

ESTABLISHING USE OF CRUTCHES BY A MENTALLY RETARDED SPINA BIFIDA CHILD¹

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A 5-yr-old mentally retarded *spina bifida* child was taught to walk with the aid of crutches. This behavior was developed through fading of physical prompting within a 10-step successive approximation sequence. Preliminary training to establish gait consisted of developing use of parallel bars through fading of physically modelled responses within a six-step successive approximation sequence. Use of parallel bars ceased during an extinction period and completely recovered upon being primed with one "free" reinforcement. Systematic use of natural reinforcers was employed as an aid in maintaining use of crutches.

The use of operant techniques in the modification of motor behavior has been suggested by Foss (1966), who recommended establishing motor control in cerebral-palsied children by reinforcing external feedback of proprioceptive cues. Rice, McDaniel, and Denney (1968) developed voluntary movement in a cerebral-palsied child by reinforcing successive approximations to touching a suspended ring. Harris, Johnson, Kelley, and Wolf (1964) reported that teachers modified regressed crawling in a nursery school child by contingent positive reinforcement when the child was on its feet. Trotter and Inman (1968) developed increased participation in progressive resistance exercises in quadri- and paraplegic adults through contingent praise and weekly feedback of progress.

The purpose of the present research was to determine if use of crutches by a mentally retarded *spina bifida* child could be established and maintained through a combination of successive approximation sequences, fading of modelled and physical prompts, and contingent scheduling of natural reinforcers.

METHOD

Subject

Dennis was described by his hospital records as a moderately retarded male with a diagnosis of cerebral defect, congenital, associated with primary cranial anomaly, *spina bifida*, hydrocephalus, with meningomyelocele corrected, and extensive paralysis of the lower extremities. He was 5 yr old and had

been institutionalized 3.5 yr at the start of the study.

Before the operant program, Dennis was described as functioning on a motor level of 10 months. He was reported to have sitting balance, ability to pull to his knees while holding on to the crib rail, and to get into a creeping position. He was also reported to be able to scoot across the floor in a sitting position, and to pull himself along in the prone position with his arms.

Dennis received varus and rotational osteotomy of both hips at the age of four to correct dislocations and upon recovery was equipped with high-top shoes and bilateral short leg braces. Post-operative physical therapy for Dennis consisted primarily of strengthening exercises for quadriceps and triceps, and placement in a sling walker in anticipation of increasing his motivation for walking instead of crawling.

Attempts by the physical therapist to get Dennis to participate in gait training on parallel bars and with crutches reportedly had been met with extreme tantrums and sustained physical resistance. The physical therapist reported that she had attempted to elicit Dennis' cooperation in the physical therapy program for six months before her request for the development of an operant program.

¹The author wishes to express appreciation to physical therapists Shirley Skanse and Jackie Wheeler for their cooperation. Reprints may be obtained from R. Don Horner, Parsons Research Project, Parsons State Hospital and Training Center, Parsons, Kansas 67357.

Apparatus

In the first part of this research, a set of parallel bars, a platform placed between the bars to elevate Dennis, and two small stools were employed. Additional apparatus included a pair of shortened crutches equipped with underarm and hand grip padding and a pair of crutches with forearm clamps (Lofstrand crutches).

Procedure

The procedure consisted of seven parts: baseline, establishing use of parallel bars, extinction, re-establishing use of parallel bars, baseline on use of crutches, establishing use of crutches, and follow-up.

Prior to baseline, root beer was determined to be a reinforcer. Dennis would consistently crawl a distance of 50 ft to obtain a small paper medicine cup containing one tablespoon of root beer. Dennis quickly satiated on root beer after approximately 25 tablespoons, so baseline and training trials were limited to 25 trials per session. In addition a 1-min time limit for initiating a response during baseline and establishing use of parallel bars was established by averaging the time intervals between the verbal request "come get the root beer" and initial crawling responses.

The baseline procedure in the parallel bars sequence consisted of providing the verbal request appropriate to step one in the successive approximation procedure, modelling the response requested once, repeating the verbal request at 10 to 15-sec intervals, and scoring plus if a complete response was initiated within 1 min of the demonstration. A minus was recorded when a response was not initiated within 1 min or failed to meet the requirement of step one. The experimenter was seated on a stool placed on the platform between the parallel bars facing Dennis, who was seated on a second stool approximately 2 ft away. Social praise and root beer were not available during baseline. The verbal request, "Dennis, pull up", was accompanied by the experimenter placing his hands on the parallel bars, gripping them, and pulling to a standing position.

The treatment procedure designed to establish use of parallel bars consisted of going through a six-step successive approximation sequence. Step 0 was added to the initial five-

step sequence due to the zero rate on Step 1 during baseline. The steps in the successive approximation sequence to establish use of parallel bars were as follows:

Step 0. Sitting on stool and gripping left parallel bar with left hand and right parallel bar with right hand.

Step 1. Step 0 plus pulling to a standing position on parallel bars and maintaining standing position long enough to consume one tablespoon of root beer.

Step 2. Step 0 and Step 1 plus taking one step using parallel bars for support before being reinforced.

Step 3. Same as Step 2 except three steps must be taken using parallel bars for support before being reinforced.

Step 4. Same as Step 2 except five steps must be taken using parallel bars for support before being reinforced.

Step 5. Same as Step 2 except 10 steps must be taken using parallel bars for support before being reinforced.

The criterion for moving from one step to the next was 23 or more successful trials at three consecutive sessions. The experimenter was seated facing Dennis allowing sufficient distance for Dennis to first pull to standing and later to take the required number of steps. A cafeteria tray placed off to the side contained 25 medicine cups, each with one tablespoon of root beer. On each trial the experimenter modelled the response once, then held a medicine cup of root beer in the position necessary to reinforce a successful response, and at 10 to 15-sec intervals made the verbal request appropriate to the particular step. Scoring consisted of a plus for a complete response initiated within 1 min of the demonstration. A minus was recorded if a response was not initiated within 1 min or failed to meet the requirement of the step. On unsuccessful responses the root beer was returned to the tray and Dennis remained in or was returned to the starting position.

After use of the parallel bars was established, an extinction procedure was initiated to demonstrate control of the behavior by the reinforcement contingency. On each trial the behavior established as a result of Step 5 was modelled once and the verbal request, "Dennis, come here", was repeated at 10 to 15-sec intervals. The physical presence as well as the contingent application of the root beer was

absent during the extinction period. After the extinction period, Step 5 was primed with one "free" reinforcement and the procedures that established Step 5 in the initial treatment period were repeated.

The treatment procedure designed to establish use of crutches consisted of going through a 10-step successive approximation sequence. Step 0 was added to the initial nine-step sequence due to Dennis' failure to position the crutches properly during baseline. The steps included in the successive approximation sequence to establish use of crutches were as follows:

Step 0. Crutches secured to hands by elastic bandages, experimenter stands behind child and reinforcer delivered for imitating the modelled response of placing the crutches on dots marked on floor 18 in. in front of and 18 in. from each side of center line bisecting starting point.

Step 1. Crutches secured to hands by elastic bandages, experimenter stands behind child and reinforcer delivered contingent upon completion of Step 0 and swinging his body to a crutches-supported erect position with total assistance provided by experimenter through underarm pressure. Erect position maintained 15 sec before reinforcer delivery.

Step 2. Crutches secured to hands by elastic bandages, experimenter stands behind child and reinforcer delivered contingent upon completion of Step 0 and swinging his body to a crutches-supported erect position with assistance provided by experimenter through pressure under the arms only to prime initial movements.

Step 3. Crutches no longer secured to hands by elastic bandages, initial assistance no longer provided, reinforcement contingent upon independently swinging his body to a crutches-supported erect position.

Step 4. Reinforcement contingent upon completion of Step 3, maintaining balance with experimenters hand placed on child's back, and placing crutches in forward position.

Step 5. Reinforcement contingent upon completion of Step 4 plus swinging feet toward an imaginary line connecting crutch tips, maintaining balance with experimenters hand on child's back, and placing crutches in forward position.

Step 6. Reinforcement contingent upon completion of Step 5 plus one additional cycle of placing crutches in forward position, maintaining balance with experimenters hand on child's back, and placing crutches in forward position.

Step 7. Reinforcement contingent upon completion of four cycles of placing crutches in forward position, *etc.*, with gradual fading of experimenter support during balancing.

Step 8. Reinforcement contingent upon completion of eight cycles of placing crutches in forward position, maintaining balance without experimenter assistance, and placing crutches in forward position.

Step 9. Reinforcement contingent upon completion of 12 cycles of placing crutches, *etc.*, using crutches with forearm clamps (Lofstrand type) instead of crutches providing underarm support.

The baseline procedure in the establishing-use-of-crutches sequence consisted of providing the verbal request appropriate to Step 1 in the successive approximation procedure and priming the response by assisting Dennis in the initial movements (positioning the crutches in front of the stool on which he was seated and applying gentle pressure under the arms in an attempt to elicit the response of swinging his body to an erect position). The verbal request, "Dennis, pull up", accompanied the priming of the motor movements. The baseline period consisted of five sessions with 25 trials per session. Competing responses such as throwing of crutches and tantrum behavior started to occur at this time. Elastic bandages were used to secure Dennis' hands to the crutches to prevent throwing and a 3-min timeout (being placed on a stool in a corner) was imposed contingent upon such behavior as tantruming, screaming, and forceful expulsion of nasal discharge.

From Session 54 on, noise was scheduled as a reinforcer as follows: three weights were stacked at a distance that would allow Dennis to complete the required number of steps, a 24-in. dowel was placed through the holes, and each time Dennis completed a trial successfully he was given support and allowed to strike the dowel with a crutch sending the weights flying. Dennis was then returned to his stool, the weights restacked, and the next trial started. This procedure was repeated each trial until the criterion of 23 or more re-

inforced responses in three consecutive sessions occurred. The program was then advanced to the next step in the successive approximation sequence. At the suggestion of the physical therapist, the crutches were changed at Step 9 from the underarm to the Lofstrand type due to their lighter weight and the greater versatility of movement allowed.

When criterion was reached on the last step of the successive approximation procedure designed to establish use of crutches, formal training was discontinued and the contingency management program initiated. This follow-up condition was designed to promote generalization to every-day living situations. With the cooperation of the living area staff, special education teacher, speech therapist, and clinic bus driver a program was developed where Dennis would be allowed access to meals, play area, school, speech therapy, and a bus ride to the clinic only if he inde-

pendently (with crutches and leg braces) walked to each of these activities. The data collected were the number of trips completed per day to each of these activities and back. Twelve walking trips per day, Monday through Friday, could produce reinforcers naturally available in the environment.

RESULTS

The acquisition, extinction, and reacquisition of use of parallel bars is presented in Fig. 1.

During the five baseline sessions, Dennis gripped the parallel bars several times but did not make a single attempt to pull up. Steps 0, 1, and 2 of Fig. 1 show rather rapid acquisition of these behaviors. Step 3 produced 100% success on three consecutive days. Step 4 took longer to reach criterion, as Dennis had difficulty perfecting placement of his feet. Six

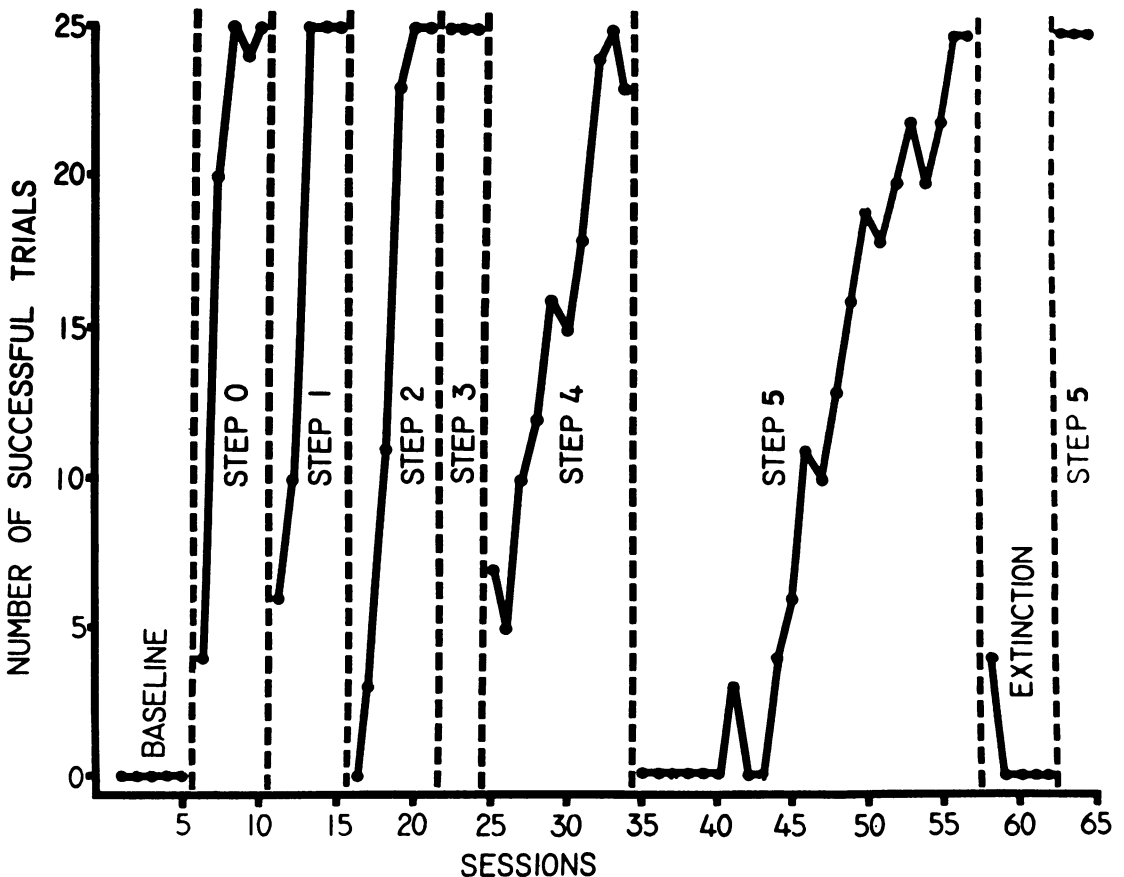


Fig. 1. Actual number of trials meeting the criterion of the appropriate step within the successive approximation sequence establishing use of parallel bars over baseline, acquisition, extinction, and reacquisition conditions.

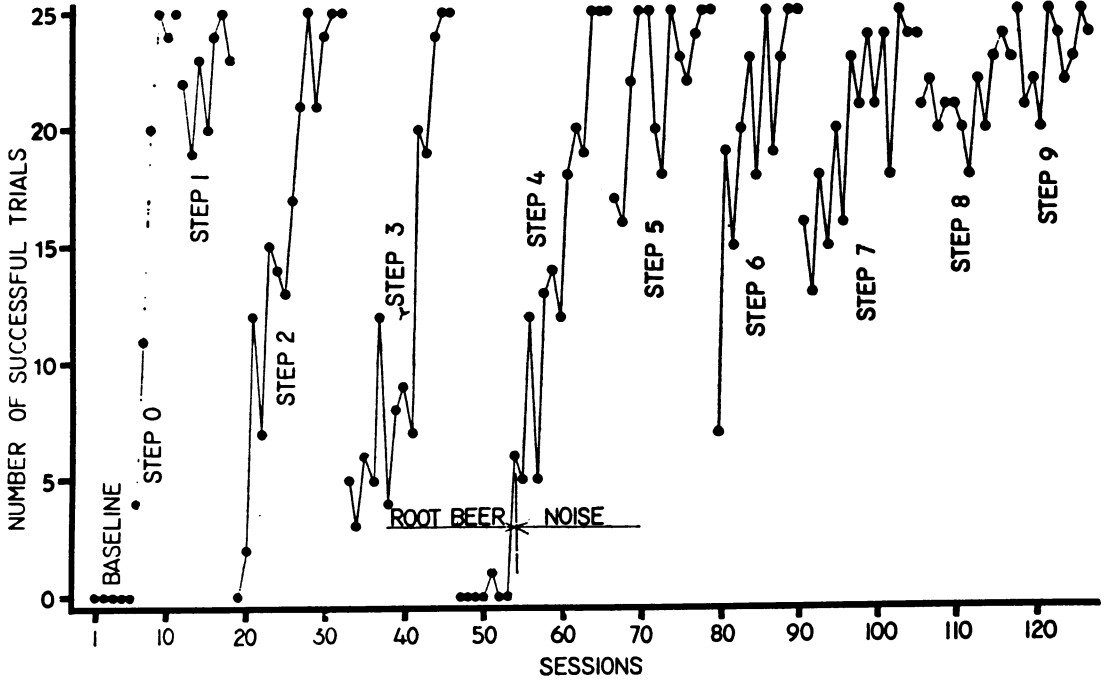


Fig. 2. Actual number of trials meeting the criterion of the appropriate step within the successive approximation sequence establishing use of crutches over baseline and acquisition conditions.

consecutive sessions occurred at the beginning of Step 5 without a single reinforced response. Three reinforced responses occurred at the seventh session of Step 5 and criterion was reached in 16 additional sessions. There was total cessation of responding during extinction after four nonreinforced performances at Step 5. The reintroduction of the physical presence of the root beer and one "free" reinforcement resulted in 100% successful responses in the reacquisition of Step 5.

The acquisition of the use of crutches is presented in Fig. 2.

Figure 2 shows a zero level of responding during baseline. Steps 0 and 1 were acquired in a total of 13 sessions. Steps 2, 3, and 4 proved difficult, with criterion on each step respectively achieved in 14, 14, and 20 sessions. The remaining steps required that Dennis make one crutches-supported walking cycle in Step 5, two in Step 6, four in Step 7, eight in Step 8, and 12 in Step 9 for each reinforcement. Steps 5 through 7 were difficult, with criterion respectively achieved in 13, 11, and 15 sessions. Steps 8 and 9 reached criterion in 12 and 10 sessions respectively and contained a larger number of successful trials than were demonstrated on any of the previous steps.

The results of the contingency management program designed to maintain use of crutches is presented in Fig. 3.

Figure 3 shows that Dennis was walking to and from all programs and activities, with an occasional exception, within 15 weekdays after treatment. Spot checks were made 25, 26, 32, 38, 44, and 50 days after formal training and showed that 100% of Dennis' 12 opportunities for walking trips per weekday were demonstrated.

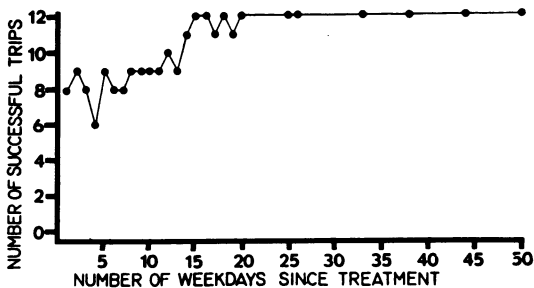


Fig. 3. Actual number of trips to and from activities successfully completed with the aid of Lofstrand crutches and short leg braces.

DISCUSSION

In establishing use of parallel bars, Step 3 had 100% success on three consecutive days and probably could have been eliminated or have included more elements of Step 4. Step 4 proved difficult mainly due to both of Dennis' feet becoming rotated so far to the right that he could fall when attempting to slide his hands forward on the parallel bars. Doubling the response requirement from Step 4 to Step 5 nearly resulted in failure at Step 5. In retrospect, the response requirement of Step 5 should have more closely approximated that of Step 4. The extent to which reinforcement was controlling the behavior of the subject is evident in the total cessation of responding during the extinction procedure and 100% reacquisition upon reintroducing reinforcement.

During initial attempts to establish use of crutches, competing responses, such as throwing of crutches and tantrum behavior, started to occur. Systematic records of these behaviors were not kept. The use of restraint and timeout procedures rapidly reduced the frequency of these behaviors and they were totally absent by the ninth step.

Step 2, establishing use of crutches, proved difficult in that the experimenter had difficulty determining the optimal point to terminate assistance. Dennis experienced many failures by returning to the starting position upon termination of the experimenter's assistance in initial movements. The main category of failure on Step 3 was Dennis not initiating a response within 1 min of the command "Dennis, pull up." The primary difficulty on Step 4 was Dennis not moving the crutches from the initial position and placing them in the forward position. He was able to maintain his balance with the experimenter's hand placed on his back but initial attempts to move his crutches forward resulted in sliding to the floor. If he fell or failed to move his crutches to the forward position within one min of his attaining a crutches-supported erect position, he was returned to the starting point. On Steps, 5, 6, and 7 Dennis' main trouble was keeping his feet straight. He often lost his balance and fell. A fall resulted in crying or whimpering and an apparent increase in the time required to initiate the next trial. Failures on the eight and ninth steps occurred mainly toward the

end of the sessions with Dennis exhibiting many indications of fatigue.

In establishing use of crutches, the complex motor movements required by the experimenter in providing assistance and immediately reinforcing correct responses with root beer proved very difficult. In a search for additional apparatus to reduce the motor movements required by the experimenter a pile of weights was inadvertently knocked over. The noise of the weights crashing to the floor produced an intense positive reaction from Dennis and was scheduled as a reinforcer from Session 54 on.

The difficulty with which Dennis acquired use of crutches, the possibility of the reoccurrence of competing behaviors, and potential satiation on the novelty of knocking over weights led to the decision to sacrifice the scientific rigor of a reversal procedure and proceed to bring the behavior under the control of natural reinforcers. The disadvantage of this decision is the inability to make empirical statements as to the extent that reinforcement techniques were controlling the behavior.

Failures in the follow-up condition were mainly a result of time limitations. The cooperating individuals could not allow Dennis unlimited time to complete the trip. If Dennis dropped to the floor they allowed as much time as their schedule permitted for him to resume walking. If he failed to do so they were instructed to continue their routine without him.

In this single-subject study, no claims are made as to the applicability of these particular procedures to others. The results of these procedures will have to be replicated across subjects before they can be considered generally useful. In addition, no attempt was made to separate and functionally analyze the individual contributions of modelling, prompting, fading, and successive approximation techniques. The study is intended to show the applicability of reinforcement procedures, carefully delineated training programs, and systematic measurement of change to the area of physical rehabilitation.

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Received 27 August 1970.

(Revised 5 January 1971.)