnosis routine, the subject was taken to Hospital B and measures of Resting Yield Pressure were obtained by Hospital B staff. The subject then returned to Hospital A and Phase 1 of the experiment was initiated approximately 48 hr after the pre-treatment Resting Pressure measurements were obtained. Within 24 hr after the last experimental session was completed, the subject again was taken to Hospital B for post-treatment measurement. The pre-treatment measures of Resting Yield Pressure was 35 mm of Hg. The post-treatment measure showed a 15 mm increase in pressure to 50 mm of Hg.

Reliability of Observations

The data reported for Sessions 1 through 4 were based on the 1-sec time-lapse pictures of the water column. Three 100-sec segments from reinforcement and extinction conditions during Sessions 1, 3, and 4 were independently scored by two observers. The observers were in agreement between 96% and 100% of the scoring opportunities.

The remaining reported data were based on event-recorder tracings. For the purpose of

checking reliability, an independent observer obtained six 15-min segments of data from the last six sessions based on the time-lapse pictures. The difference between the total time for each segment obtained by the two methods was divided by the time obtained from event-recorder records and subtracted from 100. The mean percentage thus obtained was 93% with a range of 87% to 99%.

Follow-up

On the basis of the experimental effects on sphincter pressure as measured by water column height and change in Resting Yield Pressure, the colostomy procedure was postponed and the subject was discharged from the hospital. One year after discharge, neither the hospital nor the original referring physician had been contacted by the subject's family for additional treatment.

There were some additional casual observations that are related to the clinical outcome of the study. Nurses on the ward reported that there was no soiling of bed clothes on several occasions during the last three days of the study, whereas soiling was always observed whenever the patient was checked during the previous 10 days. One month after discharge, the parents of the subject reported that there was no soiling for periods of approximately 8 hr which can be contrasted with their earlier reports that soiling and odor was observed to be continuous. Due to the casual nature of the above clinical reports and the unavailability of other follow-up data after discharge, the clinical outcome of this study should be interpreted with caution.

DISCUSSION

Differences between reinforcement and extinction conditions and reinforcement schedule effects indicate that anal sphincter pressure was brought under the control of operant contingencies. The nature of the rectal balloon apparatus, however, does not permit an unambiguous conclusion that anal sphincter muscle tone in particular was increased. Any increase

in intra-abdominal pressure, such as that produced by abdominal muscle contraction, could have increased pressure in the anal sphincter. The Resting Yield Pressure measurements, however, do tend to support the notion that sphincter muscle tone was increased.

The clinical data relating to less soiling, although these data are casual and should be interpreted with caution, also tend to suggest that anal sphincter tone was increased.

There are at least two ways in which future research could yield less ambiguous evidence of anal sphincter muscle tone. First, a pressure balloon could be passed into the stomach, thus permitting a measure of intra-abdominal pressure, reinforcement could then be made contingent only on increases in anal pressure that occur independent of intra-abdominal pressure. Second, more precise data on soiling could be used post-treatment as evidence for sphincter muscle changes. In any event, the technique and apparatus used in the present study hold promise

as an effective treatment approach for continuous encopretic soiling.

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