OPERANT CONDITIONING TECHNIQUES

for Use in the Physical Rehabilitation of the Multiply Handicapped Retarded Patient

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THE MENTALLY retarded patient with multiple handicaps has been called the "forgotten patient."[1] Physical handicaps should be ameliorated to permit maximum achievement of whatever behavioral potential exists, and even when there is no hope of improvement in functioning, consideration must be given to patient comfort.[1]

Foss[2] has suggested the possibility of using operant conditioning techniques to establish motor control in cerebral-palsied children by combining operant conditioning with the electrophysiological techniques developed by Herrerline[3] to provide external feedback of proprioceptive cues. As Foss correctly points out, this procedure would involve extensive engineering problems.[2] Other philosophies of rehabilitation used in children with neuromuscular disorders have recently been reviewed by Weiss and Betts.[4]

In our laboratory we have been primarily concerned with the cognitive functioning of profoundly retarded patients, most of whom are total nursing care patients with physical handicaps. With most patients we have had to find ways to improve motor functioning before we could study cognitive functioning. We have used operant conditioning techniques extensively to improve motor functioning in these patients. (An operant is an observable behavioral act.) These same techniques could be used to improve motor performance beyond the level required for our studies. With some patients these techniques have been used to accomplish a specific therapeutic goal.

This paper will present a simplified discussion of the techniques and methods of operant conditioning which we have found successful with the profoundly retarded, multiply handicapped child. The principles of operant conditioning are identical regardless of the patient's intellectual level. The response which we have most frequently elicited has been raising the arm to touch or pull a ring. However, the procedures of training are identical regardless of whether the response is to lift a foot and take a step or to turn a door knob.

METHOD

To illustrate our technique, we will describe the procedure used with S, a six-year-old boy who functions at a behavioral level correspond-

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ing to that of a normal three-month-old child. As a result of perinatal anoxia, this child has severe cerebral palsy. At the time we began working with him, the only movements known to be under voluntary control were movements of the eye and the muscles of facial expression. Attempts on the patient's part to "help" if he was picked up or was being dressed resulted in spastic rigidity of his entire body.

S was brought to the laboratory and placed in a crib which resembles a traction bed. A red darning hoop suspended from the cross bar above the bed was lowered to a position about 1 foot above the patient's right hand. The experimenter then observed S for twenty minutes, noting what unelicited movements occurred, and whether he would touch the ring. He did not touch the ring, but a reasonable amount of spontaneous motion took place which included movement of the right arm. If he had touched the ring at least once, the therapist would have had no difficulty at all; the therapist could simply reward each touch of the ring.

The presence of some degree of movement does not mean that the desired response may be conditioned, but the absence of any movement is significant for several reasons. First, there may be insufficient neuromuscular innervation to activate the arm. Secondly, and more important for our purpose, if no behavioral event is observable, *i.e.,* there is no operant, the behavioral event cannot be shaped or modified. In some cases it is possible to elicit an operant, *e.g.,* evoke a response to an unconditioned stimulus such as a pin-prick, and then utilize this evoked response as the basis for operant manipulation. By impairing a stimulus such as a click or tone with the unconditioned stimulus (Pavlovian conditioning), it is sometimes possible to elicit the stereotyped unconditioned response with sufficient frequency to permit its modification through operant procedures.

Since S has some movement of the arm, the experimenter started by giving a reward each time there was arm motion in any direction, so that the rate of movement became fairly high, *i.e.,* once a minute. The objective was to increase the operant rate for movements of the arm, since it is difficult to shape a desired operant response if the operant rate of the basic response is low. Any event which resulted in the increase of the activity level of the arm would be satisfactory for the accomplishment of this initial objective.

The next step was to "shape-up" the desired response by *successive approximation.* The therapist started reinforcing only those movements which were generally toward the ring. Gradually he became more and more demanding in terms of how close the arm or hand must come to the ring before administering the reward. The purpose of this step is to reinforce successively the small component parts of the desired response until the complete act is performed. At times it is necessary to approximate a dozen or so complete responses. Each time, however, fewer successive steps should be required to complete the act. For example, it may take twenty-five reinforcements to get the child to touch the ring the first time, but only three by the tenth successful complete act. Finally, the reward is given *only* for touching the ring.

Factors

Several factors must be kept in mind while carrying out the conditioning procedures. First, the reward should be immediate, preferably within a half-second after completion of the desired step or act. How slow to go or how small the steps should be is learned from experience, but in general, it is better to err on the slow side. In part, how fast one can go depends upon how "powerful" the reinforcer is. The selection of the reward or reinforcing stimulus event is a difficult problem with profoundly retarded children. A discussion of this problem may be found in Rice and McDaniel [5] and Rice *et al.*[6] A wide variety of potentially reinforcing items such as candy, ice cream, soft drinks, recorded music, movies, and television should be kept on hand. The latter devices must be equipped with an instant start/stop switch of some type. The reinforcing item has to be determined individually for each child.

A *reinforcement* is an event which alters the probability (frequency) of the response. If an event—such as the presentation of a piece of candy—increases (or decreases) the frequency of the arm movement, it is a reinforcer. If the frequency is unchanged, it is not a reinforcing event. We are interested in this study only in reinforcers that increase the probability of the response. One event is usually found to be more effective (powerful) than another. In the case of S, Coca-Cola was mildly effective and ice cream was a very powerful reinforcer. S once touched the ring over 700 times during a forty-five-minute period to obtain a spoonful of ice cream for every fifteenth touch of the ring; by this time, however, S was performing

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a relatively precision movement, and this was not "just an increase in general activity level" which may be seen in many cerebral-palsied patients as a result of nonspecific stimulation.

Continuous Reinforcement Response. Once the response has been brought under the experimenter's control, *i.e.,* the patient responds to the reinforcer, the therapist may follow one of several directions, according to the particular patient's needs. A continuous reinforcement schedule (CRF) is established when every correct response is reinforced. Initially every patient, particularly the very young and the severely damaged, should be run on a CRF schedule.

We usually use the CRF schedule for at least five forty-five-minute sessions, or until the subject is responding approximately 100 times per session. A CRF schedule produces responding at a moderate, fairly constant rate.

Fixed Ratio. Following a period of CRF training, we usually shift to a fixed ratio (FR) schedule. Under a fixed ratio schedule, every second (or any other number) response is reinforced. In all cases the transition must be in small steps, reinforcing every second response for a time, then every fourth response, and so on. For therapeutic purposes it seems unlikely that a ratio higher than one reinforcement for every fifteenth response would be necessary or desirable.

The fixed ratio schedule has several important advantages. The effect of an FR schedule is to increase the rate of responding; thus, for a given period of therapist time, the patient will have utilized the muscles more. When a consumable reinforcer such as candy or ice cream is utilized on a CRF schedule, the patient quickly becomes satiated. With an intermittent reinforcement schedule satiation is delayed. Finally, in a nonautomated situation, the therapist can become quite fatigued if it is necessary for him to be alert, spooning out ice cream every few seconds.

The high rates of responding generated by a FR schedule can conceivably be detrimental to the therapist's objective, for example, when the therapist is interested in achieving a smooth, precise movement rather than one which "just works." To successively approximate a smooth, precise movement, the therapist needs a lower rate of responding in the patient.

Variable Ratio and Variable Interval Schedule. The advantages of slow satiation effects, and so on, which are obtained on fixed ratio schedules, but without the high rate of responding are achieved by the utilization of *variable ratio* (VR) schedule. In a variable ratio schedule, the patient is reinforced on the average for a given number of responses, *i.e.,* the patient may be reinforced five times for each twenty-five responses, but it is the first, third, eighth, fourteenth, and twenty-fourth response which is reinforced. A variable ratio schedule is fairly simple to carry out in a nonautomated situation with the numbers of the responses to be reinforced written on a sheet of paper. In an automated situation, a *variable interval* (VI) schedule is probably the schedule of choice. The VI schedule is similar to the VR schedule except that the reinforcement is available on the average every thirty seconds or according to some other unit of time. The VI schedule produces responding at a very even rate and of moderately high levels.

Use of Schedules. To those who are unfamiliar with the language of operant conditioning, the distinction between the various schedules of reinforcement is often confusing. To clarify the distinctions, keep in mind that the schedule of reinforcement refers to the *availability* of the reward or more correctly the reinforcing stimulus. Thus on a CRF schedule, the reward is continuously available and every response will be rewarded. On a FR schedule every n'th, *e.g.,* fifth, response is rewarded, but the reward is not available on the first four responses prior to the fifth response or on the next four responses following the rewarded response. A continuous reinforcement schedule is therefore the same as an FR 1 schedule. In the VR or variable ratio schedule, the number of responses which must occur between the rewarded response is not fixed but varies around some average value. Thus the reinforcement is only available on an intermittent basis.

On a CRF, FR, or VR schedule of reinforcement the more rapidly a subject responds the greater will be the total number of reinforcements received. Thus all three of these schedules are to a greater or lesser extent response dependent. In contrast to this the variable interval schedule is response independent. No matter how high the response rate of the patient is, a reinforcement will only be available at certain predetermined intervals of time. If the intervals of time vary about some mean value, it is a VI schedule, and the mean value

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is specified by a number following the symbol VI. If the time interval between the availabilities of the reward is constant, it is referred to as a FI or fixed interval schedule. In either case the availability of the reinforcement is independent of the patient's response rate. Starting on a continuous reinforcement schedule, then shifting to a low fixed ratio schedule, and then maintaining the patient on one of the variable reinforcement schedules is the best procedure.

Although we have not focused our attention on the motor movements themselves, it is apparent from our cinegraphic records that many of our patients do attain control over their bodies. The patient's performance would still further improve if we utilized the successive approximation technique described to shape more precise movements than our work requires.

Miscellaneous Factors. There are a number of features of this approach which we have not mentioned, but which merit a brief discussion. Our work and that of Fuller [7] show that low intelligence in the patient is no barrier. The patient need not be verbal, nor need he be particularly motivated in the sense of finding improvement or the hope of improvement. For practical purposes low age is not a barrier, for even children under one year can be conditioned with appropriate reinforcement techniques.[8]

Once the response is shaped to the therapist's satisfaction, it can be practiced with an essentially untrained person such as the parent delivering the reinforcement. The only common problem is the "kind-hearted" therapist or parent who lets himself be brought under control of the patient's unhappy looks, tantrums, and complaints.

A record of the number of responses per unit of time should be kept to evaluate the effectiveness of various reinforcing stimuli, determine when to change the response–reinforcement ratio, and ascertain how well the procedure is working. A hand tally and a wall clock are adequate for this purpose.

DISCUSSION

We have emphasized the procedures used to institute the desired response, and have generally restricted response to such things as raising an arm, and reinforcement to the administering of ice cream and so forth by hand. A clinic would find it not only highly desirable but more economical in the long run to automate operant procedures. Movies, recorded stories, and other items are particularly convenient as reinforcers, and any response which can be made to close an electrical switch can be used to trigger the reinforcer. For example, the patient's stepping on a series of switch plates could be used to turn on a movie projector so that each step provides a few seconds of the movie as a reinforcement. Squeezing a rubber bulb could close a switch to provide reinforcement for exercising the hand and arm. The majority of the necessary apparatus is commercially available from suppliers of operant conditioning equipment who will also construct "custom" devices. The recent book edited by Sidowski is an exceptionally rich source for information on sources of supply, methods of constructing one's own devices, as well as a much more comprehensive coverage of operant and other types of conditioning procedures.[9]

Variants

Several variants of operant methodology may be of value in special situations. One of the most versatile variants with a child who is functioning at the two-year-old level or older is imitation training. An extensive, but somewhat technical, discussion of imitation training has been presented by Baer *et al.*[10]; it will be of interest to those who intend to make extensive use of this technique. A suggested procedure is to place the child at a table opposite you. Since to imitate you the child must observe you, the first step is to establish eye contact. Naturally if the child is observing you intently from the outset, this step may be omitted. Have a cup of reinforcers handy; small soft candies are convenient, but any other reinforcer that can be rapidly administered and consumed will do. No verbal instructions are necessary, and, in fact, they should be avoided at this point. Look at the child's eyes, and if he is looking at you, give him a reward. This is repeated until the child is spending most of his time observing you. Next, rap the table once with your hand; if nothing happens, wait for about 10 to 15 seconds and rap the table again; if the child raps on the table, reinforce him.

After this imitation has been performed and rewarded two or three times, knock on the table twice; if the child knocks once he is not rewarded; if he knocks twice he is rewarded. In effect, we are training the child to be precise

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in his imitation. The procedure is repeated with a variety of behaviors: pat oneself on the head, stand, sit, scratch, and so on.

The developmental sequence is fairly logical. Start with eye contact; if the child is hyperkinetic, it may be necessary to make sitting still in the chair the first or second response to be rewarded. In general, the last behavior to be shaped is the one in which the therapist is interested, *i.e.,* picking up a cup from the table and drinking or saying words.

One or two practical suggestions may be in order. Avoid verbal instructions unless their repetition is what you want imitated. If the child reaches for the reinforcement cup, a swift, smart, slap on the hand is usually effective on the first trial. If not, a stern "NO!" may be added to the slap on subsequent attempts. Several short sessions (fifteen–twenty minutes) on several different days prior to the introduction of the therapeutic acts helps to insure that the "game" is well established before the introduction of difficult or emotionally trying tasks. The use of a room which is relatively free of "interesting" toys and other distractions simplifies the initial training. As always, start out with a continuous reinforcement schedule. The shift to a more intermittent schedule is often accomplished by chaining responses together, *e.g.,* three blocks piled on top of another is the rewarded response, or three words put together; "I am going" replaces the previously rewarded "I" imitation.

Advantages

The "imitation training" technique has several distinct advantages. Once the game has been established the therapist can apply it to several different behaviors without further preliminary training. With complex behaviors such as speech, it may be the only possible approach to the child.

There does not appear to have been any major utilization of operant conditioning techniques in efforts toward physical habilitation in spite of their apparent applicability. When we practiced to a limited extent in collaboration with the physical therapist at the institution where we work with retarded children, we not only found that the approach works, but also it increases patient motivation. The patient, who previously resisted practicing in his walker, now wants to terminate whatever other physical therapy activity he is engaged in at the time the psychologist arrives so that he can get into his walker. This occurs in spite of the fact that we are making far greater physical demands upon him in the walker than were previously required.

In recent years the method described in this paper has found wide acceptance in the treatment of both the mentally ill and the mentally retarded. Many useful and stimulating suggestions for the application of operant conditioning in the treatment of the retarded and handicapped child may be found.[11–15] These articles will be particularly helpful to persons who are interested in instituting complex behavioral patterns or eliminating behavioral patterns which are disruptive to the physical therapy program.

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