*INSTRUCTIONS, FEEDBACK, AND REINFORCEMENT IN
REDUCING ACTIVITY LEVELS IN THE CLASSROOM*

JEROME L. SCHULMAN, BERNARD G. SURAN,
THEODORE M. STEVENS, AND MARY JO KUPST

CHILDREN'S MEMORIAL HOSPITAL AND
NORTHWESTERN UNIVERSITY MEDICAL SCHOOL

The biomotometer, an electronic device which simultaneously measures motor activity and provides auditory feedback, was used in combination with material reinforcers in an experiment to reduce children's activity level in a classroom setting. Subjects were nine boys and two girls, aged 9-13, from a day hospital program for emotionally disturbed children. After five baseline trials, each child had five contingent reinforcement trials in which he/she received feedback "beeps" from the biomotometer and was given toy or candy rewards after each trial in which activity fell at least 20% below mean baseline level. Then five noncontingent reinforcement trials were run in which children received rewards for wearing the apparatus without the feedback attachment. Results indicated that the intervention "package," including instructions, feedback, and contingent reinforcement, was successful in all five trials for 8 of 11 children. Activity levels increased during the final noncontingent phase.

DESCRIPTORS: activity level, biomotometer feedback, hyperactivity, children

There have been a number of successful attempts to reduce activity level in children through the application of various behavior modification procedures (Werry and Sprague, 1970). Frequently these studies have used small numbers of subjects and have targeted out-of-seat (Pihl, 1967; Twardosz and Sajwaj, 1972) or nonattending (Allen, Henke, Harris, Baer, and Reynolds, 1967) behaviors. Several investigators have indicated that the efficacy of behavioral techniques compares favorably with that of stimulant medication in reduction of activity level in the classroom (Ayllon, Layman, and Kandel, 1975; Christensen, 1975) and for changing social behavior in school and at home (O'Leary and Pelham, 1978). In addition, training parents (Wiltz and Gordon, 1974) and teachers (Drash, 1975) to implement behavioral interventions has proved useful in the control of hyperactive behavior.

The pairing of auditory or visual stimulus cues with material reinforcers has been an effective paradigm for reduction of activity level. For example, in-seat movement has been decreased using a stabilimetric cushion to measure activity and a blinking red light to signal delivery of a reinforcer (Edelson and Sprague, 1974). In order to decrease activity and nonattending in a 10-year-old boy, Patterson, Jones, Whittier, and Wright (1965) used a radio transmitter with an earphone to deliver an auditory stimulus which served as a secondary reinforcer when paired with pennies and candy. Similarly, Doubros and Daniels (1966) reduced movement in six hyperactive mentally retarded children using a token system which delivered reinforcers through a remote control dispenser equipped with a light and buzzer. Ball and Irwin (1976) reinforced in-seat behavior using a buzzer which sounded after a child remained seated for a 2-minute interval. Children were given a penny for each activation of the buzzer over a 20-minute period.

There may be some question about the measurement of physical movement alone as an index of clinical hyperactivity, a syndrome which

This study was supported by Research Grant 000-9615-1204 from The Children's Memorial Hospital and by a grant from the Margaret Etter Creche Learning Center, both of which were awarded to Jerome L. Schulman. Reprints may be obtained from Jerome L. Schulman, Children's Memorial Hospital, 2300 Children's Plaza, Chicago, Illinois 60614.

has yet to be defined adequately and whose symptoms may actually diminish depending on the demand characteristics of the setting (Jacob, O'Leary, and Rosenblad, 1978). The hyperactive syndrome includes social as well as motor behavior but, for the purpose of the present study, it was decided to study the variable of excessive motor activity rather than to equate it with the hyperactive syndrome.

A combination of auditory feedback and contingent reinforcement was successful in altering motor activity in a previous study (Schulman, Stevens, Suran, Kupst, and Naughton, 1978). An electronic device, the biomotometer (Schulman, Stevens, and Kupst, 1977), simultaneously measured activity and provided intermittent auditory feedback to the children. Using this instrument, activity level of a hypoactive child was increased in a free play setting, and activity level of a highly active child was decreased in a classroom setting.

In the present study, the application of auditory feedback with the biomotometer in conjunction with use of material reinforcers was investigated in an experiment attempting to reduce activity level of a number of highly active children in a classroom setting. The purpose was to investigate the effects of instructions, feedback, and reinforcement on activity level in these children, and also to examine the relationship between measured activity level and observed behavior.

METHOD

Subjects

Eleven children, nine boys and two girls, between the ages of 9 and 13 who were enrolled in a Day Hospital program for emotionally disturbed children at Children's Memorial Hospital served. The children were referred to the program for treatment of a variety of behavior disorders including hyperactivity and learning disabilities. Results of diagnostic evaluations indicated no significant evidence of psychosis or brain damage.

Initially, children were chosen for the study on the basis of informal observations and discussions with day hospital staff, who suggested children they perceived as moderately to highly active. The children selected by this procedure were then tested over a baseline of five trials in a classroom setting to determine if they met a preestablished minimum criterion of 500 activity counts per hour as measured by the biomotometer. Three children, two boys and one girl, were dropped from the study because their baseline activity was below criterion.

Apparatus

The biomotometer, a new instrument developed for conditioning activity level, has been described in detail in a previous study, in which it was demonstrated to provide a reliable and valid measure of activity level (Schulman *et al.*, 1977). The apparatus consists of a small plastic box (8.26 cm $\times$ 5.38 cm $\times$ 2.84 cm; wt. 85 g) worn at the waist. It measures activity by angular displacement of mercury wetted microswitches. Activity counts are computer stored within the unit and are tabulated after the experiment through a separate readout box unit and digital display counter. The initial cost of a pilot unit was \$450, readout box \$225, and Fluke Multi-Counter \$375, but it is anticipated that additional units should be less expensive.

During feedback, the child monitors his/her own activity level through a crystal earphone connected to an adjustable audio feedback circuit inside the apparatus. When a child exceeds a designated number of activity counts during a preset time interval (for instance, 3 counts in 20 seconds), he/she receives a feedback tone signal (a "beep") through the earphone. Immediately after an excessive activity count is registered and a beep produced, a new time interval begins; thus an overactive child receives frequent feedback at short intervals. An adjustable volume control allows the setting of the feedback signal within a range audible to the child but not loud enough to be startling or painful, and not audible to others.

In the contingent phase of the present study, the feedback/time ratio was adjusted to provide the maximum number of feedback beeps within the capacity of the four biomotometer units used. Maximum settings on each unit differed slightly, and units were assigned to children on the basis of availability during a given classroom hour. Each child wore the unit assigned for all trials involving auditory feedback. For Child 1 and Child 10, the biomotometer delivered one beep if three activity counts were registered in a 20.7 sec interval. For Children 2, 5, 7, and 9, a beep was delivered if three counts were registered in 17.3 sec. For Children 3, 4, 6, and 8, the interval was 19.9 sec; for Child 11, the interval was 15.8 sec.

Procedure

A simple operant design was used, with five trials each in baseline, contingent reinforcement, and noncontingent reinforcement conditions. Each child served as his/her own control. Before the experiment, children were allowed to familiarize themselves with the apparatus and to listen to the feedback beep through the earphone.

All trials were conducted during regular classroom sessions at the day hospital program. Trials were run on consecutive weekdays during each child's scheduled academic hour. There were usually one to seven other children present, and classes were staffed by a combination of clinical educators, child care workers, and volunteers. Measurement intervals were from the beginning to the end of the child's daily assignments, and consequently varied from 20 to 60 minutes (mean = 42; $SD = 8$). Five trials were conducted with each child in each of the following three conditions:

Baseline. Before the first trial, each child was instructed as follows: "This is a study of energy and movement. This box (the biomotometer without earphone) measures how much energy you use when you move around." The term *activity* was not used in the explanation to avoid any association with *hyperactivity*. "You will be

wearing the box each day until your classwork is done. After you wear the box for six sessions, you will have a chance to earn rewards."

The initial trial was discarded as an adaptation period to the apparatus, and the next five trials were used as a measure of baseline activity level.

Contingent reinforcement. Before the five contingent reinforcement trials, the biomotometer with the earphone was demonstrated again to the children. Instructions were as follows: "For the next five sessions, the purpose of our energy study is to help you learn to move around less when you are in the classroom. You will be wearing the box with the earphone. When you hear a beep, that means you are moving around too much and you should try to slow down. If you do a good job of not moving around, you will get a reward at the end of the hour. The fewer beeps you hear, the better chance you will have to earn a reward. If you hear too many beeps, you will not get a reward. Remember to try to get as few beeps as possible."

Individual criteria for reward were established by subtracting 20% from the mean of each child's baseline activity. On all trials when activity fell below criterion, children were rewarded immediately after the session with a choice from a variety of candy and toy reinforcements. In order to sustain the lowest possible activity, children were not informed of the criterion level necessary to obtain rewards.

Noncontingent reinforcement. To assure continued participation in the experiment, noncontingent rewards were provided after feedback was withdrawn. Instructions before the noncontingent reinforcement trials were as follows: "For the next five sessions, you will wear the box without the earphone, so you will not be hearing any more beeps. You will still have a chance to earn rewards. All you have to do to earn a reward is to wear the box for the whole session. You will earn a reward for wearing the box, and not for getting as few beeps as possible." Thus no instructions were given concerning attempts to reduce activity, and reward was

Fig. 1. Activity level across baseline, contingent reinforcement, and noncontingent reinforcement trials for 11 children.

contingent only upon wearing the apparatus. Rewards were given immediately after each session. The experimenter was present to adjust the apparatus initially and to remove it at the end of the session. He observed the motor behavior of the child, noting the type of behavior (standing up, walking around room, raising hand) and duration.

We attempted to minimize the impact of the experiment with regard to other students. If asked about it, we replied that this was a study of movement in children. Some were initially curious, but the other students tended to forget about the biomotometer and to accept the presence of the experimenter as a usual thing.

RESULTS

Whenever possible, trials were run on consecutive weekdays. However, Child 9 took a 3-week vacation which interrupted the conditioning phase of the study. He was later terminated from the program before the final two trials of the noncontingent reinforcement phase could be completed. Child 11 was frequently absent from the program and as a result, only four trials of the noncontingent reinforcement phase were completed during the time allotted for the study.

It was common for the children to be absent before or after a weekend and this group was no exception. All together, there were 25 in-

Figure 1 *continued*.

stances of absences on a Monday or a Friday; 12 instances of one absence in the middle of the week; and four instances of two consecutive absences. No more than three weekdays intervened between trials. Also, during trials 2 and 3 of noncontingent reinforcement, Child 11 was removed from the classroom before the end of the hour because of his disruptive behavior. Since the measurement periods for these trials were 35 and 45 minutes, respectively, before removal of the apparatus, both trials were included in the data analysis. On five other occasions in the baseline phase the child had to leave the room briefly.

Since variable measurement intervals were

used, activity counts were standardized into a counts per hour rate measure. Figure 1 shows the activity counts per hour for each child across the five trials in baseline, contingent, and noncontingent reinforcement conditions. The dotted line in each figure represents the criterion for reward set at 20% below each child's mean baseline activity. The figures indicate that in 61 of 65 conditioning trials, activity level was below criterion and children received rewards. Thus, for 8 of 11 children the contingent reinforcement procedure was successful in all trials, and for the remaining three in the majority of trials. It should be noted that the differences in biotometer settings did not appear to affect

Fig. 2. Summary of mean activity for all children across baseline, contingent reinforcement, and noncontingent reinforcement trials.

the nature of the results. Prolonged interruption of contingent reinforcement for Child 9 produced no marked effects. In all cases, mean activity level for five contingent trials was at least 20% lower than the mean of the five baseline trials.

The data also show little evidence of generalization after the contingent phase because the activity of all the children returned quickly to a level at or near their own baseline performance.

Figure 2 presents a summary graph of mean activity level for all children across 15 trials. A considerable reduction in activity level beyond the 20% decrease set as criterion for reinforcement was achieved during contingent reinforcement, which had an overall mean of 273, compared to overall means of 643 and 655 for baseline and noncontingent reinforcement, respectively.

There were significant differences among the means of the three conditions ($F(2,20) = 34.23$; $p < .001$). Activity level in the contingent reinforcement condition was significantly higher than baseline activity level ($t(10) = 8.69$; $p < .001$), and significantly higher than noncontingent reinforcement activity level ($t(10) = 5.83$; $p < .001$).

Observers recorded time spent and behavioral data ("S gets up; S raises hand"). This observational data revealed a decrease in out-of-seat behavior from baseline ($\bar{X} = 9.90$ times the child was out-of-seat; $SD = 7.2$) to the contin-

gent condition ($\bar{X} = 1.72$; $SD = 1.61$), which was significant ($t(10) = 3.68$; $p < .01$). The frequency of out-of-seat behavior in the noncontingent condition was significantly lower than baseline ($\bar{X} = 3.36$; $SD = 3.35$; $t(10) = 2.50$; $p < .05$). Baseline and noncontingent reinforcement were not significantly different in out-of-seat behavior.

DISCUSSION

The results of the present study are consistent with those of a previous study on reduction of activity in the classroom using auditory feedback and reward (Schulman, Stevens, Suran, Kupst, and Naughton, 1978). The cumulative results of these studies indicate that the experimental intervention has worked to reduce activity level substantially in 11 of 13 children.

Decrease in activity level did not generalize to the noncontingent reinforcement phase, possibly because there were no instructions to move less; or the feedback was removed; or the switch to a noncontingent reinforcement condition was made. It is interesting, however, that observer data on out-of-seat behavior showed a significant decrease during the contingent reinforcement phase, which also generalized to the noncontingent reinforcement condition. It should be noted that these results are not necessarily significant with regard to the hyperactive syndrome.

The biomotometer is a relatively unobtrusive device that elicited few comments or questions from other children present in the classroom during the experiment. Children wearing the apparatus adapted quickly, and there were no complaints of discomfort. In contrast to other behavioral techniques that require the presence of an observer to record and/or reinforce behavior, the biomotometer offers greater flexibility. Although an observer was used due to the pilot nature of the present study, once the instrument has been placed on a child, a minimum of direct monitoring was generally necessary. The biomotometer does not make qualitative distinction

about the appropriateness of given movement, but it does register fidgeting as well as more gross movements, such as walking and running (Schulman *et al.*, 1978).

Thus, it combines the capacities of free-ranging measurement devices such as the actometer (Schulman and Reisman, 1959) and sedentary devices such as the stabilimetric cushion (Sprague and Toppe, 1966) with feedback conditioning potential. Data can be obtained from the biomotometer quickly, and little technical expertise is required (Schulman *et al.*, 1977). These features make the apparatus potentially suitable in other settings, including the public school classroom.

REFERENCES

- Allen, K. E., Henke, L. B., Harris, F. R., Baer, D. M., and Reynolds, N. J. Control of hyperactivity by social reinforcement of attending behavior. *Journal of Educational Psychology*, 1967, **58**, 231-237.
- Ayllon, T., Layman, D., and Kandel, H. J. A behavioral-educational alternative to drug control of hyperactive children. *Journal of Applied Behavior Analysis*, 1975, **8**, 137-146.
- Ball, T. S. and Irwin, A. E. A portable, automated device applied to training a hyperactive child. *Journal of Behavior Therapy and Experimental Psychiatry*, 1976, **7**, 185-187.
- Christensen, D. E. Effects of combining methylphenidate and a classroom token system in modifying hyperactive behavior. *American Journal of Mental Deficiency*, 1975, **80**, 266-276.
- Doubros, S. G. and Daniels, G. J. An experimental approach to the reduction of overactive behavior. *Behaviour Research and Therapy*, 1966, **4**, 251-258.
- Drash, P. W. Treatment of hyperactivity in the two-year-old child. *Pediatric Psychology*, 1975, **3**, 17-20.
- Edelson, R. I. and Sprague, R. L. Conditioning of activity level in a classroom with institutionalized retarded boys. *American Journal of Mental Deficiency*, 1974, **78**, 384-388.
- Jacob, R. G., O'Leary, K. D., and Rosenblad, C. Formal and informal classroom settings: Effects on hyperactivity. *Journal of Abnormal Child Psychology*, 1978, **6**, 47-59.
- O'Leary, S. G. and Pelham, W. E. Behavior therapy and withdrawal of stimulant medication with hyperactive children. *Pediatrics*, 1978, **61**, 211-217.
- Patterson, G. P., Jones, R., Whittier, J., and Wright, M. A. A behavior modification technique for the hyperactive child. *Behaviour Research and Therapy*, 1965, **2**, 217-226.
- Pihl, R. O. Conditioning procedures with hyperactive children. *Neurology*, 1967, **17**, 421-423.
- Schulman, J. L. and Reisman, J. M. An objective measure of hyperactivity. *American Journal of Mental Deficiency*, 1959, **64**, 455-456.
- Schulman, J. L., Stevens, T. M., and Kupst, M. J. The biomotometer: A new device for the measurement and remediation of hyperactivity. *Child Development*, 1977, **48**, 1152-1154.
- Schulman, J. L., Stevens, T. M., Suran, B. G., Kupst, M. J., and Naughton, M. A. Modification of activity level through biofeedback and operant conditioning. *Journal of Applied Behavior Analysis*, 1978, **11**, 145-152.
- Sprague, R. L. and Toppe, L. K. Relationship between activity level and delay of reinforcement in the retarded. *Journal of Experimental Child Psychology*, 1966, **3**, 390-397.
- Twardosz, S. and Sajwaj, T. Multiple effects of a procedure to increase sitting in a hyperactivity retarded boy. *Journal of Applied Behavior Analysis*, 1972, **5**, 73-78.
- Werry, J. S. and Sprague, R. L. Hyperactivity. In: C. G. Costello (Ed), *Symptoms of psychopathology*. New York: Wiley, 1970, 397-417.
- Wiltz, N. A. and Gordon, S. B. Parental modification of a child's behavior in an experimental residence. *Journal of Behavior Therapy and Experimental Psychiatry*, 1974, **5**, 107-109.

Received 18 July 1977.

(Final Acceptance 31 January 1979.)