TRAINING CHILDREN WITH ASTHMA TO USE INHALATION THERAPY EQUIPMENT¹

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In Experiment I, four children with asthma were taught to use the intermittent positive-pressure breathing (IPPB) apparatus, a device that delivers bronchodilator medication to the lungs under positive pressure. Because these youngsters had not learned to use the device with repeated instructions, script with back-up reinforcement was introduced to train sequentially three responses—eye fixation, facial posturing, and diaphragmatic breathing—according to a multiple-baseline design. The procedures were effective in teaching appropriate use of the IPPB apparatus. Further, the children's use of the apparatus after training resulted in significantly more effective relief of asthma symptoms. In a second experiment, nurses were instructed in the application of the operant techniques used in the first study, and then served as experimenters in a partial replication of Experiment I. The data once again reflected a strong impact of the intervention program on IPPB responses.

DESCRIPTORS: asthma, inhalation therapy, medication apparatus, nurses, change agents, prompting, shaping, generalization, natural reinforcers, children

A common complaint among medical practitioners is that patients do not follow prescribed medication or treatment regimens. According to Azrin and Powell (1969), the rate of such inappropriate responding is astonishingly high, ranging from 20 to 70% for patients in various disease categories.

A related problem, which has received little or no attention, is that some patients do not make proper use of equipment that dispenses medication. Misuse of such equipment occurs relatively frequently at the Children's Asthma Research Institute and Hospital (CARIH), a division of the National Asthma Center in Denver, Colorado, where at any given time some 4 to 5% of the total population, even with repeated instructions, does not use the Intermittent Positive-Pressure Breathing (IPPB) apparatus correctly.

The IPPB machine converts liquid bronchodi-

lator medication into inhalable form and delivers it under positive pressure to the patient's airways. The apparatus consists of a flow-sensitive valve that opens with slight inspiratory effort and an air-pressure gauge, both of which are housed in a small cabinet. A flexible hose is connected to the unit. A container that holds liquid medication and a mouthpiece can be readily attached to and detached from a mechanism that is connected to the end of the hose.

Before using the IPPB equipment, the children are instructed by the nurse to "sit up straight" and to look at the air-pressure gauge located on the front of the machine. The gauge is not functionally necessary, but it does serve as a point of visual fixation, and as a cue reminding the children to sit up straight and to keep their heads at a 90° angle to the apparatus. Eye fixation may also help to reduce interfering or distracting stimuli, thereby allowing the children to attend better to instructions and to monitor the responses emitted while using the equipment. The youngsters are then shown how to hold the mouthpiece so that, with the end held comfortably but firmly in their mouths, it is at a right-

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angle to their faces. They are told to keep their mouths firmly around the mouthpiece and to avoid puffing their cheeks and breathing through their noses (facial posturing). Cheek puffing or nostril flaring indicates that the medication is escaping into the room, rather than being transported into the lung. Next, the children are given instructions on how to breathe as they operate the apparatus. Since abdominal wall excursions must be coordinated with the respiratory cycle, the children are told that the abdominal wall must be pushed out when breathing in and pulled in when breathing out. This method, diaphragmatic breathing, as opposed to primarily intercostal breathing, is used because it is the most effective method of pulling the medication-laden air deep into the lungs.

These three distinct behaviors have to be simultaneously emitted and synchronized into a response pattern if the children are to use the equipment correctly, and thereby benefit from the treatment it provides. Obviously, the procedure will be inefficient and, consequently, the benefit minimal for those children who do not use the device properly. In fact, such patients usually require further treatment and hospitalization before their asthma attacks can be brought under control. It was this latter fact that led the nursing staff to refer such youngsters to the Behavioral Science Division at the Center so that a program could be devised to teach them to use the IPPB.

EXPERIMENT I

This study attempted to increase the amount of medication transported to patients' lungs by teaching them how to use the IPPB apparatus appropriately. The training was accomplished via a reinforcement program aimed at three behaviors: eye fixation, facial posturing, and diaphragmatic breathing. Thus, a primary goal was to help youngsters to medicate themselves better and, consequently, to derive greater benefit from the treatment as evidenced in fewer asthma symptoms and reduced treatment of such

symptoms following use of the IPPB. A second goal was to ensure generalization of the trained behaviors, once they were acquired, by passing control to the natural reinforcement contingencies associated with relief from asthma.

Subjects and Setting

Two boys and two girls, ranging in age from 7 to 12 yr, were referred for training by the nursing staff. All had been given repeated instructions on the use of the equipment, but to no avail. These children had been in residence at the Center (a residential treatment facility for approximately 120 children between the ages of 5 and 16 yr who suffer from chronic intractable asthma) for about six months when the study began. Children at the Center live in cottages and report to a centrally located hospital facility for all medical treatment. The IPPB study was carried out in the treatment room of the hospital. This setting was chosen, because, as pointed out by Walker and Buckley (1972), subject-specific behaviors are partly a function of stimulus similarity existing across settings. Thus, using the treatment room for IPPB training was an attempt to maximize generalization of training to the treatment situation.

Definitions of Target Behaviors

Eye fixation was defined as the subject looking at the dial on the front of the apparatus whenever the mouthpiece was inserted into his or her mouth. Breaking eye contact by looking away from the dial during any given trial was recorded as an instance of inappropriate behavior. Appropriate facial responses were defined as holding the mouthpiece at a 90° angle to the face, with lips held motionless and firmly secured around the mouthpiece, and no visible movement of the cheeks or nostrils. Any one or a combination of the following behaviors—flaring of the nostrils, puffing of the cheeks, movement of the lips or lifting of the lips from the mouthpiece, and holding the mouthpiece at an angle less than 90° relative to the child's face—that occurred during any trial was recorded as an

inappropriate response. Appropriate diaphragmatic breathing was defined as distention of the abdominal wall upon inspiration and contraction upon expiration. The abdominal wall had to move outward with inspiration and inward on expiration in order to count as a correct response. No visible movement of the abdominal wall or any movement out-of-phase with the breathing cycle on any trial was recorded as an inappropriate response.

Procedure

Experimental sessions were held at the same time of day for each child. To keep potentially distracting stimuli and incompatible behaviors to a minimum, other children were not permitted to use the treatment room during sessions, and training procedures were conducted when the children were symptom-free.

The subjects were seen individually and told by a nurse:

"I am going to help you learn how to use the IPPB in a way that may help your asthma. First, sit up straight and look directly at this dial. Next, hold the mouth-piece so that it points straight out from your mouth as you look at this dial. Keep your lips held firmly around the mouth-piece and avoid puffing your cheeks or breathing through your nose when using the IPPB. Finally, you should use your stomach and abdomen to help you breathe. Push your stomach out when you breathe in and pull your stomach in when you breathe out. Now take 15 breaths on the machine and then relax."

These instructions were given slowly and deliberately, and repeated for each target behavior whenever inappropriate behaviors were emitted.

The first 15 breaths were observed by the experimenters, who then selected and defined specific target responses for each child. After the responses were targeted, the subjects were told to take 15 breaths (one trial) on the IPPB and to pause a few seconds before taking another 15

breaths. The pause was introduced because the experience of the nursing staff indicated that pausing to relax after taking a few breaths was the most efficient way to use the equipment. Fifteen breaths were specified as a trial because this number ordinarily provides a sufficient amount of medication to help a child obtain immediate relief from asthma symptoms.

Three baseline trials were recorded on all target behaviors simultaneously, after which the instruction was repeated for a specific target behavior as that behavior became the focus of intervention. Only those parts of the instruction applicable to a specific subject were given. For example, some subjects did not puff their cheeks, and so the instruction on puffing cheeks was omitted for them.

The first target behavior was eye fixation. The subjects were told that they could earn one ticket at the end of each trial if they did not look away from the dial more than a specified number of times. The criterion of success on the first training trial for all target behaviors was the subject's best score on the respective behaviors during the baseline trials. The criterion of success was modified on each succeeding trial according to the subject's performance on the preceding trial. At the start of training, subjects were also told that when they had earned a total of 25 tickets they could purchase a surprise gift. The script was manipulated such that 25 tickets had to be earned by each subject only after learning to use the equipment. This was done by varying the number of tickets that could be earned on later trials, for example, by giving bonus tickets and pacing the success criterion according to the number of trials completed. In addition to requiring a criterion of success for the specific target behavior focussed on at the moment, the subjects later had simultaneously to maintain the final success criterion achieved on each of the preceding target behaviors. This was presented as an instruction before the start of one of the later trials after the then-targeted behavior appeared to be under operant control. The surprise gifts were the subject's choice of items costing

\$2.00 or less and a shopping trip to purchase the item. Script for achieving the criterion was delivered immediately after each trial was completed. Presentation of the script was always accompanied with a positive comment from the experimenter such as "That's good, (name), you have earned a ticket".

Prompting was given before and during the early intervention trials on the diaphragmatic breathing response. Prompting consisted of the experimenter pushing in on the abdomen of the subjects while, at the same time, instructing them to breathe out as fully as possible from their mouths. They were then told to use their stomachs to push the experimenter's hand away while breathing in as deeply as possible through their mouths. The prompting seemed to speed the learning process for those subjects who exhibited no diaphragmatic breathing on the baseline trials. Prompting was faded by first eliminating the "hand-against-the-abdomen" procedure before the start of the first trial while continuing the verbal instruction following any inappropriate responding through the first two trials.

Verification

A multiple-baseline design (Baer, Wolf, and Risley, 1968) was employed to verify the effectiveness of the proposed intervention program. For each child, baseline measurements were simultaneously obtained on all target behaviors. Intervention was started on eye fixation at the fourth trial, while baseline measures continued to be taken on facial posturing and diaphragmatic breathing. Intervention on facial posturing occurred at the seventh trial and on the diaphragmatic breathing at the thirteenth trial. The experimental procedures were completed for each subject in one 26-trial session, including the baseline observations and the training trials.

Eye fixation was selected as the first target behavior for intervention because it was assumed that attending would in fact compete with many of the interfering behaviors exhibited by the subjects. Another rationale for ordering the behaviors in terms of an intervention sequence was

the difficulty expected in modifying them. Eye fixation was considered the "easier" response to learn and it seemed logical on this basis to target it for intervention ahead of the other behaviors. By so doing, it was hoped that early experiences of success and reinforcement would keep the subjects at the task longer with less discouragement and frustration.

Preliminary observations of the children using the IPPB revealed that one youngster in particular would have more difficulty than the others in learning the appropriate IPPB responses. This subject emitted inappropriate, competing behaviors, such as leaving his chair, talking, pushing, shoving, *etc.*, at a much higher rate than the other youngsters. He was therefore selected as the first subject for intervention so that the number of trials (26) needed to reach the criterion of success for each behavior might set a standard for the remaining subjects. Indeed, all subjects easily reached the expected criterion of success using this schedule. The criterion for introducing the intervention on successive behaviors for the first subject was arbitrarily set at 85% appropriate responding on two of three trials. This meant 13 of 15 correct responses per trial on two of three trials before intervention began on the next behavior.

Reliability

Two experimenters conducted the study and continuously observed and recorded the target behaviors. An additional naive observer, otherwise uninvolved in the experiment, recorded target behaviors on randomly selected trials interspersed throughout all phases of training. The manner in which the data were recorded did not allow for a breath-by-breath comparison using the more precise agreement-disagreement formula for estimating per cent agreement. Therefore, interobserver reliability was computed on a trial-by-trial basis by dividing the frequency total of the observer with the smaller number of inappropriate responses on each trial by the frequency total of the observer with the larger number of inappropriate responses on the same

trial. The per cent agreement between observers across trials for eye fixation averaged 94% and ranged between 60 and 100%. Interobserver reliability for facial posturing across trials averaged 96% and ranged from 73 to 100%. The average observer agreement for diaphragmatic breathing across trials was 87%, with a range from 67 to 100%.

Generalization

Learning to use the IPPB in the absence of asthma symptomatology constituted, in effect, a different stimulus situation or condition than would have been the case had asthma symptoms been present. This is so in spite of using the same equipment in the same room for both training and asthma treatment. Thus, an important question regarding generalization was whether or not youngsters would later use the IPPB equipment appropriately when suffering from asthma.

As one attempt to maximize generalization, the subjects were told when the study ended that they could earn a second surprise gift if they either had no more asthma for the remainder of their stay at the Center or they used the IPPB apparatus in the instructed manner during subsequent attacks of asthma. The nursing staff informed the experimenters of the youngster's first postintervention use of the IPPB and observations determined if appropriate responding had indeed generalized to the asthma treatment situation.

Results

The results of the intervention program on the three target behaviors are summarized in Figure 1, where the inappropriate behaviors antagonistic to eye fixation, proper facial posturing, and diaphragmatic breathing all decreased dramatically following successive intervention on the behaviors. The inappropriate behaviors interfering with eye fixation and facial posturing decreased rapidly, with little or no recovery. Diaphragmatic breathing, on the other hand, was more

difficult to learn, as evidenced by the greater variability in the data after intervention, and by the fact that it was the only response requiring prompting during training. However, some of the variability may be partly attributable to the greater difficulty encountered in observing diaphragmatic breathing, since the average per cent of observer agreement was somewhat lower for this response than for the other target behaviors.

Figure 1 is a composite graph summarizing the performance data of four subjects. In general, all four subjects showed similar decreases in inappropriate behavior when training was started. However, subjects showed some differences in the baseline level of performance. For example, during baseline, the mean level of inappropriate eye-fixation responses per trial for one subject was only 3.3 (compared to a mean of 14.4 for the other three subjects). Nevertheless, after training, this subject's inappropriate eye-fixation responses decreased to zero.

To evaluate whether medication dispensed by the IPPB apparatus was better transported to the lungs and hence more effective in relieving the child's asthma symptoms following the intervention program, each subject's medical chart was examined both for incidence of IPPB treatments over two months pre- and postintervention and to determine whether additional follow-up treatment of any kind, *e.g.*, other medications, hospitalization, *etc.*, occurred within a 2-hr period after using the IPPB machine on these occasions. A per cent effectiveness score (Table 1) for each subject was derived from this information by dividing the number of IPPB treatments not followed by additional treatment within a 2-hr period after using the device by the total number of IPPB treatments. The mean per cent effectiveness before intervention was 41%. After intervention, the mean per cent effectiveness increased to 82.25%. A *t*-test for matched samples ($t = 3.41$; $df = 3$) indicates that the difference of 41.25% between pre- and postintervention mean per cent effectiveness is statistically significant at the 0.025 level. This represents a 50%

Fig. 1. The mean number of inappropriate events recorded by the experimenters over a 26-trial series for four subjects on three target responses: eye fixation, facial posturing, and diaphragmatic breathing. The maximum number of inappropriate responses per trial was 15 for each behavior.

Table 1

The total number of IPPB treatments and the per cent of IPPB treatment effectiveness for a two-month pre- and postintervention period.

<i>Subjects</i>	<i>Pre-Intervention</i>		<i>Postintervention</i>	
	<i>Total Treatments</i>	<i>% Effectiveness Score</i>	<i>Total Treatments</i>	<i>% Effectiveness Score</i>
1	23	56%	24	83%
2	22	46%	15	67%
3	16	37%	14	79%
4	12	25%	9	100%
Mean Per cent Effectiveness		41%		82.25%

average increase in the effectiveness of the IPPB treatment. The increase in per cent effectiveness suggests that the subjects were using the IPPB equipment more effectively, thereby transporting more medication to the lungs and, in turn, obtaining greater relief from asthma symptoms.

Follow-up

All subjects remained at CARIH for six months or more following the intervention program and all required numerous IPPB treatments for asthma during this time. Three youngsters used the IPPB apparatus appropriately on the first postintervention treatment occasion and on all subsequent occasions. One subject, on the other hand, reverted to inappropriate responding on the first postintervention IPPB treatment. After unobtrusively observing the child responding on this occasion, the experimenters entered into the youngster's view. The sight of the experimenters seemingly served as a cue that immediately triggered the complete chain of appropriate responding. Without further intervention, the nurses reported this subject to use the IPPB equipment correctly on all subsequent occasions. Consequently, all subjects received a second surprise gift as their promised reward for continued appropriate responding at the time of their discharge from the Center. Thus, the changes in the targeted behaviors occasioned by the intervention procedures employed had apparently not only generalized to the actual treatment situation, but were maintained over time.

EXPERIMENT II

A number of studies have demonstrated the feasibility of utilizing persons untrained in behavioral modification as change agents in therapy with, and in the behavioral management of, children (*e.g.*, Hawkins, Peterson, Schweid and Bijou, 1966; Lindsley, 1966; Patterson, McNeal, Hawkins, and Phelps, 1967; Wahler, Winkel, Peterson, and Morrison, 1965; Zeilberger, Sampen and Sloane, 1968). Teachers, parents, psychiatric aides, and child-care workers, after but minimal exposure to behavioral modification, have been reported to be rather sophisticated change agents. In one representative article, Hall, Cristler, Cranston, and Tucker (1970), discussed a series of experiments in which teachers and parents successfully employed multiple-baseline designs to assess the effectiveness of their intervention or treatment. In another study, Neisworth and Moore (1972) described a reduction in asthma symptoms after parents were trained to manage "therapeutic" contingencies. Such results suggested that nurses at the Center should be trained to carry out the intervention procedures described in the first experiment. Consequently, a second investigation was undertaken both to replicate the results of the first experiment and to demonstrate the utility of training nurses in the application of the operant procedures employed in that study.

Subjects and Setting

Two children, 8 and 9 yr of age, respectively, were referred because of repeated failure to use

the IPPB correctly. The intervention again took place in the treatment room of the hospital.

Procedure

The instructions, intervention, and verification procedures in this project were similar to those employed in the first experiment, except that eight nurses served as experimenters and/or observers. Another exception was that intervention was started on facial posturing after two, rather than three, intervention trials on eye fixation.

The nurses first participated in two 50-min training sessions, where the basic principles of reinforcement and the intervention strategies of the first study were presented didactically, and their application demonstrated in a rehearsal of the procedures used. Personal participation was required in the demonstration project in which a youngster from the Center helped in training the nurses by serving as a practice or pilot subject for them.

After training was completed, half of the nurses conducted the training program for the first subject while a second group of nurses observed them and recorded data for assessing reliability. For the second subject, these observers were the experimenters and the first group of nurses made independent observations for them.

Reliability

Reliability was computed on a trial-by-trial basis using the computational method described in the previous research. The average per cent agreement across trials between observers was 96% for eye fixation, 91% for facial posturing, and 85.5% for diaphragmatic breathing.

RESULTS

Figure 2 presents the results obtained by the nurses and illustrates the multiple-baseline verification procedure they employed. The data represent an average of the inappropriate target responses in three behavioral areas for two subjects across 26 trials. As in Experiment I, inap-

propriate responding decreased for each target area when the intervention program was introduced. The mean level of inappropriate behavior exhibited on both the baseline and intervention trials was similar for the two subjects, *e.g.*, the baseline means for diaphragmatic breathing were 14 and 14.5, respectively. In addition, the rate of inappropriate responding for each subject was zero when the study ended. One-month follow-up observations on each child indicated that they continued to use the equipment appropriately in all subsequent asthma-treatment situations. These findings strongly suggested that the intervention effect observed in Figure 2 typified both subjects and that the behavioral changes made were durable.

GENERAL DISCUSSION

The data from Experiments I and II demonstrate the effectiveness of the intervention program in shaping IPPB target behaviors. In addition, follow-up observations suggest that there was generalization of the acquired responses to asthma treatment situations, and that the behavioral changes were maintained. Finally, from the data in Table 1, it appears that learning to make proper use of the IPPB led to delivery of more medication to the lungs and, hence, greater medication effectiveness.

In the present study, reinforcement, instructions, informational feedback, and sequential focussing on individual responses were employed as part of the total training package. Thus, it is impossible to determine the contribution of each component of the package. The rapid drop in inappropriate responding on the first training trial for each behavior suggests an instructional effect. However, instructions alone do not appear to account for the amount of change obtained because instructions were repeatedly presented to the subjects, both in a general and in a specific manner, as inappropriate behaviors were manifested, before baseline trials began. Also, the variability, albeit low, on the intervention trials with diaphragmatic breathing argues against in-

Fig. 2. The mean number of inappropriate events recorded by nurses over a 26-trial series for two subjects on three behaviors: eye fixation, facial posturing, and diaphragmatic breathing. The maximum number of inappropriate responses per trial was 15 for each behavior.

struction being the primary cause of change, at least for this behavior.

An essential reason for conducting a second study was to demonstrate the utility of passing on the administration of the intervention program to nurses. Because nurses and other members of the medical staff have the greatest opportunity of witnessing children using inhalation therapy equipment in the emergency room, they need to be able to recognize and define any specific interfering behaviors involved, as well as to have some skill in teaching others to respond appropriately when using the equipment. The same is true for physicians in private practice, professionals in hospital out-patient facilities, and the parents of children with asthma—there are 4.5 million of the latter in this country (Allergy Foundation of America, 1970)—who rely upon inhalation therapy equipment in the treatment of their asthma. The results of the second investigation suggest that with but minimal time spent in teaching the basic operant principles underlying the intervention procedures used in this study, and in practising implementing the procedures themselves, nurses can effectively employ them in training patients to use inhalation therapy equipment. One of the primary implications to be derived from these results is that courses in operant technology should be included in the training of nurses, inhalation therapists, and other medical personnel responsible for instructing others in the use of inhalation therapy equipment.

For subjects in the first experiment, better performance on the IPPB markedly diminished the measured amount of follow-up treatment and medication they received. This meant that the more intense forms of treatment, *e.g.*, intravenous fluid therapy and hospitalization, were required less frequently to establish greater control over their asthma. It also meant that for some children the more powerful drugs needed to be administered less frequently to manage asthma. This latter finding has important physical and psychological implications for asthma patients. For example, corticosteroids are commonly used

to control asthma attacks in children (Ellis, 1972). While these drugs are often necessary and of immense benefit, they also have potential side-effects. The most common of these are weight gain; edema, including swelling of the face; crampy muscle pains; ecchymoses; increased appetite; and dyspepsia (Tuft and Mueller, 1970). Since the residents of the Center are very much aware of the side-effects of medications, avoiding them, in addition to the relief from asthma symptoms, should constitute a powerful consequence resulting from proper use of the equipment. Indeed, the subsequent appropriate use of the IPPB when having asthma suggested that the youngsters' behavior was then under the control of such contingencies from the natural communities of reinforcement (Baer and Wolf, 1970).

Chai and Newcomb (1973) pointed out that medication side-effects can be drastically reduced or eliminated, often without sacrificing the control over asthma, by manipulating the dosage and the schedules of administering medications. Even so, whenever more innocuous methods of controlling the illness are available at little cost to the child's activity schedule, they should be employed with the goal of either supplanting or assisting in a reduced use of medication. Certainly, if the probability of reducing side-effects is increased as a result of an overall reduction in follow-up treatment requirements after learning to use the IPPB, such training should be included in every child's treatment program wherever the equipment constitutes an essential part of the treatment.

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