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SENSORY REINFORCEMENT IN THE OPERANT CONDITIONING OF NONAMBULATORY PROFOUNDLY MENTALLY RETARDED ADOLESCENTS

By

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ABSTRACT

Four experiments were conducted to assess the effectiveness of sensory stimuli as reinforcers of head turning in nonambulatory profoundly mentally retarded adolescents.

In Experiment 1, 10 subjects were exposed to four 30-min sessions each containing 10 min of baseline, 10 min of conditioning, and 10 min of reversal. Contingent stimulation consisted of the simultaneous presentation of music, pictures, and vibration for 5 sec. Five subjects were continuously reinforced (CRF) during conditioning and five subjects were reinforced for omitting a response (DRO) for 5 sec. Neither the CRF schedule nor the DRO schedule of reinforcement was effective in controlling the rate of head turning of subjects. Higher response rates during conditioning phases were found across both groups as well as an overall decline in response rate

across sessions. These two main effects suggested that (a) the sensory stimuli either elicited head turns or raised general arousal levels, and (b) the subjects habituated to the experimental situation across sessions.

In the second experiment, there were two 30-min baseline sessions, eight 30-min conditioning sessions, and two 30-min reversal sessions. Only one of the four CRF subjects displayed reliable increases in rate of head turning during conditioning. There was no evidence that the DRO schedule controlled response rate for any of the DRO subjects.

In Experiment 3, only subjects who achieved high scores on a sensorimotor test were employed. The subjects were exposed to CRF contingencies only and the stimulus content of the reinforcer was varied. Vibration was removed from the contingent stimulus after several conditioning sessions. For one subject vibration was later reinstated, and for a second subject, music was removed in addition to vibration. The latter two subjects showed highly reliable increases in response rate during conditioning, two other subjects showed marginal evidence of conditioning under CRF, and the other two subjects showed no evidence of conditioning.

In the fourth experiment, nine of the original ten subjects were employed. The stimulus components of the reinforcer were varied systematically, new apparatus was employed, session length was shortened to 15 min, the number of baseline and conditioning sessions was increased, and physical prompts were employed in a systematic manner. Six of the subjects were successfully conditioned in Experiment 4. Of these six subjects, two conditioned with reinforcement consisting of pictures, music, and vibration, two conditioned under a combination of music and pictures, one with a combination of pictures and vibration, and one with pictures only.

These experiments suggest that the use of a low effort response (head turning), prompting, extended training, and the systematic variation of contingent stimulation are variables contributing to successful conditioning in this population. The results were seen to have both theoretical and practical implications for the care of such profoundly handicapped people.

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INTRODUCTION

In recent decades, there has been a dramatic growth in the development and study of behavioral technologies applied to retarded children. However, a review of the literature reveals a scarcity of research on the nonambulatory profoundly mentally retarded (NPMR) child. Since Fuller's pioneer work of 1949, only a handful of studies have dealt with this population of retarded children.

Nonambulatory profoundly mentally retarded children and adolescents form a unique population. Landesman-Dwyer and Sackett (1978) define NPMR individuals as having three major characteristics: (a) they are incapable of moving through space, (b) they are totally lacking in adaptive behavior skills, and (c) they are extremely small for their chronological age. They are typically untestable by standard psychological testing devices and have little apparent control over gross muscle movement, such movements often being weak and infrequent. They sometimes display stereotypic behaviors such as rocking and handbiting (Cleland & Clark, 1966; Stevens & Heber, 1964). These children are doubly incontinent, must be tube or spoon fed, and spend all their time confined to a bed, mat, or wheelchair. Nearly all individuals in this category display a multitude of symptoms of severe neurological damage such as symptoms of cerebral palsy and encephalopathy (Stevens & Heber, 1964). Their sensorimotor handicaps limit interactions with the environment, and stimulation is restricted further by their custodial environment which is usually designed to serve only the individual's physical needs.

In the past, such individuals were often referred to as "vegetative idiots" (e.g., Fuller, 1949), a term reflecting the view that such people were almost totally unable to learn or behave in a functional manner. It is only quite recently that the literature on mental retardation has begun to indicate that behavioral programs for the NPMR can and should be developed (Robinson & Robinson, 1976; Landesman-Dwyer & Sackett, 1978; Whiteley & Dewson, Note 1).

The uniqueness of NPMR subjects, both in terms of their mental and physical handicaps as well as their long exposure to severely restricted environments, makes it important to study the quantitative and qualitative characteristics of their learning. The acquisition of such knowledge will also be necessary for the implementation of programs designed to ameliorate the behavioral deficiencies of NPMR individuals. The development of effective techniques for controlling the behavior of NPMR individuals would also provide useful tools to aid in the assessment of their sensory and motor abilities. In the past such assessment has presented difficult problems for both treatment and research.

Review of Operant Conditioning Research with Nonambulatory Profoundly Mentally Retarded Children and Adolescents

Appetitive Reinforcement

Fuller (1949) conducted what is apparently the first study of an NPMR individual to appear in the psychological literature. The subject of the study was an 18-year-old boy described as a "vegetative idiot". He was perpetually bedridden and his behavioral repertoire was limited to occasional movements of the arms or head, and vocalizations. In the first experiment, the subject was food deprived for 15 hours. During four 20-min sessions run on consecutive days, a small amount of milk-sugar solution was injected into the subject's mouth each time he raised his arm to a vertical or near vertical position. From the first to the fourth session, the mean rate of arm-raising responses increased from .67 to 1.67 responses per min.

Several months later, a second experiment was conducted using the same procedure. There were four sessions of varying lengths run on consecutive days including 20 min of baseline measurement on the first day and 75 min of extinction following the last session. The mean rate of arm-raising increased from less than 1 response per minute during baseline to 3 responses per minute during the fourth session and declined to the baseline level by the end of the extinction period.

This study suggests the feasibiliy of developing operant control over the behavior of an NPMR individual, but it has certain weaknesses in experimental design and control. No baseline or reversal condition was employed in the first study. In the second study, the baseline period was immediately followed by a conditioning session in which the subject showed no change in rate of responding. Since it was only in the fourth period, held on the next day, that there was a significant increase in the rate of responding, the data could reflect day-to-day changes in the activity level of the subject. Furthermore, the extinction data could reflect fatigue of the subject since the 75-min extinction period followed a 40-min conditioning session.

Rice, McDaniel, Stallings, and Gatz (1967) briefly described a case in which a NPMR subject was trained to raise his arm for a taste of ice cream and verbal stimulation. The authors report that after some initial difficulties, they were able to maintain responding when the reinforcement schedule was changed from FR-1 to FR-5 and later to FR-15.

In a procedure somewhat analagous to Fuller's, Piper and MacKinnon (1969) conditioned a 15-year-old NPMR girl to raise her arm on a CRF schedule of reinforcement. Reinforcement consisted of a 2-oz portion of liquid food delivered directly to the subject's stomach by means of a cannula through a fistula in her abdomen. Over a two-week period, the subject was shaped to raise her arm a sufficient number of times per session (16) to receive her complete evening meal under the CRF schedule. This study was a methodological improvement over Fuller's in that a baseline measure was taken (the baseline rate was close to zero); however, no reversal or reconditioning was undertaken.

These studies have shown that appetitive reinforcers can be effective in the conditioning of NPMR subjects. However, the general usefulness of appetitive reinforcers with NPMR subjects is limited. It is often very difficult to feed these children edibles, and indeed, it is sometimes questionable whether food is reinforcing to such children (Friedlander & Knight, 1973; Rice et al., 1967).

Sensory Reinforcement

Kish (1966), in a review of sensory reinforcement with animals, concluded that a fifth category of reinforcement, sensory reinforcement, was needed to account for the many stimuli which have reinforcing properties, but which do not fall into the four traditional categories of reinforcement (primary positive and negative reinforcement, and secondary positive and negative reinforcement). Millar (1976) has further suggested that the category of sensory reinforcers should be divided into social and non-social stimuli, with the term sensory reinforcement reserved for non-social stimuli.

In research with subjects who have limited skills, such as infants and NPMR children, sensory reinforcement has several potential advantages over other types of reinforcement. Sensory stimuli can be precisely controlled for their physical characteristics, and presented through the use of automated programming equipment. The effectiveness of sensory stimuli does not depend on deprivation to the same extent as does the effectiveness of biological reinforcers. They are also less likely to elicit interfering chains of behavior as compared to appetitive stimuli (Millar, 1976; Sameroff, 1972).

In addition to the studies on sensory reinforcement in the NPMR population to be discussed below, there is already considerable evidence demonstrating the effectiveness of sensory reinforcement with severely retarded subjects and normal infants. The work with these two populations is particularly relevant to the study of NPMR individuals due to the number of similarities between these populations and the population of NPMR individuals.

Severely retarded subjects. Research with the severely retarded is clearly relevant as this population is the one which most resembles the population of NPMR subjects in terms of variables such as MA, CA, and general level of functioning. Examples of the use of sensory reinforcement are found in a series of studies of operant conditioning with severely retarded children conducted by Friedlander and his colleagues (Friedlander, McCarthy, & Soforenko, 1967; Friedlander & Knight, 1973;

Friedlander, Silva, & Knight, 1974).

In the Friedlander, McCarthy, and Soforenko study, which is described in more detail in the next section on NPMR Studies, one subject was a 29-mo-old, severely retarded child who was able to crawl and to walk with support. This subject demonstrated clearly differential response rates to the buttons on a Playtest apparatus which produced different forms of musical feedback depending on the response location. The child also learned to change response location when the contingencies on the buttons were reversed.

In the Friedlander and Knight experiment, 15 deaf-blind retarded children operated a bi-directional lever which produced an 8-sec period of room illumination at one of two intensities depending on the direction of the lever response. All the subjects demonstrated differential response rates for the differing light intensities indicating both the reinforcing value of light, as well as clear preferences for certain intensities of light.

Friedlander, Silva, and Knight used a similar procedure to investigate preferences for in-focus and out-of-focus visual images amongst 20 deaf-blind, severely and profoundly retarded children. The children operated a bi-directional lever to produce an image of ten vertical lines which were either in focus or out of focus according to the direction of the lever response. Differential response rates for 12 of the subjects demonstrated a clear preference for in-focus images.

These studies have demonstrated that visual and auditory stimuli are reinforcing events for the severely retarded, even for subjects with diagnosed sensory impairments.

Infant subjects. In the case of the normal human infant, there are also a number of similarities to the NPMR individual which suggest that infant research may provide some useful guidelines for the study of NPMR subjects. Both young infants and NPMR individuals are entirely dependent on adult caretakers for feeding, clothing, cleanliness, and locomotion. In both populations, responsiveness to social stimuli is usually limited to smiling, gross motor behaviors, or vocalizations. Many of the NPMR subjects observed by Whiteley and Dewson (Note 2) spent years rarely moving beyond the confines of a crib in their bedroom or a mat in a dayroom. In general the motor, social, and behavioral development of the NPMR subject has many similarities to that of infants.

In extensive reviews of infant conditioning studies, Hulsebus (1973) and Lancioni (1980) describe a variety of studies successfully employing sensory reinforcement. Most used visual (e.g. Siqueland & Delucia, 1969; Caron, 1967) or auditory (e.g. Butterfield & Siperstein, 1972; Eimas, Siqueland, Jusczyk, & Vigorito, 1971) stimuli and a few other studies used tactile (e.g. Sheppard, 1969) or kinesthetic (e.g. Delucia, 1972) stimuli.

In the Siqueland and Delucia study, the effects of visual reinforcement on the rate of high-amplitude, non-nutritive sucking were studied in 30 4-mos-old infants. The infants were assigned to one of three groups: a baseline control group, a sucking reinforcement group, and a sucking withdrawal group. The rate of sucking on a non-nutritive nipple was recorded for a single 15-min session for infants in the baseline control group. For the other two groups, a single 15-min session was divided into five phases: 2 min of baseline, 4 min of conditioning, 2 min of baseline, 4 min of conditioning, and 3 min of baseline. During the conditioning phases, the sucking reinforcement group were placed on a conjugate schedule of reinforcement. Each time the infant sucked the nipple in excess of 18 mm-Hg, the intensity of the projection of a 35-mm slide was increased, beginning from no illumination at the start of each conditioning phase. The sucking withdrawal group was on a DRO schedule of reinforcement during conditioning. The slide was removed for 5-sec each time the infant produced a criterion sucking response. For the latter two groups, a new slide became available after each 30 sec of time spent in a conditioning phase.

The response rate in the sucking reinforcement group rose sharply in the first conditioning phase, declined in the subsequent baseline phase, rose again in the next conditioning phase, and then declined sharply during the final 3 min of baseline. The rate of sucking in the baseline group and in the sucking withdrawal group declined steadily during all phases of the 15-min session, and there was little difference between the response rates of these two groups.

These results indicate that visual stimuli are effective reinforcers for infants. The potential eliciting or arousal effects of visual stimuli were well controlled for by the sucking withdrawal condition. The design of the study, which involved compressing several phases of baseline and conditioning into a single session, proved to be adequate for the demonstration of the effects of the different contingencies, while avoiding potential behavioral problems which could arise from restraining young infants for an extended period of time.

In the Caron study, head turning responses in 22 14-wk-old infants were reinforced with visual presentations of varied geometric patterns. In the first session, there was one minute of baseline measurement followed by six minutes of CRF conditioning for left head-turns of at least 20 deg. A day later each infant was again exposed to the CRF contingency for left head-turns during a second 6-min session. During these two sessions, the infants' rate of left head-turning increased, while their rate of right head-turning decreased after a brief increase at the beginning of session one.

Of those subjects who displayed reliable left head-turning behavior in the first two sessions, 14 subjects were later returned to the laboratory to undergo a session consisting of a conditioning phase, an extinction phase, and a reconditioning phase. During the conditioning phase, these subjects responded at levels comparable with their previous rates of correct responding. During extinction, rates of left turning declined sharply and then rose again during the reconditioning phase. Two subjects were subsequently trained to emit right head-turns under the CRF contingency, and in both cases the procedure was successful.

The Caron study adds to the evidence that visual stimuli are effective reinforcers for young infants, and also indicates that the head turning response can be reliably controlled in such young subjects.

<u>NPMR</u> <u>subjects</u>. In a series of three articles (Rice, 1968; Rice & McDaniel, 1966; Rice et al., 1967), Rice and his co-workers have reported some success in the operant conditioning of two multiply handicapped, profoundly retarded children. Little data was included in the articles; however, the authors indicate that one subject responded at a high rate when a movie sound track was presented contingent on the subject touching a ring placed over him in the crib. The rate of responding dropped when the movies were replaced by slides, returned to the previous levels when the movie was reinstated, and dropped to zero when the sound track was replaced with classical music. When the movies with sound track were reinstated as the reinforcer, responding returned to the

previous high rate. The same subject also demonstrated differential rates of vertical and lateral head movements when vibratory stimulation was contingent on vertical movements.

The three articles by Rice and his colleagues contain a great deal of anecdotal information about the problems of conducting research with this population and point out areas which merit further study. These researchers suggest that NPMR patients differ from normals in qualitative ways, such as greater day-to-day variability of response rates, unusual patterning of responses over time, and the occurrence of "spontaneous extinction", defined as a sudden, sharp decline in response rate following periods of high and stable responding. Problem areas suggested by Rice include the choice of reinforcers and their effectiveness over time, the choice of operant responses, and the maintenance of responding during modifications in reinforcement contingencies.

Friedlander, McCarthy, and Soforenko (1967) examined the operant discrimination behavior of two retarded, handicapped children. One of the subjects was a profoundly retarded 40-mo-old child who could neither walk nor crawl. The other subject was 29-mos old and able to crawl and stand with support. The apparatus used was a Playtest panel containing two large knobs illuminated by flashing red lights. One knob was programmed to produce a single chime when it was pressed while the other knob produced the continuous playing of an organ scale for as long as the knob was depressed. Each subject was placed in a crib with the apparatus attached to the side, and left alone with the device for the duration of the session. The older subject received one 15-min session; the younger subject was given a 36-min session. During each session, the contingencies on the knobs were reversed several times. The dependent measures in the study were the frequency, location, and duration of knob pressing responses. An analysis of response location patterns or sequences was also made.

Both subjects responded actively on the panel. The younger, less disabled child emitted 749 responses in 36 min and the older, more handicapped child made 185 responses in 15 min. For both subjects, there was little difference between the frequencies of responses resulting in chime feedback and those resulting in organ-scale feedback. However, the durations of responses for organ-scale feedback averaged nearly four times the durations of responses for chime feedback. The younger subject was observed to switch his pressing behavior from one knob to the other when contingencies on the knobs were reversed. This behavior occurred mainly in the later stages of the session and served to maximize organ-scale reinforcement for the subject. The older subject rarely switched knobs and apparently had great physical difficulty in doing so. Since the study was concerned with discrimination, no baseline periods were employed to assess the operant level of the knob pushing responses in the absence of auditory feedback.

Meyerson, Kerr, and Michael (1967) conducted two experiments with a 4-year-old boy who was described as bedridden, hyperactive, and self-destructive. He was labelled autistic; however, in a later study (Bailey & Meyerson, 1969), he was diagnosed as profoundly retarded. Despite the different labels, the subject description appears to meet Landesman-Dwyer's criteria for defining a NPMR subject. In an attempt to control the subject's self-destructive behaviors, 10-min periods of noncontingent applications of either vibration or backscratching were alternated with 10-min periods of no stimulation. Two 50-min sessions separated by a one-week interval were given and each session contained three periods of no stimulation, a period of vibration, and a period of backscratching. The frequency of self-destructive behaviors remained at a high level during periods of no stimulation but gradually dropped to a very low level during periods of either backscratching or vibration. The fact that external stimulation effectively suppressed self-stimulatory and self-destructive behavior suggests that tactile stimulation may prove to be an important class of reinforcers for NPMR subjects.

Two years later, Bailey and Meyerson (1969) conducted another study of the same subject. A large padded lever was placed in the subject's crib 24 hours a day. Following eight hours of baseline measurements of lever pressing, an FR-1 schedule of reinforcement was introduced with 6 sec of vibration contingent on each lever press. Following 21 days of conditioning, baseline conditions were reinstated for 23 days. During the first baseline condition, the subject responded an average of 135 times a day. In the conditioning period, the average daily number of responses increased to 1000, with a range of 700 to 2000. During the second baseline period, the rate dropped to 400 responses a day in the first week and then to 140 responses a day in the last week. The use of extended baseline and conditioning periods makes this study a convincing demonstration of control over the behavior of an NPMR child. The results also suggest that vibration merits further investigation for use as a reinforcer for handicapped, retarded children, particularly since there was no evidence of a decline in its effectiveness over a long period of continuous availabiliy.

A study by Griffin, Patterson, Locke, and Landers (1975) demonstrates the idiosyncratic nature of operant conditioning in NPMR children. The manipulandum consisted of a wooden frame encircling the inner circumference of a crib about 41 cm above the bed springs, with nylon cords laced across the frame. Any downward movement anywhere on the cords or frame operated the programming equipment. The reinforcement consisted of 5 sec of vibration delivered through the base of the crib. The subjects were one 5-year-old and two 3 1/2-year-old, crib-bound, profoundly retarded children. Following six baseline sessions, all subjects were placed on a CRF schedule of reinforcement. The 5-year-old achieved a relatively high and stable response rate after several sessions and maintained his high rate across 26 of 30 sessions. During subsequent extinction sessions, his response rate dropped to zero after six sessions. The two younger subjects showed no change in response rate during the first seven conditioning sessions so the contingencies were changed to an avoidance schedule. One of the subjects responded at a high rate on this schedule, and during subsequent extinction, responding dropped to zero after three sessions. The third subject displayed no changes in response rate to schedule manipulations. In summary, the Griffin et al. study found highly reliable conditioning of gross motor behavior in two of three subjects with vibration serving as a positive reinforcer in one case and as a negative reinforcer in the other case.

Murphy and Doughty (1977) trained several NPMR subjects, aged 9 to 20 years, to perform controlled arm movements. Four subjects were reinforced on a CRF schedule with a 5-sec presentation of vibration each time they pulled on a handle to which their hand had been tied. Another three subjects received the same reinforcement for pressing on a plexiglass panel. After response rates had increased reliably over baseline rates for all subjects, the procedures were modified. The subjects who pulled the handle were now required to do so without their hand being tied to the handle and a greater force was required to operate the manipulandum. These changes produced a sharp decrement in response rate for handle pulling followed by a return to the high rates evidenced in the first phase of conditioning. The three subjects who panel pressed were switched to an FR-5 schedule which produced a sharp increase in rate of panel pressing.

Remington, Foxen, and Hogg (1977) examined the effects of several auditory reinforcers on the rate of a lever pulling response. In Experiment 1, four NPMR subjects pulled a lever for auditory reinforcement which varied from 2 to 5 sec. Three types of music (rhymes, blues, and Spanish drum music) were tested as potential reinforcers. When a subject's response rate increased with a particular combination of music and reinforcer duration, the same combination was used in at least one subsequent session, and if it proved effective, the schedule of reinforcement was gradually increased from the initial CRF. This procedure yielded effective reinforcers for three of the four subjects. However, the results showed that the schedule of reinforcement had to be kept very low to maintain responding. The subjects were found to satiate rapidly within sessions but the phenomenon of sudden response rate decrement which Rice et al. (1967) had noted, did not occur. In a second experiment, two of the subjects from Experiment 1 were tested with both mixed and multiple schedules of reinforcement. Two schedule components were employed: a CRF schedule using the effective reinforcer from the first experiment and a CRF schedule using a 500 Hz tone. Changing intensity of room illumination served as discriminative cues for the two schedule components when the multiple schedule was in effect. The results showed, with the multiple schedule, that the subjects had distinct preferences for auditory stimulation. One subject preferred the music whereas the other preferred the tone.

The final two studies in this review add to the findings of Remington et al. that discriminative behavior can be established in NPMR individuals. Macht (1971) developed a procedure for determining the visual acuity of nonverbal subjects. In his study, one of the subjects appears to be similar to the type of child discussed in the preceding articles. The subject, a 7-year-old girl with Down's Syndrome, was non-verbal, nonambulatory, and not toilet trained. The subjects were trained to press a lever when a letter "E" was presented in the correct orientation and not to press the lever when the letter was in any other orientation, or not visible. By placing the letter in its correct orientation at varying distances from the subject and comparing the frequencies of responses at each distance, the experimenter was able to determine an estimate of visual acuity. The subject in question performed as reliably as the other retarded subjects at this task and all the subjects displayed a high level of discriminative behavior. This study presents another case of the conditioning of an NPMR individual. However, the lever response would not be possible for many severely handicapped children.

Haskett and Hollar (1978), in two experiments, investigated the abilities of four NPMR children to discriminate response-dependent and response-independent stimulation. The operant response consisted of depressing a large wooden lever. In the first experiment, conducted in a dark room, reinforcement consisted of a 5-sec period of room illumination. Two subjects were exposed to three conditions: CRF, baseline, and response-independent reinforcement. Both subjects demonstrated discrimination of the CRF and baseline conditions with a greater percentage of time spent lever pressing under CRF conditions than under baseline conditions. One subject demonstrated discrimination between CRF and response-independent reinforcement conditions.

In the second experiment, the other two subjects were exposed to two conditions: CRF and an omission training (or DRO) schedule (5-sec). Reinforcement consisted of a 5-sec presentation of music (Handel's <u>Messiah</u>). One of the subjects displayed discrimination between the two schedules, evidenced by high response rates under CRF and low response rates under omission training.

Haskett and Hollar's study demonstrated that three of four NPMR children's operant responding could be readily controlled by sensory reinforcement and that a discrimination could be established between response-contingent and response-independent conditions of reinforcement. The authors conclude that NPMR children have more sophisticated behavioral potentials than observation of their behavior in an institutional setting would suggest.

Summary

These studies of sensory reinforcement provide a basis for future research by indicating some of the areas of particular concern for studies of the NPMR child. They indicate that the choice of a response to serve as an operant must be made with particular care to avoid problems such as those encountered by Friedlander, McCarthy, and Soforenko (1967) where the older subject was able to perform the response but had great difficulty in changing the location of his response. Ideally, the response should be one that a substantial proportion of the NPMR population exhibits so that a training program has general applicability to many individuals.

The majority of the studies of the NPMR population used sensory reinforcers in the form of visual stimuli (2 studies), auditory stimuli (3 studies), and tactile stimuli (4 studies) indicating that these classes of stimuli should receive considerable use in future research and applied programs.

The generalizability of these studies is limited in several areas. Since so few subjects were employed in each study (range = 1 to 4), it is not possible to generalize about the effectiveness of the various procedures for other NPMR children. Control procedures were sometimes absent or inadequate, thus limiting intrasubject generalization. For example, of eleven studies, only four included procedures to control for possible eliciting or arousing effects of reinforcement, baseline data were inadequate or absent in three studies, and no reversal data were collected in seven studies.

All of the studies employed CRF schedules of reinforcement and several also attempted to control behavior with more complex schedules such as FR (Murphy & Doughty), DRO (Haskett & Hollar), multiple schedules

(Remington et al.), or avoidance schedules (Griffin et al.). All of these procedures resulted in at least some degree of success in the studies which employed them.

An Overview of the Thesis Experiments

The four experiments described in this thesis represent attempts to develop procedures for the operant conditioning of head turning responses in NPMR adolescents.

The head turning response was selected on the basis of an observational study conducted on the same subjects who served in these experiments. Whiteley and Dewson (Note 2) observed each subject for eight 30-min periods and found that the head turning response was a gross motor response emitted by every subject. It was also noted that several of them emitted head turning responses subsequent to hearing a voice or being touched. The head turning response has been established as a conditionable response in human infants (e.g. Caron, 1967).

In the first two experiments, the stimulus tested for its reinforcing effects was a 5-sec presentation of a multi-modal sensory event consisting of music, pictures, and vibration. A multi-modal stimulus was used in an attempt to ensure that all the subjects would be exposed to at least some sensory stimulation, in light of known or probable sensory impairments suffered by some of the subjects (see Appendix A). In addition, it was assumed that such an event might maximize the reinforcing value of the stimulation. None of the previous studies with NPMR subjects have combined auditory, visual, and vibratory stimuli.

In the first two experiments, both a CRF schedule of reinforcement and a schedule of differential reinforcement of other behavior (DRO) were employed. The CRF schedule was selected as it has proven to be an effective way to control the behavior of NPMR subjects. The DRO procedure was chosen to serve as a control for the possible eliciting or arousing effects that the stimulation might have on head turning behavior. If the DRO schedule was found to suppress head turning while CRF produced increased rates of responding, then the argument that head turning increased under CRF due to the contingent effects of reinforcement would be considerably strengthened. A second advantage of the DRO schedule as a control procedure is that it can itself yield information about the conditionability of the subjects.

The initial methodological orientation was based on experimental designs employed in many infant operant conditioning studies using sensory reinforcement. The first experiment employed baseline, conditioning, and reversal conditions in each session; a procedure similar to Siqueland and DeLucia's (1969) study with infants. One major difference between the Siqueland et al. study and the present research was that in the first two thesis experiments there were two groups, one receiving CRF during conditioning, and one receiving DRO. The approach to the study of the profoundly retarded based on the designs of infant studies has been suggested in reviews by Webb and Koller (1979) and Weisberg (1971).

In Experiment 1, 10 subjects were exposed to four 30-min sessions each containing 10 min of baseline, 10 min of conditioning, and 10 min of reversal. Five subjects were on a CRF schedule during conditioning and five subjects were on a DRO (5-sec) schedule of reinforcement. In the second experiment, there were two 30-min baseline sessions, eight 30-min conditioning sessions, and two 30-min extinction sessions. During the conditioning sessions, subjects were exposed to the same contingencies they had received in Experiment 1.

Of the original ten subjects, only seven, selected on the basis of their high scores on a sensorimotor test, served in Experiment 3. Because the DRO procedure was ineffective in the previous two experiments, all of the subjects were exposed to CRF contingencies only. The composition of the contingent stimulation was varied by removing the vibration component after several conditioning sessions. There were from 10 to 14 conditioning sessions and four reversal sessions.

In the fourth experiment, nine of the original ten subjects were employed. The composition of the contingent stimulation was varied systematically, new apparatus was employed, session length was shortened to 15 min, the number of baseline and conditioning sessions was increased, and physical prompts were employed in a systematic manner. This was the first study with NPMR subjects to systematically vary the content of a multi-modal stimulus in an attempt to identify an effective reinforcer for a particular subject.

These four experiments represent attempts to develop procedures for the conditioning of NPMR subjects which will be generalizable to other NPMR individuals. As a consequence of this goal, the studies differ from previous experiments in several respects. These experiments employed more subjects than all previous studies. The novel response of head turning was selected because it is one which most NPMR subjects are able to perform. The procedure in the fourth experiment provides a systematic approach to identifying sensory reinforcers for particular subjects, and thereby addresses the problem of variable reinforcer preferences in NPMR individuals.

EXPERIMENT 1

The first experiment had two major goals: (a) to investigate the use of multi-modal sensory stimuli as reinforcers for the control of head turning behavior, and (b) to examine the effects of two schedules of reinforcement, CRF and DRO, on the behavior of NPMR subjects. It was predicted that the CRF schedule would result in increasing rates of head turning across sessions; whereas, the DRO schedule would suppress head turning behavior.

Method

Subjects

Ten subjects, three boys and seven girls, from the Parkhaven Ward at the Manitoba School for Retardates in Portage la Prairie served as subjects in the study. Their mean age was 15.91 years, with a range of 11.25 years to 29.17 years.

The subjects had been assigned to this ward on the basis of their severe mental and physical handicaps. All had been diagnosed as profoundly retarded and had at least one major physical disability; the diagnoses included cerebral palsy, paralysis, epilepsy, scoliosis, congenital deformities, and spasticity. These subjects required total nursing care as none of them displayed any self-help behaviors and only one subject was able to walk short distances with assistance. The subjects spent their days either lying on mats or in wheelchairs in the day room. A detailed description of the subjects appears in Appendix A. All names employed in the text are pseudonyms.

Apparatus

Testing of the subjects took place in a bedroom approximately 3- x 4-m. The subject was lain in a standard hospital crib surrounded by a screen on all four sides to reduce distractions. The arrangement of the apparatus is shown in Figure 1. A Mundo "Refreshette" massage unit[1] was placed under the subject's back and the vibration setting was at gentle. The manipulandum consisted of a 20- x 20-cm padded board, which was placed under the subject's head, with a 20- x 10-cm padded board projecting vertically on each side of the head. Pressure on either of these vertical boards caused the operation of a microswitch. A Kodak Carousel projector was used to project colored slides of people and drawings from children's books onto a projection screen, 40- x 40-cm in

1 Manufactured by Mundo Enterprises Limited, Box 1023, Postal Station A, Vancouver, British Columbia.

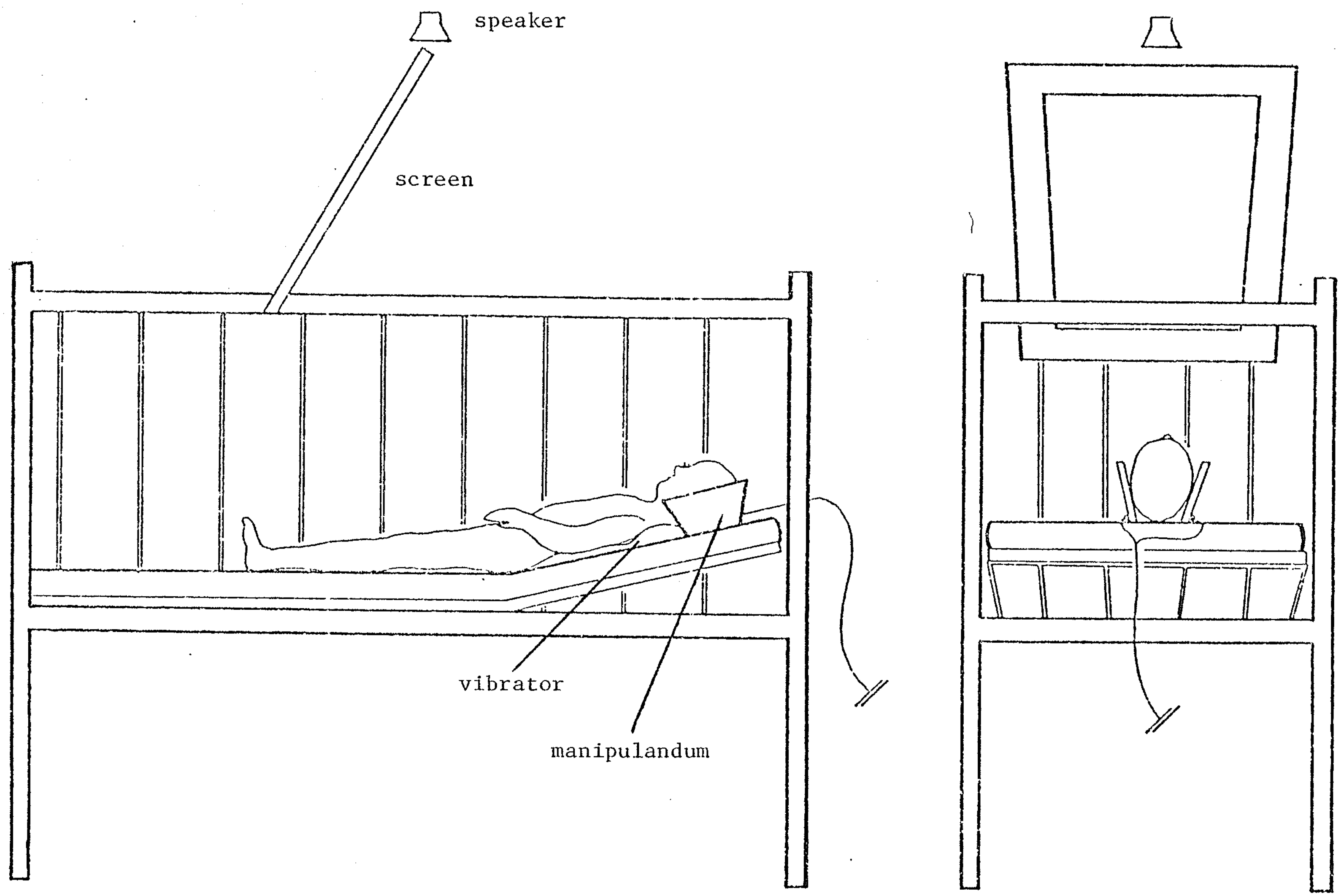

Figure 1. Apparatus used in experiments 1, 2 and 3.

size, which was suspended above the end of the crib at a distance of about 1.5 m from the subject's head. Located out of sight behind the screen was a speaker connected to a tape recorder containing a tape of children's songs. Programing equipment automatically controlled presentation of the vibration, pictures, and music. Responses were recorded on counters and a cumulative recorder.

Procedure

Each subject was tested for one 30-min session on each of six consecutive days. At the beginning of each session, the subject was placed in the crib in a supine position, and if there were no signs of distress, the experimenter withdrew from view. Each subject was tested at about the same time each day.

The first two sessions served to determine baseline rates of head turning. Subjects were rank ordered on the basis of rates of head turning displayed during the baseline sessions; odd numbered ranks were assigned to the DRO group and even numbered ranks were assigned to the CRF group. A coin toss determined which group received the even or odd ranks. Each of the four experimental (ABA) sessions were divided into three phases for all subjects. The first ten minutes of each session served as a baseline period during which head turning responses were recorded but no reinforcement was presented. The second 10-min period was a conditioning phase, and the final ten minutes was a reversal period.

During the conditioning phases, subjects in Group CRF received a 5-sec presentation of a multi-dimensional stimulus consisting of vibration, music, and a picture following each head turning response. Subjects in Group DRO received a 5-sec presentation of this multi-modal stimulus following any 10-sec period during which no head turning response was emitted. A 10-sec period started at the beginning of the session, following termination of a stimulus presentation, or following a head turning response.

Results

Baseline Sessions

Each baseline session was divided into three 10-min intervals. The response rate (r/min) was calculated for each interval to facilitate comparisons between baseline sessions and conditioning sessions.

The group and individual baseline response rates appear in Figure 2 and Figure 3 for CRF and DRO conditions, respectively. These figures indicate considerable variability amongst baseline response rates both within and between subjects. For Group DRO, the overall mean rate of baseline responding was 1.71 r/min and the median was .73 r/min; whereas, for Group CRF, the mean baseline response rate was .77 r/min and the median was .60 r/min. The principle reason for this large discrepancy in mean rate of response was the extreme score of one subject in Group DRO. This subject, Tim, responded over three times as often as the next highest ranked subject.

A scattergram of cell means and standard deviations indicated a high positive correlation between the two variables. The data were transformed according to the formula $x = \sqrt{x} + \sqrt{x+1}$ and a scattergram of the means and standard deviations of the transformed scores indicated a near zero correlation. A mixed analysis of variance was computed using the transformed scores with Groups (CRF vs DRO) as the between-subjects variable, and two within-subjects variables, Baseline Sessions (1 vs 2) and Intervals (1st vs 2nd vs 3rd ten minute period). A summary of the analysis appears in Table 1 and indicates that there were no significant effects.

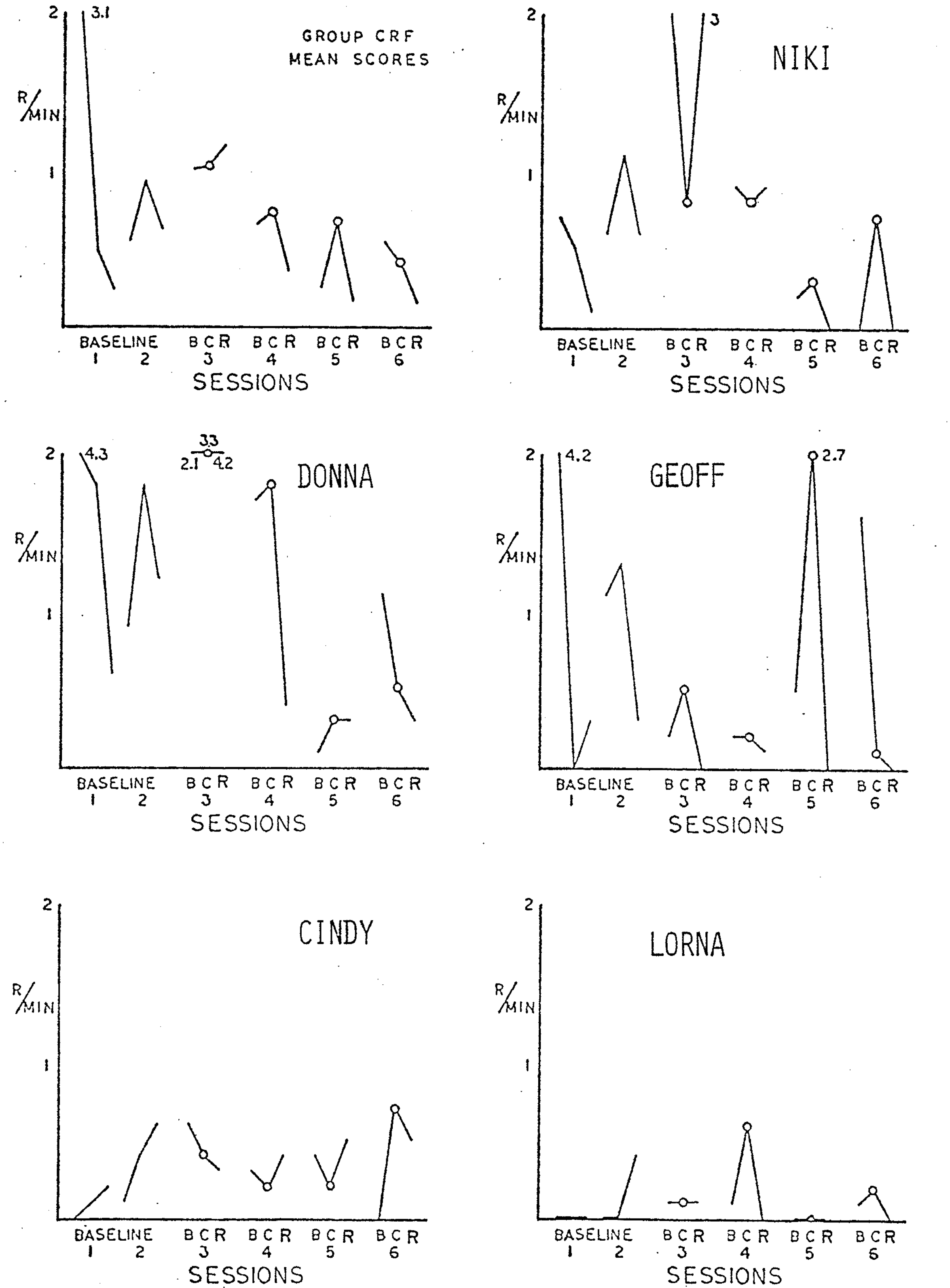

Figure 2. Mean responses per minute for each 10-min segment of baseline and conditioning sessions for CRF subjects in Experiment 1 (B = baseline, C = conditioning, R = reversal).

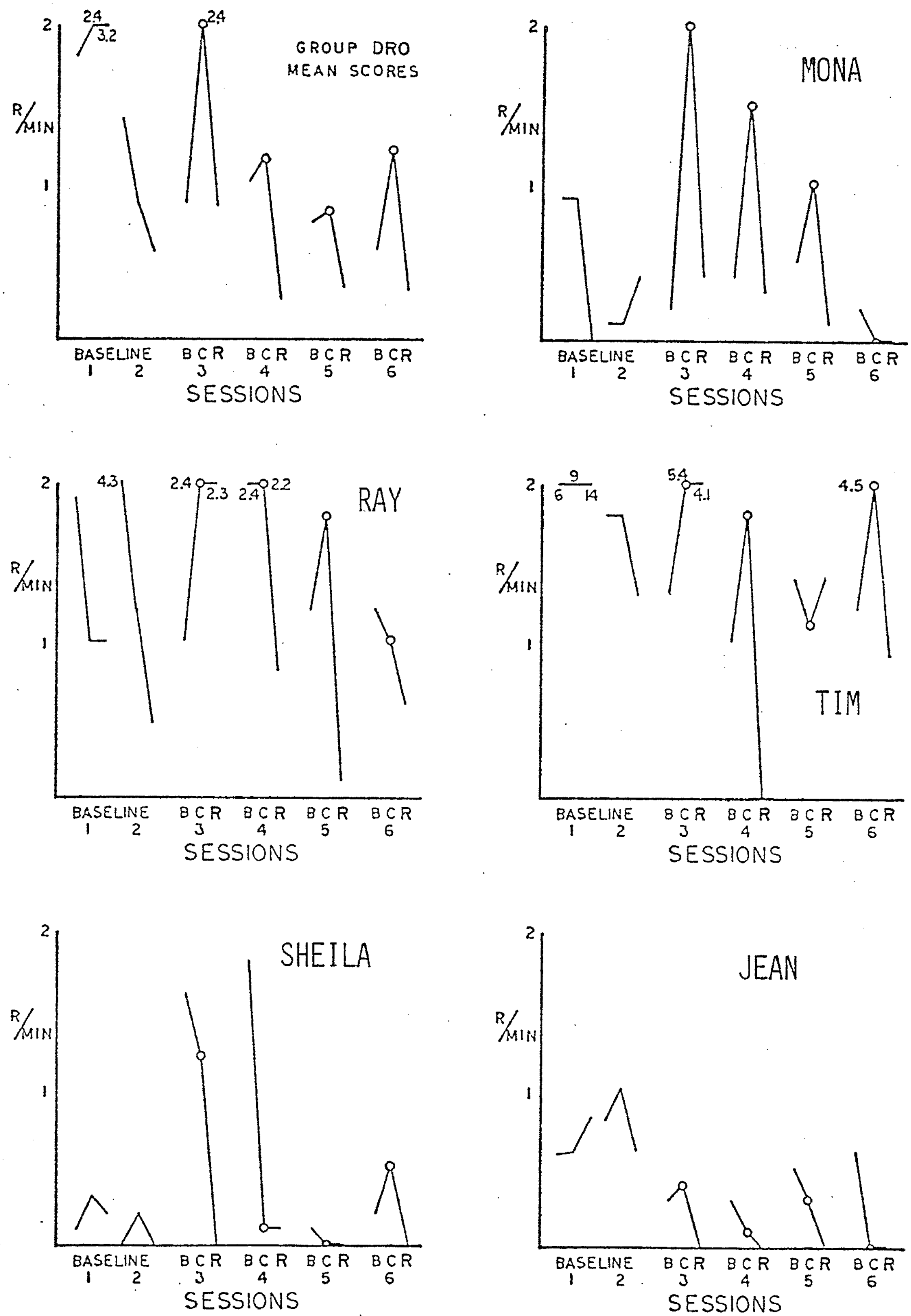

Figure 3. Mean responses per minute for each 10-min segment of baseline and conditioning sessions for subjects in group DRO in Experiment 1 (B = baseline, C = condition, R = reversal).

Table 1

Summary of ANOVA of Transformed Baseline Data

Source	SS	df	MS	F	p
Groups	4.536	1	4.536	.723	.420
Error	50.211	8	6.276		
Sessions	1.467	1	1.467	.800	.397
Sessions x Groups	2.624	1	2.624	1.431	.266
Error	14.665	8	1.833		
Intervals	.832	2	.416	.728	.498
Intervals x Groups	.253	2	.126	.221	.804
Error	9.145	16	.572		
Sessions x Intervals	.448	2	.224	.561	.581
Sessions x Intervals x Groups	2.785	2	1.393	3.492	.055
Error	6.381	16	.399		

ABA Sessions

Each subject's number of responses for each condition (Baseline, Conditioning, Reversal) for each session was divided by 10 to give response rate per minute (r/min). As was the case with the baseline data, the cell means and standard deviations in Experiment 1 were highly correlated. The mixed ANOVA was therefore computed using scores transformed by the formula $x = \sqrt{x} + \sqrt{x+1}$. In the analysis, Group (CRF vs DRO) was the between-subjects variable, and Conditions (baseline vs conditioning vs reversal) and Sessions (3 to 6) were within-subjects variables. The ANOVA program also performed orthogonal trend analyses on the within-subjects variables. As can be seen in Table 2, there were significant main effects for sessions, $F\ (3,24) = 4.03$, $p = .019$, and for Conditions, $F\ (2,16) = 8.05$, $p = .004$. The orthogonal comparison for linear trend for Sessions was significant, $F\ (1,8) = 7.58$, $p = .025$, and the orthogonal comparisons for both linear and quadratic trends for Conditions were significant, $F\ (1,8) = 5.86$, $p = .042$; $F\ (1,8) = 10.55$, $p = .012$; the quadratic trend had the highest F-ratio.

Table 2

Summary of ANOVA of Transformed Experiment 1 Data

Source	SS	df	MS	F	p
G	2.002	1	2.002	.576	.469
Error	27.790	8	3.474		
S(1)	6.876	1	6.876	7.584	.025
S(1)G	.001	1	.001	.001	.973
Error	7.254	8	.907		
S(2)	1.640	1	1.640	2.200	.176
S(2)G	.043	1	.043	.058	.815
Error	5.963	8	.745		
S(3)	.001	1	.001	.002	.965
S(3)G	.154	1	.154	.334	.579
Error	3.693	8	.462		
S	8.517	3	2.839	4.029	.019
SG	.199	3	.066	.094	.963
Error	16.910	24	.705		
C(1)	2.648	1	2.648	5.858	.042
C(1)G	.300	1	.300	.664	.439
Error	3.616	8	.452		
C(2)	4.190	1	4.190	10.545	.012
C(2)G	.546	1	.546	1.374	.275
Error	3.179	8	.397		
C	6.838	2	3.419	8.050	.004
CG	.846	2	.423	.996	.391
Error	6.795	16	.425		
SC	1.039	6	.173	.569	.753
SCG	1.293	6	.216	.708	.644
Error	14.600	48	.304		

Note. G = Groups (CRF vs. DRO), S = Sessions, C = Conditions (Baseline, Conditioning, Reversal). Numerals in brackets denote the order of orthogonal comparison: (1) = linear, (2) = quadratic, (3) = cubic.

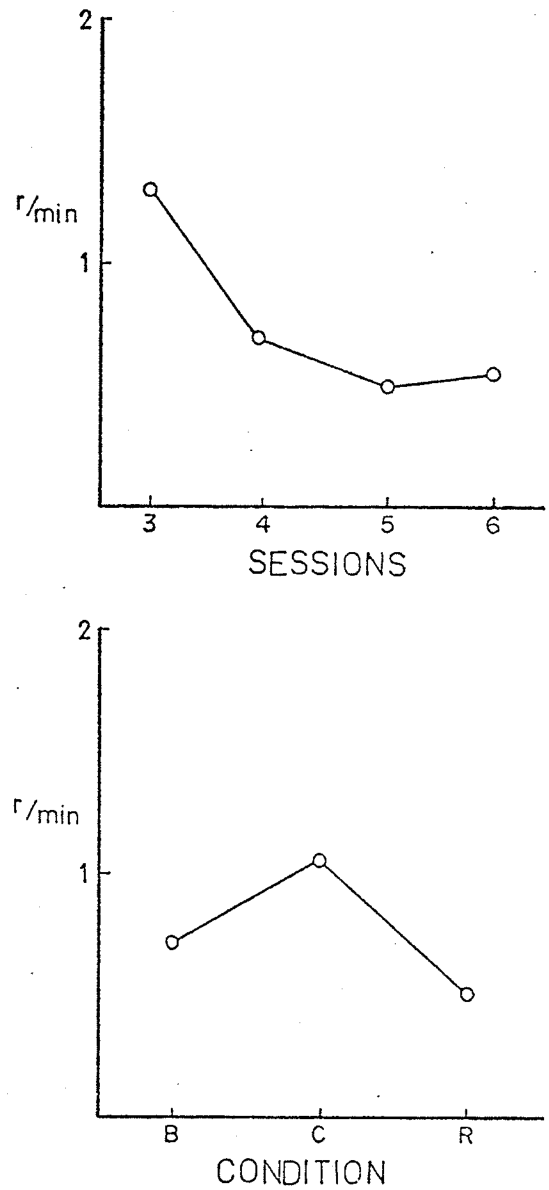

Figure 4. Mean response rate for all subjects in Experiment 1 for sessions and for conditions.

The overall means for Sessions and for Conditions appear in Figure 4. The significant linear trend for Sessions resulted from the decline in response rate from sessions 3 through 6. The significant quadratic trend for Conditions was due to an increase in response rate from the baseline to conditioning phases followed by a decline in response rate from the conditioning to reversal phases. The predicted interaction between Groups and Conditions was not significant, indicating that the DRO and CRF conditioning procedures did not have differential effects on the subjects' behavior.

The finding of an inverted U-shaped quadratic trend for Conditions suggests that the CRF procedure may have been successful. However, examination of Figure 2, which contains individual and group means for Group CRF, indicates that in no case did an individual subject demonstrate consistently higher rates of responding during conditioning phases than in baseline or reversal phases. The overall mean response rates in the baseline, conditioning, and reversal phases were .61 r/min, .71 r/min, and .46 r/min respectively.

Examination of Figure 3 similarly indicates a failure of the DRO procedures to produce the predicted effects on response rate. Rather than reducing responding, the DRO contingency tended to result in rates of responding during conditioning phases which were higher than the rates observed in baseline and reversal phases. The overall mean rate of responding in the conditioning phases was 1.39 r/min while the mean rate during baseline phases was .83 r/min and the mean rate during reversal phases was .56 r/min. In 19 of the 20 individual sessions, response rate in the conditioning phase was as great or greater than response rate in the reversal phase and in half of the sessions response rate in the conditioning phase was greater than response rate in the baseline phase. These results appear to be the main source of the overall significant quadratic trend for conditions which was found in the ANOVA.

The results for four of the five DRO subjects (Mona, Ray, Tim, and Sheila) indicate that, during the conditioning phases, response rates declined sharply across sessions. This trend is apparent across all four sessions for Mona and Ray and across the first three sessions for Tim and Sheila. The fifth subject, Jean, displayed very low rates of responding in all four sessions. Within sessions, Jean displayed a clear trend of declining response rates from the baseline to the reversal phases. This resulted from the subject removing her head from the apparatus during the conditioning phases.

Discussion

The results indicate that neither the CRF nor the DRO conditioning procedure was effective in controlling subjects' head turning behavior in the predicted manner. The finding of higher overall response rates in conditioning phases for both groups suggests that presentation of the multi-dimensional stimulus elicited head turning responses or raised general activity levels. The decline in response rates across sessions may have been due to an initial response-eliciting effect of the novel experimental situation which habituated as a result of repeated exposure to the testing environment.

The procedures of Experiment 1 failed to demonstrate the control of head turning responses by either the CRF or DRO schedules of reinforcement. These results are in contrast to the successful conditioning of infants by Siqueland and Delucia (1969) and Caron (1967).

There are many possible reasons for the failure of these experimental procedures. First, there may have been an insufficient number of conditioning sessions for learning to occur in these individuals. Second, the conditioning period within each session may have been too brief. Third, any learning that did occur may have been eliminated by the subsequent reversal and baseline periods. Fourth, the multi-dimensional stimulus might not have been a positive reinforcer for these subjects. The results of Experiment 1 led to the modification of these aspects of the procedure in the subsequent experiments.

EXPERIMENT 2

The second experiment was conducted in an attempt to overcome two of the limitations of Experiment 1; the small amount of time devoted to conditioning in each session and the limited number of sessions. It was hypothesized that a larger number of sessions in which the contingencies remained constant would enhance the liklihood of bringing head turning responses under the control of sensory reinforcement.

Method

Subjects

All the subjects from Experiment 1, except Geoff (Group CRF) and Sheila (Group DRO) who were unavailable, were employed as subjects in Experiment 2. Each subject was assigned to the same group as in Experiment 1.

Apparatus

The apparatus was the same as that employed in Experiment 1.

Procedure

Experiment 2 was begun one week after the conclusion of Experiment 1. Each subject received 12 daily sessions, and during conditioning sessions they received the same reinforcement procedures as those employed in Experiment 1 (i.e., either CRF or DRO). Following two 30-min baseline sessions, there were eight 30-min conditioning sessions and then two 30-min reversal sessions. Three of the four CRF subjects received prompts during one of the conditioning sessions. A prompt consisted of the experimenter rotating the subject's head manually from a position directly behind the subject.

Results

The response rate (r/min) was calculated for each session for each subject and the rates were transformed by the formula $x = \sqrt{x} + \sqrt{x+1}$. A mixed ANOVA was computed with Groups as the between-subjects factor, and Sessions as the within-subjects factor. As can be seen in Table 3, there were no significant F-ratios in the analysis.

Table 3

Summary of ANOVA of Transformed Experiment 2 Data

Source	SS	df	MS	F	p
Groups	11.761	1	11.761	1.28	.301
Error	55.135	6	9.188		
Sessions	3.903	11	.348	1.088	.384
Session x Group	1.977	11	.179	.551	.861
Error	21.521	66	.326		

The individual results from Group CRF appear in Figures 5 and 6. Niki, Cindy and Lorna showed no evidence of conditioning, even after manual prompts were used in Sessions 6,7 and 8, respectively. Donna gradually increased her rate of head turning from a level in Session 3 (first conditioning session) just above baseline rates to a high stable rate in Sessions 7 to 10. There was a rapid return to baseline rates of responding in the reversal sessions, 11 and 12.

The results from Group DRO appear in Figures 7 and 8. Examination of individual results indicates that the DRO contingency was not controlling head turning behavior. Jean and Mona emitted low rates of responding throughout baseline and conditioning sessions; whereas, Ray and Tim displayed high rates of responding with considerable variation between sessions. During conditioning, none of the subjects showed rates of responding that differed consistently from rates in both baseline and reversal sessions.

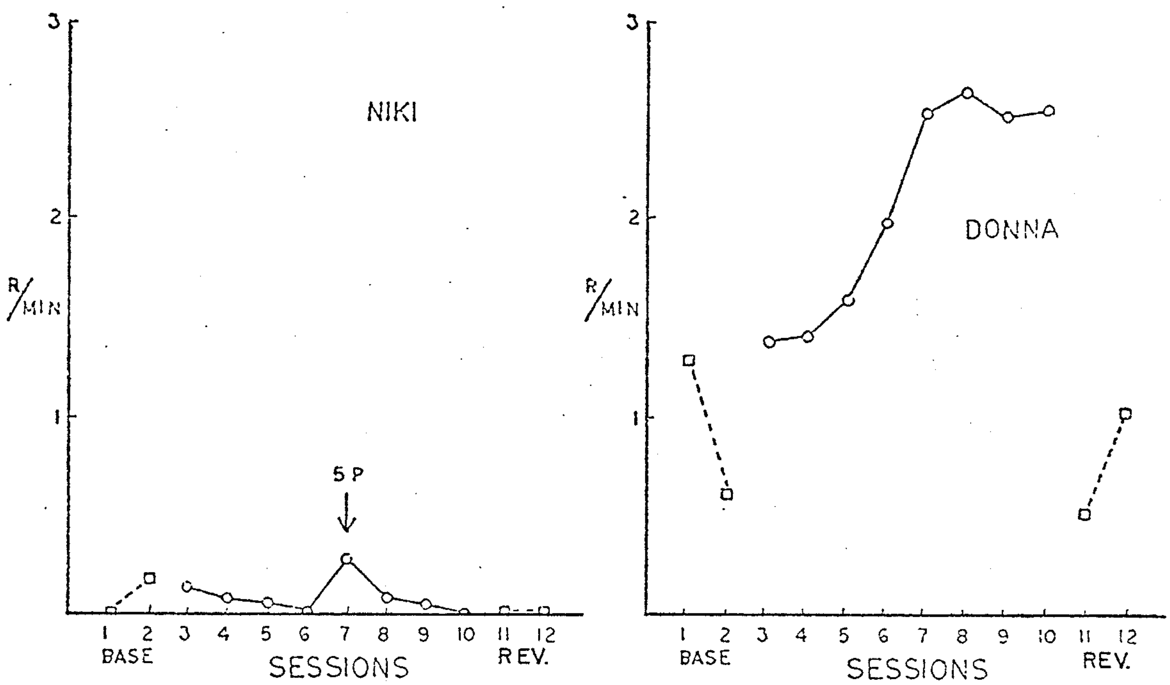

Figure 5. Mean responses per minute for two CRF subjects, Niki and Donna, in Experiment 2 (P indicates prompts).

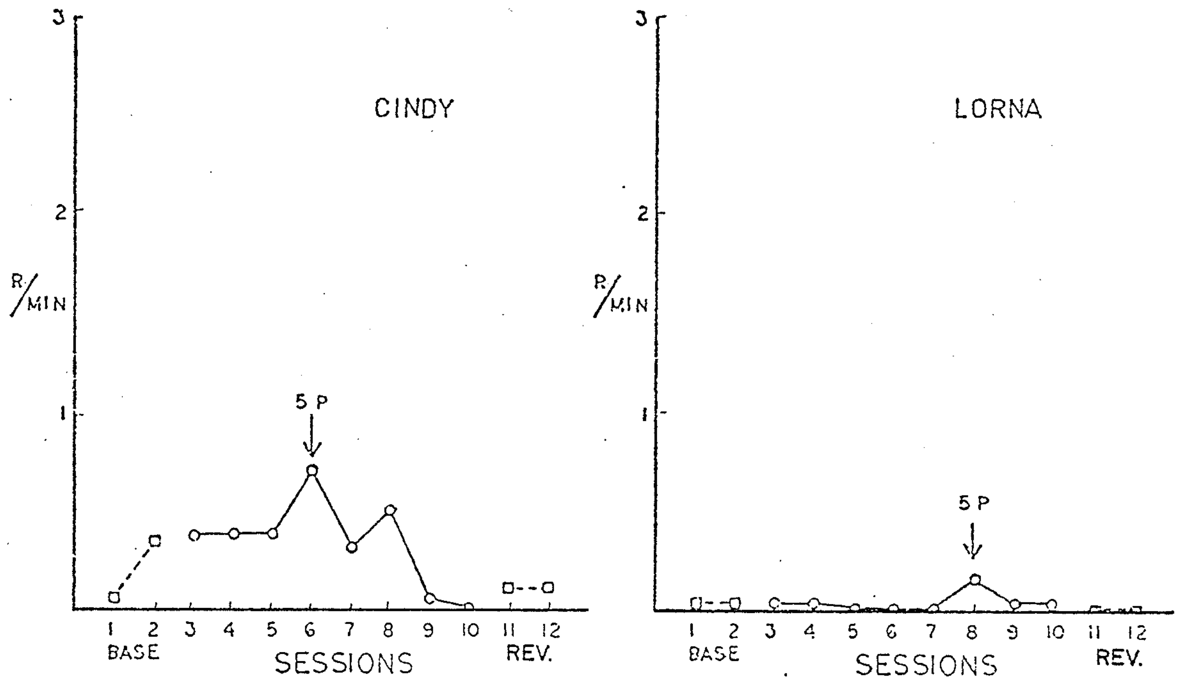

Figure 6. Mean responses per minute for two CRF subjects, Cindy and Lorna, in Experiment 2 (P indicates prompts).

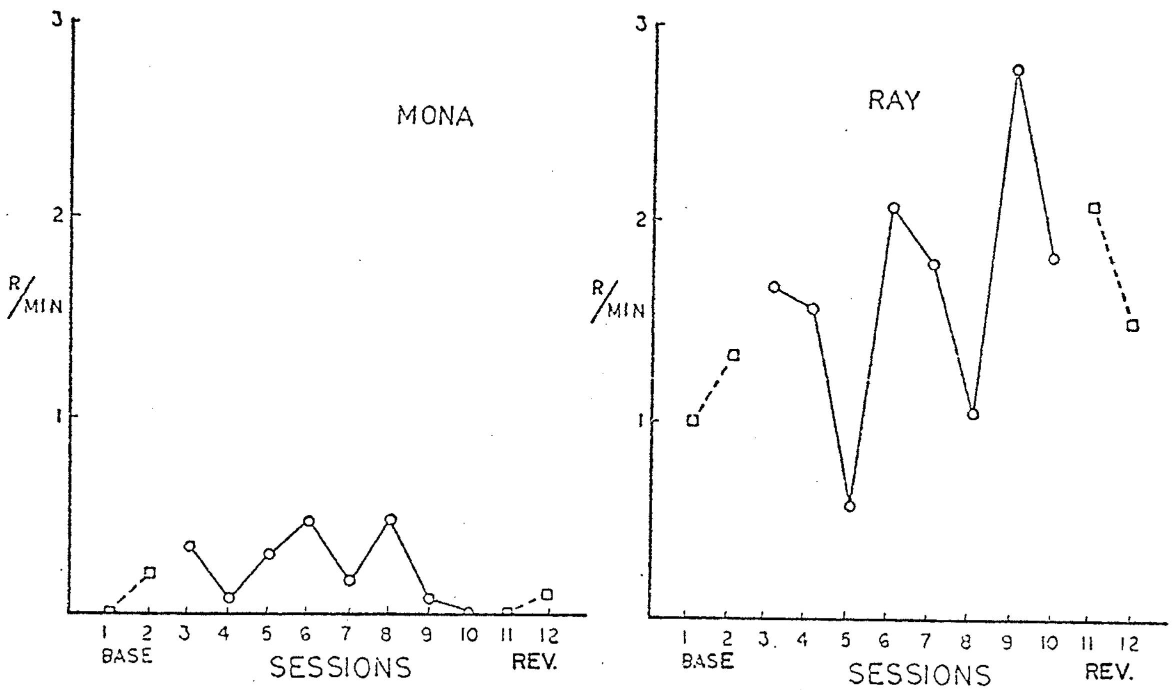

Figure 7. Mean responses per minute for two DRO subjects, Mona and Ray, in Experiment 2.

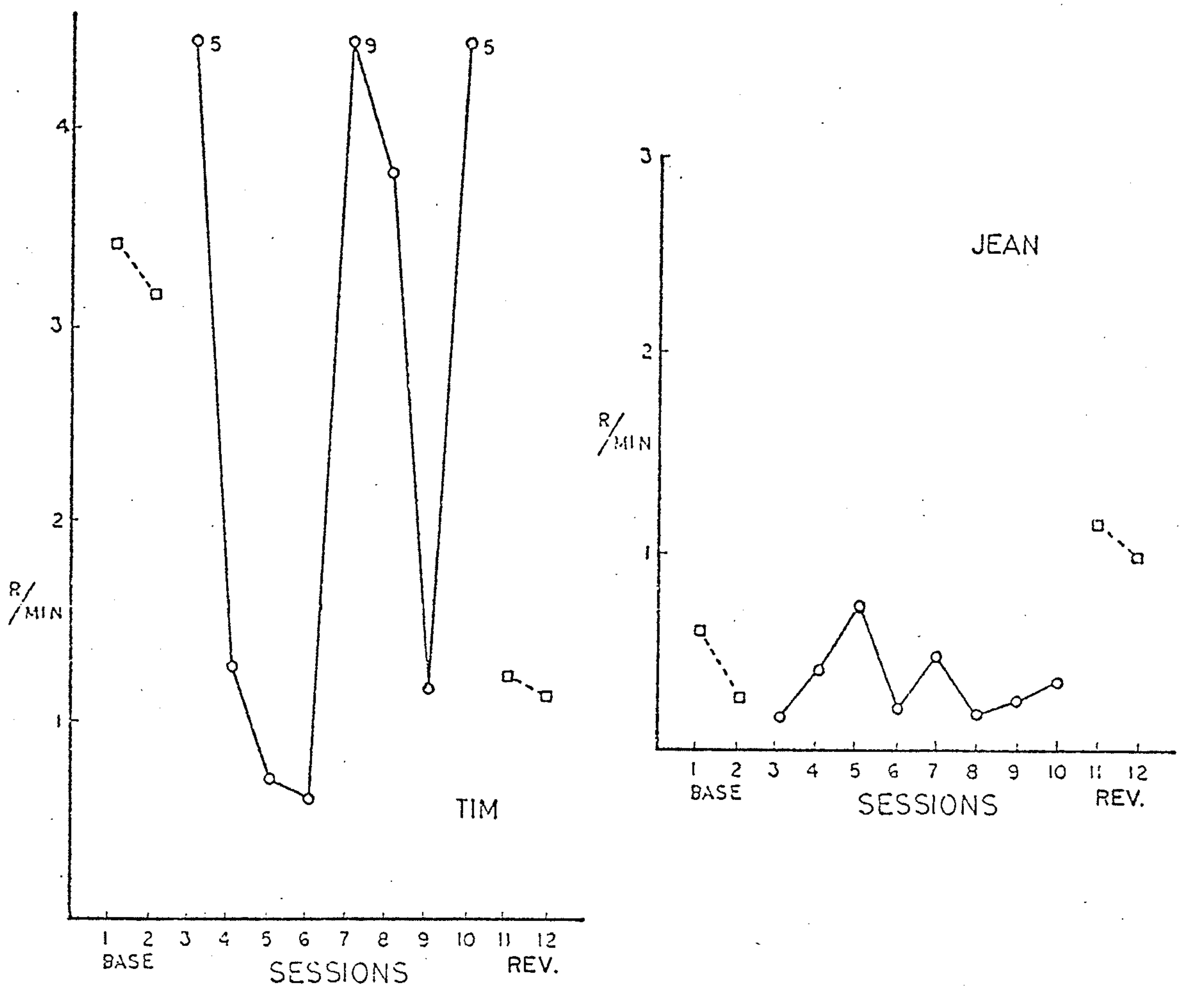

Figure 8. Mean responses per minute for two DRO subjects, Tim and Jean, in Experiment 2.

Discussion

These results indicate that the CRF contingency was effective in controlling the head turning behavior of Donna. The finding that Donna did not reach a stable rate of responding until the fifth conditioning session supports the contention that the procedure used in Experiment 1 did not provide sufficient experience for this subject to come under the control of the CRF contingency.

The failure to condition the other three CRF subjects may stem from a variety of causes. In the case of Niki, the event programed for reinforcement appeared to be a noxious event. Normally Niki appeared relaxed in the crib and displayed occasional eye and hand movements; however, her typical reaction to the onset of the multi-modal stimulus was to become very tense and still. In the cases of Cindy and Lorna, there was little or no reaction of any kind to contingent stimulation. Both subjects were very quiet and unresponsive in general.

The DRO schedule of reinforcement did not appear to be controlling the behavior of any of the subjects. One possible reason for the failure of the DRO procedure is that responding had a relatively small effect on rate of reinforcement. Due to the design of the schedule, if a subject responded during a stimulus presentation, the response did not produce any delay in the next reinforcement. A second problem with the DRO schedule was that several subjects were responding at very low rates during baseline sessions. A DRO schedule can only be shown to be controlling behavior when it suppresses rate of responding, and such an effect is difficult to demonstrate with subjects who are responding at a very low rate.

Two additional reasons which may account for the failure of the DRO procedure have been suggested by Repp, Deitz, and Deitz (1976). They indicate that in studies where DRO has been unsuccessful, the effectiveness of the reinforcer has not always been clearly established, and the starting time intervals of the DRO schedule have been larger than the average baseline interresponse times. In Experiment 2, the reinforcing value of the stimulus presentation was not clearly established. In addition, the time interval of 5-sec for the DRO schedule was significantly smaller than the average baseline interresponse time for most of the subjects. It is possible that extreme deviations either above or below baseline interresponse times are responsible for ineffective control in a DRO schedule.

In summary, the procedures used in Experiment 2 were successful in conditioning one of the four CRF subjects and were unsuccessful in conditioning any of the DRO subjects.

EXPERIMENT 3

The aim of Experiment 3 was to modify the procedures to bring head turning behavior of the subjects under the control of a CRF schedule of reinforcement. In this experiment, there were three major departures from the procedures of Experiment 2: (a) the most unresponsive subjects were not used, (b) all subjects were exposed to the CRF contingencies only, (c) the composition of the contingent stimulus was varied.

Several subjects in Experiments 1 and 2 appeared to be so unresponsive to sensory stimulation that it was assumed to be fruitless to continue working with them. A sensorimotor test was devised to evaluate the sensory responsiveness of the subjects. Items on the test included visual fixation, visual following, and orienting responses to auditory stimuli. A full description of the test and the test results appears in Appendix B. The test scores were bimodal (see Table 8, Appendix B). Of the ten subjects, four scored between 0 and 3, and six scored between 8 and 14 (maximum possible score 17). The low scoring subjects, Cindy, Lorna, and Geoff from Group CRF and Tim from Group DRO, were eliminated from the experiment. None of these subjects had shown any evidence of conditioning in Experiments 1 and 2.

The DRO schedule was not used in Experiment 3 because of the very low rate of responding of several subjects. A DRO schedule can only be shown to be controlling behavior when it clearly suppresses rate of responding; therefore, there was no point in continuing to use the schedule with subjects responding at low rates. Because subjects from Group DRO in Experiment 2 had no prior experience with the CRF schedule of reinforcement, four extra conditioning sessions were run for these subjects in Experiment 3.

The same CRF conditioning procedures used in Experiment 2 were employed in this experiment, with the exception that the composition of the multi-modal stimulus was varied. The principle variation was to remove the vibration component for a number of sessions. The behavior of Niki in Experiment 2 indicated that the contingent stimulus might be aversive and since vibration was the most novel form of stimulation, it was chosen as the first component for analysis.

Because Experiment 3 was essentially an extension of the CRF procedures of Experiment 2, the reversal data from Experiment 2 was used as the baseline for Experiment 3.

Method

Subjects

Niki and Donna from Group CRF and Mona, Ray, Sheila, and Jean from Group DRO served as subjects in this experiment.

Apparatus

The apparatus was identical to that used in Experiments 1 and 2.

Procedure

The experiment was begun two weeks after the termination of Experiment 2. The basic CRF procedure of Experiment 2 was used for all the subjects. Subjects who were in Group DRO in Experiment 2 received 14 conditioning sessions followed by 3 reversal sessions and subjects from Group CRF received 10 conditioning sessions followed by 4 reversal sessions. The vibration component of the stimulus was withheld for the subjects from Group CRF beginning in Session 1; whereas for subjects from Group DRO, the vibration component was removed after Session 8. In this way, the three dimensional stimulus was presented under CRF contingencies to subjects from

Group DRO for the same number of sessions (eight) as the CRF subjects had received in Experiment 2.

The vibration component was reinstated in Session 5 for Donna as her response rate in the first four sessions had declined from the levels evidenced in Experiment 2 conditioning sessions. During the first three sessions, Niki received 20 physical prompts during the first 5-min of each session. The prompted responses were not included in the data analysis. Because this procedure was not producing any spontaneous responding on the part of Niki, an additional component of the stimulus, music, was removed on Session 3. For the remaining eight sessions, pictures alone served as the reinforcer for this subject.

Results

The data from Experiment 3 was not amenable to statistical analyses as the individual subjects were receiving different treatments, the number of subjects was small, and subjects from Group CRF received fewer sessions than subjects from Group DRO. The mean response rates (r/min) per session were plotted for individual subjects. The mean response rate in the reversal sessions of Experiment 2 is also indicated for each subject, with the exception of Sheila who did not participate in Experiment 2.

Two of the four subjects from Group DRO, Mona and Ray, showed some evidence of conditioning under the CRF contingencies. During the first eight sessions, Mona (see Figure 9) responded at a rate higher than in her Experiment 2 reversal sessions; however, her rate of responding was still very low and only marginally greater than her final reversal rates. Following removal of the vibration component of the stimulus in Session 9, Mona displayed an initial decline in responding in Sessions 9 to 11 followed by a sharp increase in responding in the final sessions; however, the increase is not very reliable in view of Mona's variable rate of responding in Sessions 1 to 8. Ray's rate of responding was highly variable during the first eight sessions but the average response rate was slightly higher than in his Experiment 2 reversal sessions (see Figure 9), and his reversal response rate in Experiment 3 was below the rate displayed during conditioning.

The other two subjects from Group DRO, Jean and Sheila, showed no evidence of an increase in response rate during conditioning. As can be seen in Figure 10, Jean declined in rate from her Experiment 2 reversal

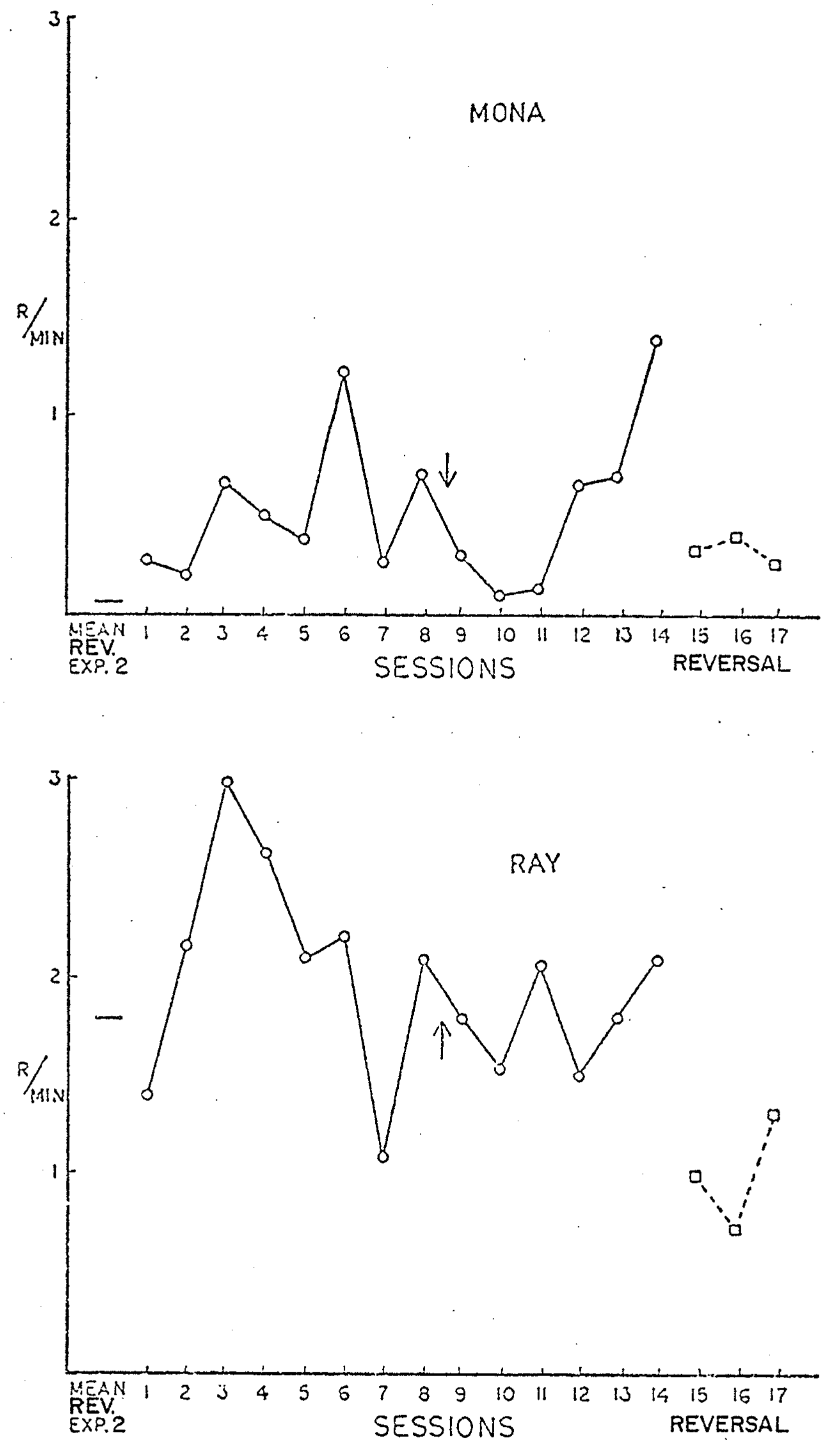

Figure 9. Mean responses per minute during conditioning and reversal for Mona and Ray in Experiment 3. The arrow indicates termination of the use of vibration.

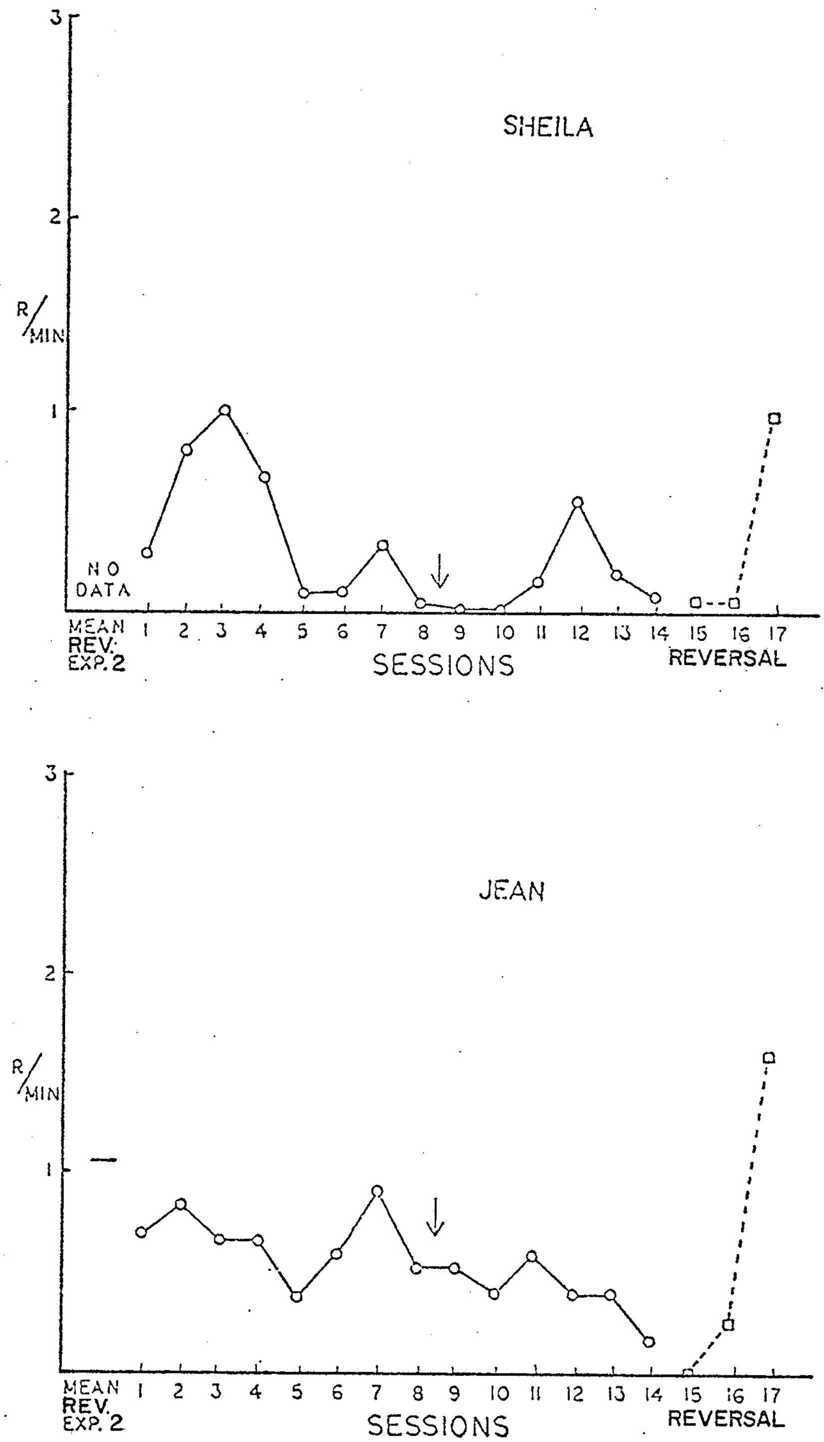

Figure 10. Mean responses per minute during conditioning and reversal for Sheila and Jean in Experiment 3. The arrow indicates termination of the use of vibration.

sessions, and her response rate subsequently rose during reversal. Sheila showed increases in rate of responding across the first three sessions then declined to near zero rates of responding. Sheila was very light (weight 15 kg) and had a small head (diagnosed microcephalic). She was often observed making head turns which failed to operate the microswitches in the head turn apparatus, particularly in the early sessions. These observations may indicate that Sheila was responding to the CRF contingency initially, but that the behavior extinguished due to excessive response cost or too infrequent reinforcement.

The two subjects from Group CRF showed very clear evidence of conditioning. During Sessions 1 to 4 with vibration absent, Donna (see Figure 11) responded at a rate above her previous reversal rate but below the 2.5 r/min rate attained in Experiment 2 when vibration was present. When vibration was reinstated on Session 5, her rate of head turning rose to about 2 r/min. During the four reversal sessions Donna's response rate was initially very low, rose for two sessions, and then declined to near zero.

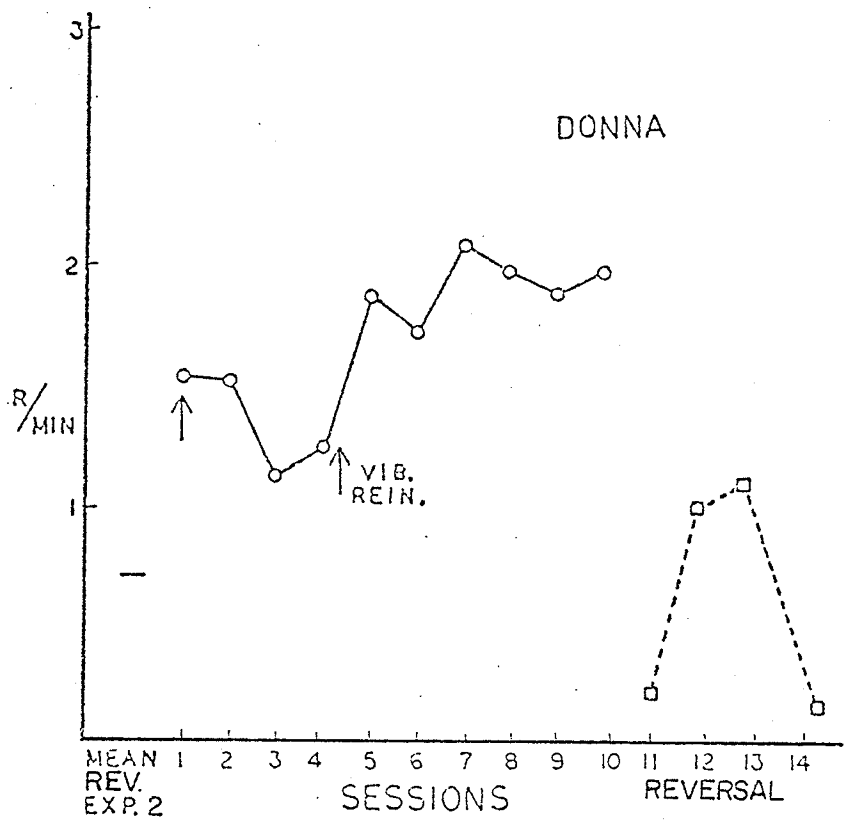

Figure 11. Mean responses per minute during conditioning and reversal for Donna in Experiment 3. The arrow indicates termination of the use of vibration unless otherwise indicated (VIB. REIN. = Vibration Reinstated).

During Sessions 1 (pictures, music, and vibration) and 2 (pictures and music), Niki (see Figure 12) showed no change from her previous low rate of head turning. For Session 3, the music component of the stimulus was also removed. The effect of pictures alone was dramatic; by Session 5, Niki was responding at such a high rate that she appeared exhausted by the end of the session. The slight tapering off in response rate in the last two sessions represented an increase in efficiency in Niki's behavior. While response rate declined, the rate of reinforcement remained almost constant. This was due to the fact that responses emitted during stimulus presentations were not reinforced. Reversal conditions resulted in a return to near zero rates of responding by Session 13.

Discussion

This experiment indicates that for Niki pictures were positive reinforcers, while the combination of pictures, music, and vibration and the combination of pictures and music were not reinforcing. In the case of Donna, the inclusion of vibration did appear to be reinforcing; whereas, the presence or absence of

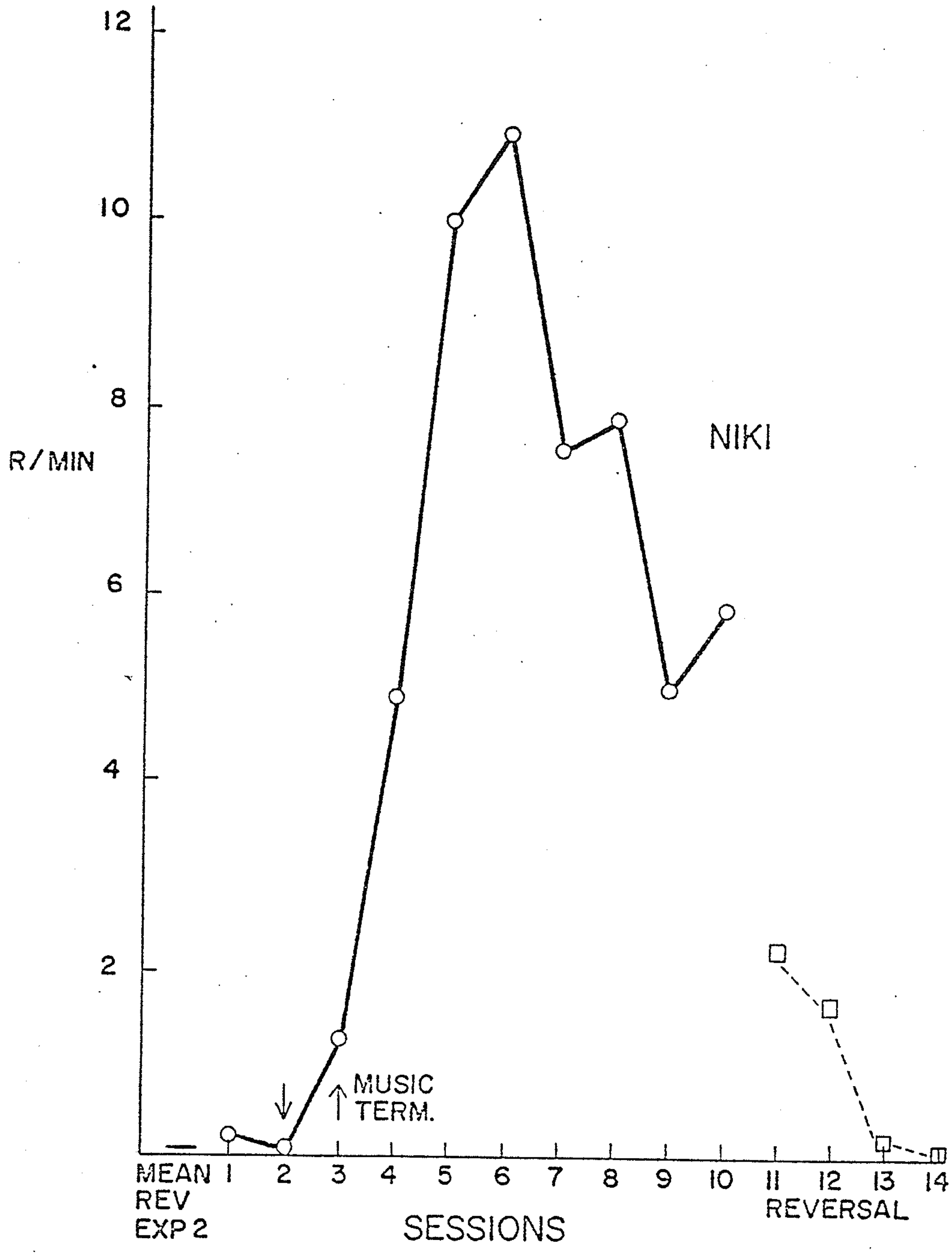

Figure 12. Mean responses per minute during conditioning and reversal for Niki in Experiment 3. The arrow indicates termination of the use of vibration unless otherwise indicated (TERM = terminated).

vibration had little effect on the other subjects, Mona and Ray, had displayed some evidence of conditioning in this experiment.

The findings of reliable conditioning of two CRF subjects and marginal evidence of conditioning of two of the DRO subjects indicate that sensory reinforcement for head turning can be an effective procedure. The lack of substantial changes in head turning in DRO subjects could stem from several causes. DRO subjects were only exposed to two combinations of reinforcement, both of which had failed to produce conditioning in Niki. The increased response rate of Sheila and Jean during the reversal phase may indicate that the combinations used were slightly aversive. In addition, the DRO subjects lacked the previous exposure to CRF contingencies experienced by CRF subjects in Experiments 1 and 2, and it is possible that the effects of the first two experiments may have confounded the results of Experiment 3.

EXPERIMENT 4

The preceding experiments demonstrated that the use of sensory reinforcement for head turning can be an effective procedure for some subjects. The goal of the fourth experiment was to modify the experimental procedures in order to achieve CRF conditioning amongst subjects who failed to condition in Experiment 3. The areas modified in Experiment 4 were: (a) the components of the contingent stimulus; (b) the design of the apparatus; (c) the number of baseline sessions; (d) the use of prompts, and (e) the session length.

The results of Experiment 3 indicated that the content of effective sensory reinforcement is not homogeneous for different subjects. During the conditioning sessions of the fourth study, the three elements of the contingent stimulus were systematically varied in an attempt to find an effective combination for each subject.

The head turn apparatus used in the previous experiments had two serious drawbacks. First, it required a certain amount of force to operate; in the case of at least one subject (Sheila), this force was apparently excessive. Second, the subject's head was not restrained in the apparatus and a few subjects occasionally removed their heads from the apparatus. In this experiment, a new apparatus was employed which required almost no force to operate, which functioned equally well regardless of head size, and from which the subject was unable to remove his or her head. Subjects wore an adjustable cap which transferred rotational movements through a cable to a device which converted rotation into switch closures.

The use of 30-min sessions in Experiment 3 was somewhat excessive as it produced clear signs of fatigue in one subject (Niki). In this experiment, two 15-min sessions were run daily at different times instead of one 30-min session per day.

The numbers of baseline sessions and reversal sessions were increased to eight. This change provided a sufficient number of data points to permit the use of Time-Series Analysis (Glass, Willson & Gottman, 1975), a statistical approach for analyzing changes in level and slope of data collected from single subjects.

Physical prompting was employed systematically thus ensuring that subjects received some experience with each of the various reinforcers.

Nine of the ten subjects employed in Experiment 1 participated in Experiment 4. Each subject was pretested with the author's sensorimotor test. Low scoring subjects who had not participated in Experiment 3 were included in order to examine the validity of the test as a predictor of conditionability.

Method

Subjects

Nine of the ten subjects who served in Experiment 1 were employed in this study. Ray, the subject omitted in Experiment 4, had broken the apparatus on several occasions during the first two baseline sessions. Since no simple means could be found to protect the equipment, it was decided not to include him in the study.

Apparatus

The apparatus used in the sensorimotor test is described in Appendix B. The principle change in the conditioning apparatus was the development of a new head turning measurement device. The new apparatus (see Figure 13) consisted of an adjustable cap which was

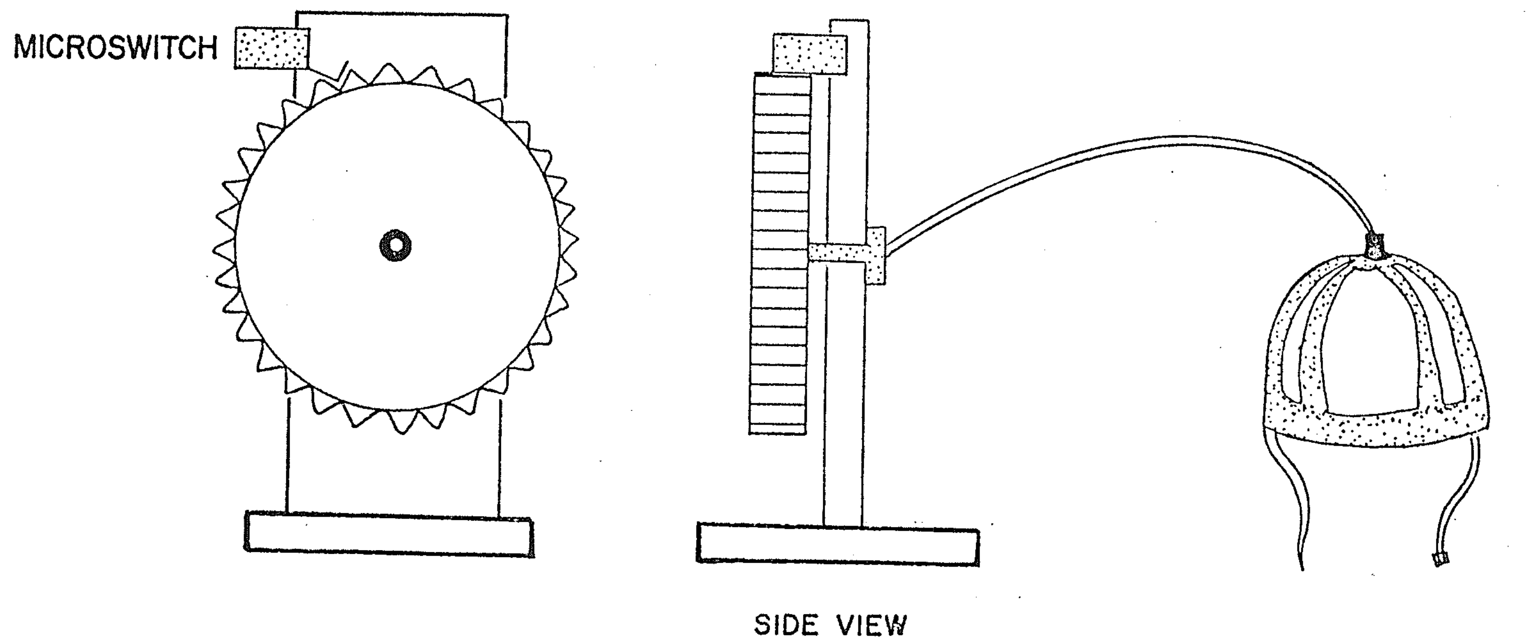

Figure 13. Apparatus employed in Experiment 4 to measure head turning.

connected by means of a cable to a plexiglass gear. When the subject's head rotated, the core of the cable caused the gear to rotate and a microswitch mounted above the gear closed and opened each time a lobe of the gear passed under it. The lobes were eight degrees apart. The microswitch closures operated a predetermining counter set at four, thus a response was defined as four switch closures or 32 degrees of rotation of the gear. An important functional difference between the old and the new apparatus was that with the new apparatus a head turn response did not have to be a discrete movement as was the case with the old apparatus. With the new apparatus, a subject needed only to cumulate four 8-degree movements in either direction. For example, a subject could turn the gear left 16 degrees then right 16 degrees and a response would be scored. Due to this functional difference in the apparatus, the data collected in Experiment 4 is not directly comparable to the data from Experiments 1, 2 and 3. The frequency of head turns in Experiment 4 should be viewed as a relative measure of head turning activity, not as a frequency measure of discrete head rotations.

Procedure

Experiment 4 was begun approximately one year after the completion of Experiment 3. The basic procedure was similar to that of Experiment 3. Each subject received two 15-min sessions a day, one in the morning and one in the afternoon. The number of head turns emitted during each 5-min interval was recorded. There were eight baseline sessions prior to CRF conditioning and eight reversal sessions following conditioning. During the conditioning phase, the various combinations of the three stimulus components of the reinforcer were presented in a systematic fashion. Subjects received a minimum of four sessions with each combination of stimuli until an effective reinforcer was found. The sequence for examining different combinations of stimuli appears in Table 4. If a particular set of stimuli did not result in an increase in rate of head turning within four sessions, the next set of stimuli was introduced. When a subject's response rate, during the four sessions with a particular stimulus combination, showed either a clearly positive slope and/or a clear increase over the previous four sessions, eight additional sessions (criterion sessions) were run with those stimuli to determine if the combination was an effective reinforcer. The reversal sessions began after the last criterion session.

Table 4

Sequence for Testing Combinations of Stimulus Components

ORDER	VIBRATION	MUSIC	PICTURES
1	+	+	+
2	0	+	+
3	0	0	+
4	0	+	0
5	+	0	+
6	+	+	0
7	+	0	0

Note. A "+" indicates the presence of a component whereas a "0" indicates its absence.

There was one exception to the above procedure: Niki started conditioning with pictures only since music and vibration had not been reinforcing in Experiments 2 and 3 while pictures alone had been a very effective reinforcer for Niki.

During the first 5-min of each of the conditioning sessions, except the eight criterion sessions, the experimenter manually rotated the subject's head once in every 20-sec period in which the subject had not responded spontaneously. These prompted responses were not included in the data analysis.

Results

Time-Series Analyses (Glass, Willson & Gottman, 1975) were computed for the data of each subject using the ARIMA (0, 1, 1) model. A description of Time-Series Analysis, the reasons for its use, and the justification of the choice of the ARIMA (0, 1, 1) model are given in Appendix C.

The mean rate of head turning per minute (r/min) was calculated for each subject for each session and the data were then transformed to their natural logarithms. This transformation is recommended for Time-Series Analysis by Bower, Padia, and Glass (Note 3) in cases where data showed large fluctuations. The data for each subject was divided into three series in one of two ways. For those subjects who did not meet the criteria for running the eight additional criterion sessions under any of the stimulus combinations, the three series consisted of the baseline sessions, the conditioning sessions, and the reversal sessions. For the remaining subjects, the first series consisted of baseline sessions plus all conditioning sessions up to the session in which a new stimulus combination was introduced which produced criterion changes in response rate. The second series consisted of all the conditioning sessions involving this stimulus combination, and the reversal sessions formed the third series. Two Time-Series Analyses were computed for each subject; the first analysis compared the first and second series, and the second analysis compared the second and third series. It should be noted that in the case of the data for the six subjects who received the criterion sessions, the division of the data into Series 1 and Series 2 was based on the subjects' change in behavior and not on a pre-determined or randomly determined point of intervention. As a result the first analysis does not meet the standard assumptions for

Time-Series Analysis.

The results of these analyses appear in Table 5. Six of the nine subjects (Donna, Lorna, Mona, Niki, Sheila, and Tim) displayed a change in response rate during conditioning and received the eight criterion sessions. Two subjects (Mona and Niki) showed statisticaly significant changes in the predicted direction for both level and slope in each analysis (Series 1 vs Series 2, Series 2 vs Series 3), and the other four subjects had at least one significant change (slope and/or level) in the predicted direction in each analysis. Amongst the other three subjects only one, Cindy, showed any significant changes. From Series 2 to Series 3, Cindy displayed a positive change in level and a negative change in slope, indicating that response rate rose initially at the beginning of reversal but declined subsequently.

The specific stimulus combinations employed for each subject are listed in Table 6. Of the three stimulus components, pictures were present for all six subjects where conditioning occurred, music was present in four cases, and vibration in three. None of the six subjects who conditioned successfully was exposed to all possible stimulus combinations, and only Lorna was exposed to more

Table 5

Summary of Time-Series Analysis of Individual Subjects in Experiment 4

Subject	Comparison									
	Series 1 vs Series 2					Series 2 vs Series 3				
	t for change in level	Δ	df	*t* for change in slope	Δ	*t* for change in level	Δ	df	*t* for change in slope	Δ
Cindy	.86	+	34	.79	+	*1.94	+	34	**2.62	–
Donna	*1.87	+	16	1.09	+	*2.03	–	16	***8.06	–
Geoff	.44	–	32	1.53	+	.36	–	32	.32	+
Jean	.52	–	32	.10	–	1.38	+	32	1.29	–
Lorna	***5.96	+	32	.82	–	*1.89	–	16	*1.76	–
Mona	**2.33	+	16	***4.57	+	***3.07	–	16	*1.97	–
Niki	***10.29	+	16	**2.19	+	***6.17	–	16	***5.14	–
Sheila	.64	+	20	***3.10	+	.23	+	16	**2.69	–
Tim	1.37	+	20	*1.87	+	*1.76	–	18	**2.60	–

Note. Probability levels are based on 1-tailed values of *t*. Δ indicates the direction of change in level or slope (+ = increase, – = decrease).

* $p < .05$

** $p < .025$

*** $p < .005$

Table 6

Combinations of Stimulus Components

Employed for Each Subject in Experiment 4

SUBJECT	STIMULUS COMBINATIONS
Cindy	VMP, MP, P, M, VP[a] VM, V
Donna	<u>VMP</u>
Geoff	VMP, MP, P, M, VP, VM, V
Jean	VMP, MP, P, M, VP, VM, V
Lorna	VMP, MP, P, M, <u>VP</u>
Mona	<u>VMP</u>
Niki	<u>P</u>
Sheila	VMP, <u>MP</u>
Tim	VMP, <u>MP</u>

Note. Underline indicates a combination resulting in significant changes in rate of head turning. V = vibration, M = music, P = pictures.

[a] Six sessions

than two different combinations.

The mean response rate per minute over sessions for individual subjects are plotted in Figures 14 to 19. Lorna (Figure 14) had a near zero response rate during baseline and the first 16 conditioning sessions. In session 17, the fifth stimulus combination was introduced (vibration and pictures) and Lorna displayed a sudden increase in response rate. Her response rate rose dramatically for two sessions and then declined to an average of about five r/min during the remaining sessions. In reversal her response rate returned to near zero levels.

In Experiment 4, Tim (Figure 15) continued to display the highest variability in response rate of all the subjects. Nonetheless, the combination of music and pictures resulted in an increase in his response rate. In sessions 6 to 16 his response rate was generally very high and showed little overlap with baseline and reversal response rates. Because of Tim's great variablity in response rate during conditioning and reversal two additional reversal sessions were run.

Sheila (Figure 16) displayed a near zero reponse rate during baseline. When the pictures and music combination was introduced during conditioning, her

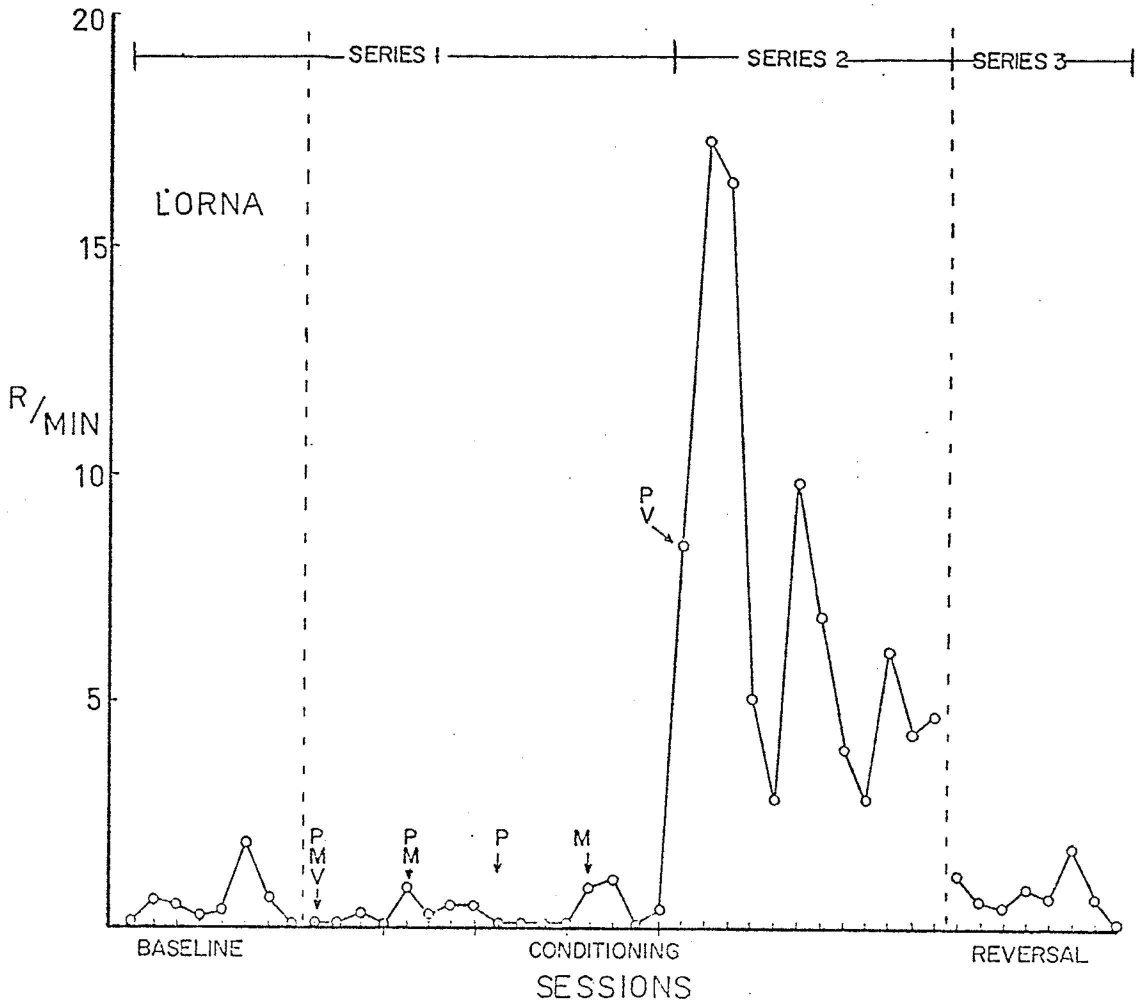

Figure 14. Mean responses per minute for each session with Lorna in Experiment 4. The arrows indicate onset of new stimulus combinations (P = pictures, M = music, V = vibration). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

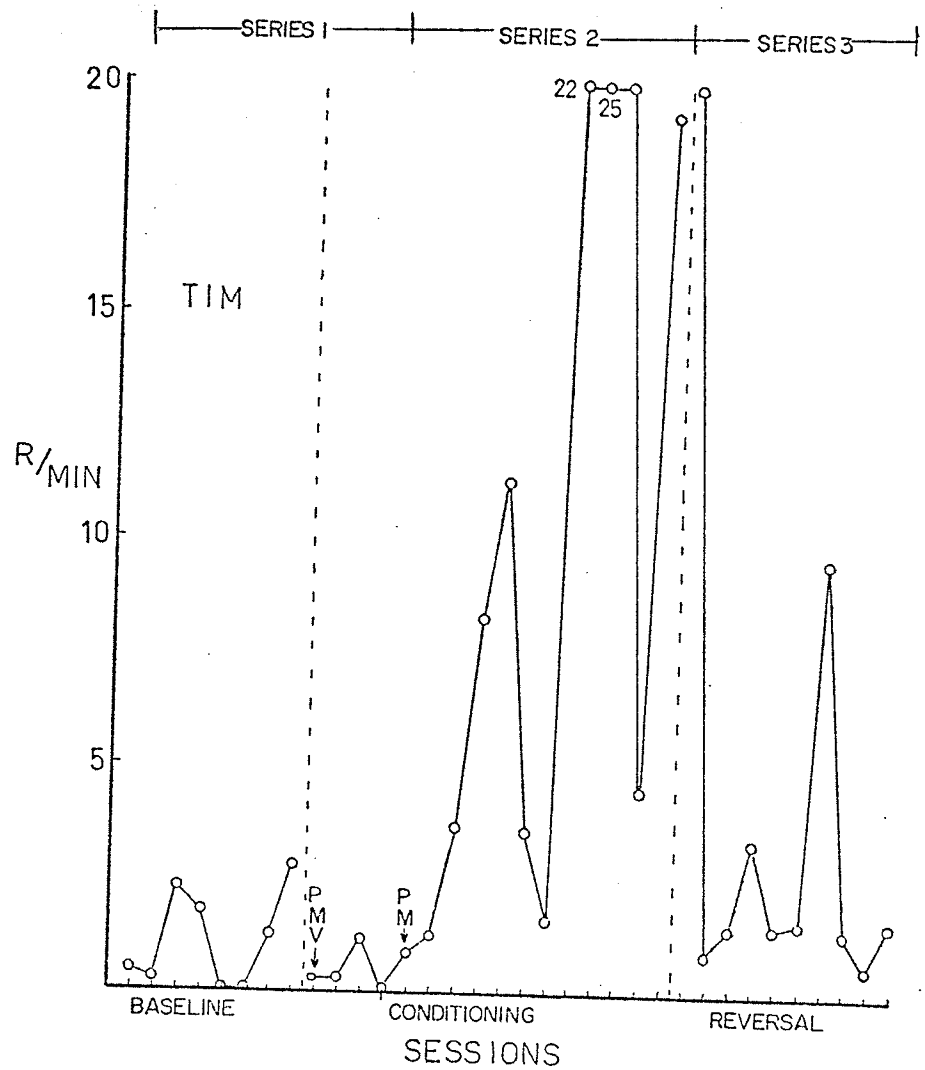

Figure 15. Mean responses per minute for each session with Tim in Experiment 4. The arrows indicate onset of new stimulus combinations: (P = pictures, M = music, V = vibration). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

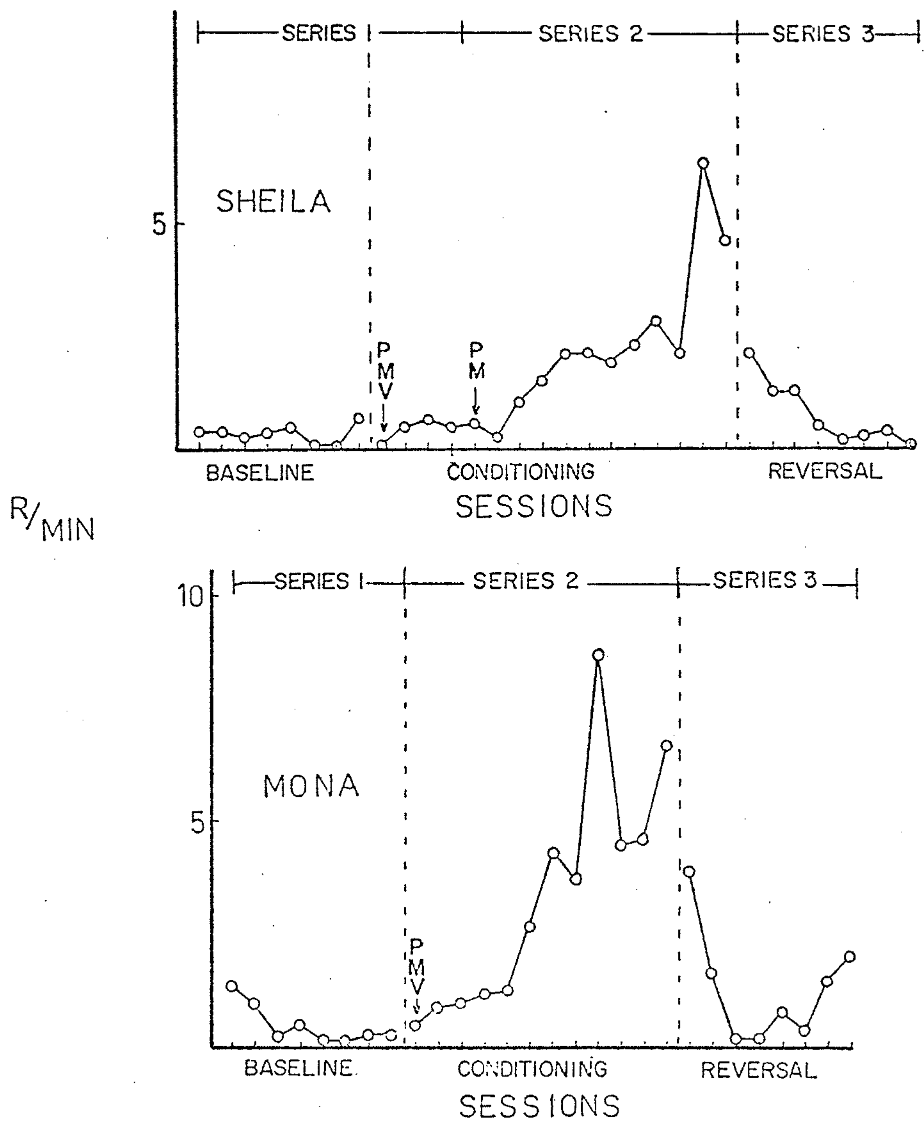

Figure 16. Mean responses per minute for each session with Sheila and Mona in Experiment 4. The arrows indicate onset of new stimulus combinations (P = pictures, M = music, V = vibration). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

response rate gradually increased until the final two conditioning sessions where there was a sharp increase in rate of head turning. During reversal the decline in response rate across sessions was also very gradual, returning to near zero levels by the fourth reversal session.

Mona (Figure 16) responded at near zero rates during baseline. During conditioning, her response rate increased consistently across sessions and then declined sharply during the first two reversal sessions. On the last two reversal sessions there was a slight increase in response rate.

Niki (Figure 17) displayed very high rates of responding during the early baseline sessions and it was suspected that this represented spontaneous recovery of the high rates Niki had displayed in Experiment 3. Four additional baseline sessions were run, and the last seven baseline sessions showed a moderate and stable rate of responding. As soon as contingent pictures were introduced Niki's responding immediately jumped to a high rate and continued to increase across the twelve conditioning and criterion sessions. In reversal her response rate dropped sharply in the first session and continued to decline until it reached baseline rates by

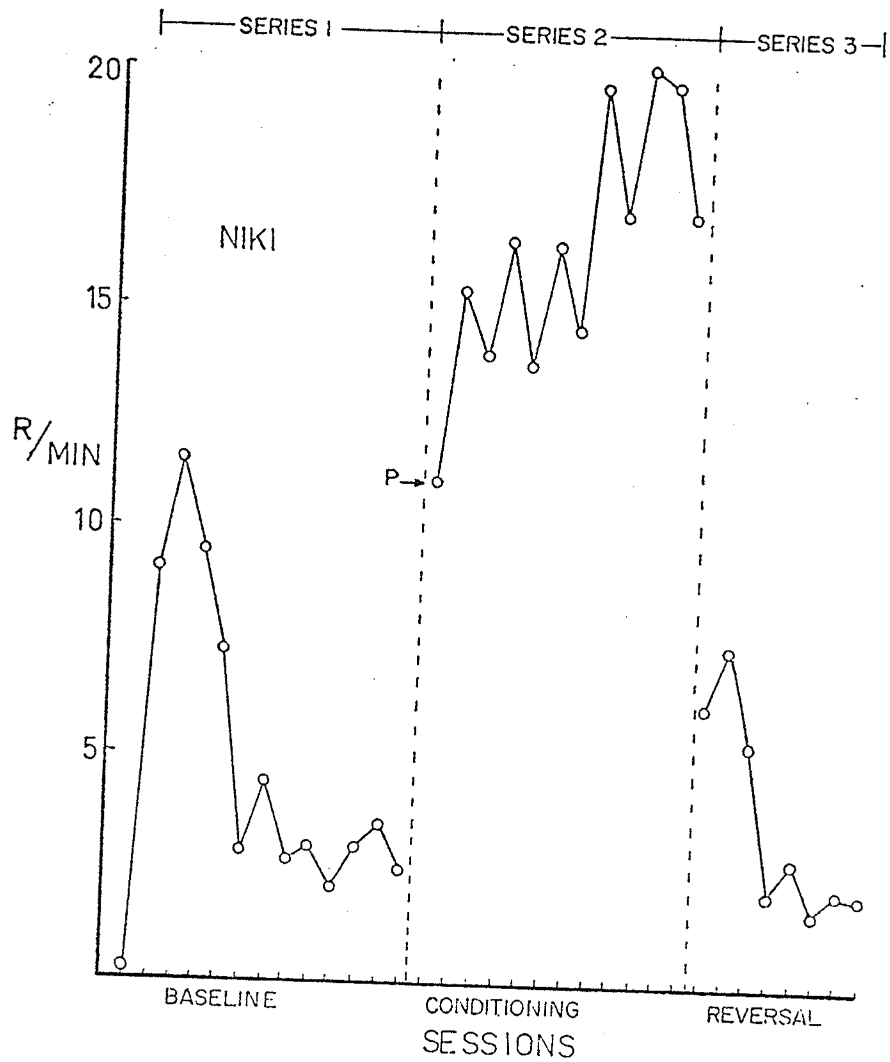

Figure 17. Mean responses per minute for each session with Niki in Experiment 4. The arrow indicates onset of new stimulus combination (P = pictures). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

the fourth reversal session.

Donna's response pattern across sessions (Figure 18) was very similar to the patterns she had displayed in Experiments 2 and 3. From low baseline rates she displayed a very gradual and continuous increase in response rate across the first ten conditioning and criterion sessions. During reversal, her response rate declined gradually across the eight sessions.

Amongst the other three subjects, (Cindy, Geoff and Jean; see Figures 18 and 19), there was no evidence of conditioning. Cindy displayed a marginal increase in responding under the vibration-pictures combination so two additional sessions were run under this combination; however, her response rate fell to near zero in these two sessions. Jean displayed highly variable low rates of responding throughout all of the baseline, conditioning, and reversal sessions. Geoff responded at highly variable rates during baseline, but his response rates were close to zero throughout all of the conditioning and reversal sessions.

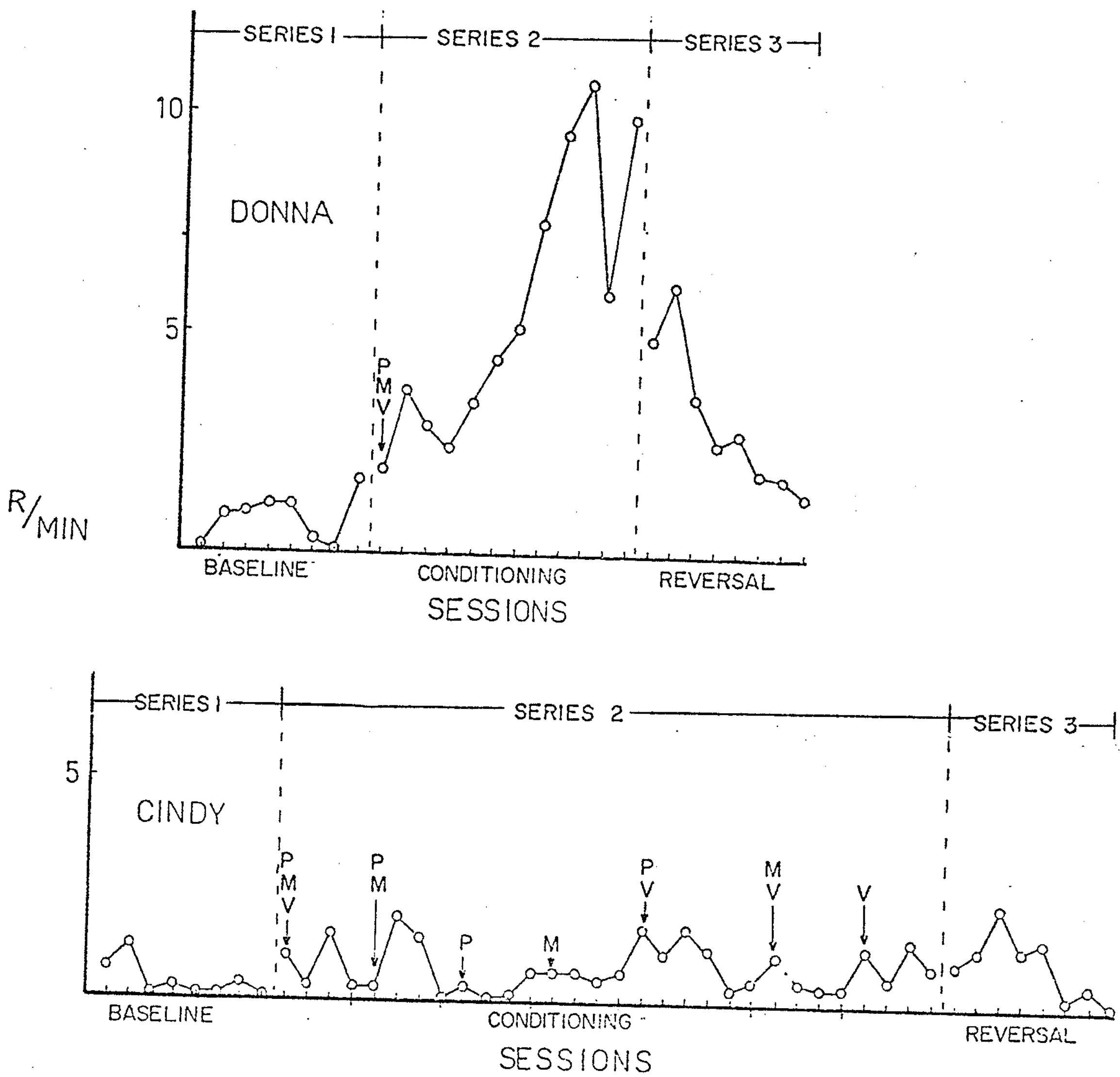

Figure 18. Mean responses per minute for each session with Cindy and Donna in Experiment 4. The arrows indicate onset of new stimulus combinations (P = pictures, M = music, V = vibration). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

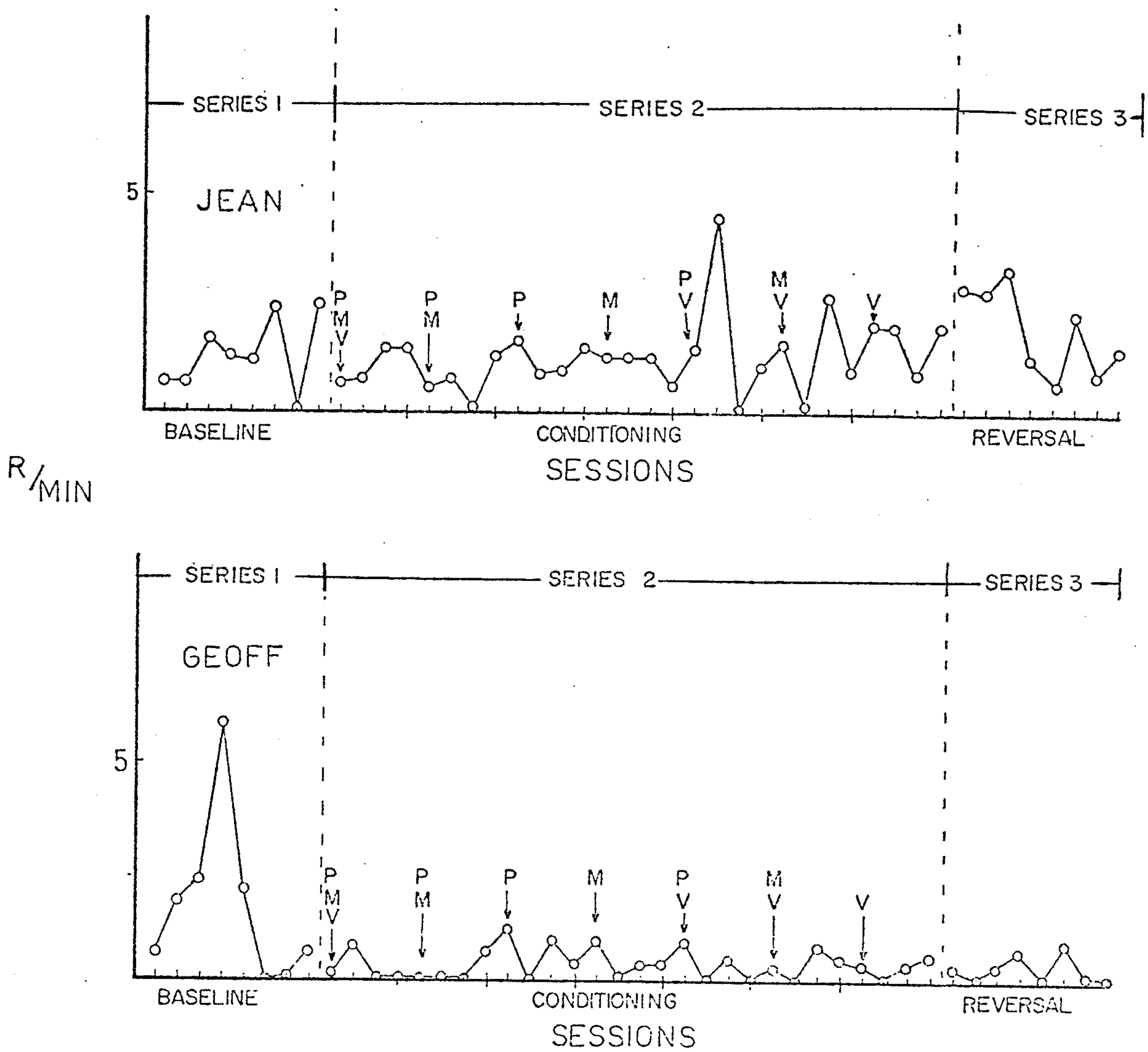

Figure 19. Mean responses per minute for each session with Jean and Geoff in Experiment 4. The arrows indicate onset of new stimulus combinations (P = pictures, M = music, V = vibration). Series 1, 2, 3 indicate the division of data for Time-Series Analysis.

Discussion

The finding of reliable CRF conditioning in six of nine subjects indicates that the procedures employed in this experiment were more effective than those of the previous three experiments. The data do not permit determination of which components of the new procedure were most important in producing the conditioning; however, it is likely that the three principal changes, a low effort response, prompting, and systematic variation of the stimulus components, all contributed to the success of conditioning in one or more subjects.

Examination of the various combinations of stimulus components found to be positively reinforcing with different subjects reveals considerable heterogeneity across subjects. Four different combinations of pictures, music, and vibration (VMP, VP, MP, and P) were required to achieve conditioning amongst six subjects. Pictures were present in all six cases, music in four cases, and vibration in three cases.

This experiment provided an opportunity to measure the usefulness of sensorimotor testing as a predictor of conditionability. In the sensorimotor test (see Appendix B) administered just prior to Experiment 4, three subjects (Donna, Niki and Sheila) received high scores (12 or more out of 17) while the other six subjects received very low scores (5 or less). All three high scoring subjects conditioned reliably in the experiment while of the six low scorers, only three conditioned. This data indicates that sensorimotor test scores may prove to be reliable predictors of conditionability only when test scores are high, while predictability of low scores is at a chance level.

GENERAL DISCUSSION

Summary of the Four Experiments

In Experiment 1, subjects were exposed to four 30-min sessions, each of which contained 10-min of baseline, 10-min of conditioning, and 10-min of extinction. Neither the CRF schedule nor the DRO schedule of reinforcement was effective in controlling the rate of head turning. Higher response rates during conditioning phases were found across both groups as well as an overall decline in response rate across sessions. These two main effects suggest that (a) the multi-modal stimulation either elicited head turns or raised general arousal levels, and (b) the subjects habituated to the experimental situation across sessions.

In the second experiment, there were two 30-min baseline sessions, eight 30-min conditioning sessions and two 30-min extinction sessions. The procedure was essentially the same as in Experiment 1, with the addition of the use of prompts in one session for three of the four CRF subjects. Only one of the four CRF subjects displayed reliable increases in rate of head turning during conditioning. There was no evidence that the DRO schedule controlled response rate for any of the DRO subjects.

In Experiment 3, only six of the original ten subjects were employed. These subjects were chosen on the basis of relatively high scores on the sensorimotor test. All the subjects were exposed to CRF contingencies and the content of the contingent stimulus was varied. The procedure was similar to the procedure in Experiment 2. The two subjects who had previously been in Group CRF showed highly reliable increases in response rate during conditioning. Two of the subjects previously in Group DRO showed marginal evidence of conditioning under CRF while the other two subjects showed no evidence of conditioning.

In the fourth experiment, nine of the original ten subjects were employed. The components of the contingent stimulus were varied systematically, new apparatus was employed, session length was shortened to 15 min, the number of baseline and conditioning sessions was increased, and physical prompts were employed in a systematic manner. Six of the subjects were successfully conditioned in Experiment 4.

Variables Associated with Successful Conditioning

The first instance of successful conditioning occurred in Experiment 2 for one subject, Donna. In this experiment, two changes had been made to the procedure employed in the unsuccessful first experiment: baseline and extinction phases were eliminated during conditioning sessions, and the time per session in the conditioning phase was increased from 10 min to 30 min. The simplification of the session structure, i.e., conditioning only versus baseline, conditioning and extinction, appears to be the critical variable since short conditioning sessions (15 min) later proved effective in Experiment 4.

Donna and one other subject, Niki, were successfully conditioned in Experiment 3. The conditioning of Niki was clearly due to the modification of the contingent stimulation, with pictures alone proving to be a positive reinforcer whereas combinations of pictures with music and vibration were not reinforcers.

In Experiment 4, several additional variables may be related to the conditioning of six of nine subjects. Response effort was lowered, the components of the contingent stimulus were systematically varied, and prompts were employed systematically. In the case of

Mona, the combination of lower response effort and prompting appears to have promoted conditioning since stimulus combinations were not varied. In the case of the three subjects (Lorna, Sheila, and Tim) who conditioned for the first time in Experiment 4, the three experimental variables are confounded; however, it is likely that they all contributed to successful conditioning. The finding that these three subjects conditioned with combinations of stimulus components which they had not previously experienced suggests that the systematic variation of the components of the contingent stimulation was an important contributor to successful training.

In summary, the following factors were associated with successful conditioning: single-treatments within sessions, varying the stimulus composition to isolate an effective reinforcer, low response effort, and prompting.

Subject Variability

The subjects displayed considerable heterogeneity in their behavior supporting Rice's (1968) view that NPMR individuals vary a great deal in such areas as conditionability, reinforcer preference, and day-to-day responsivity. There were considerable differences in the ease with which different subjects could be conditioned. At one extreme, Donna conditioned after a few sessions in Experiment 2, while at the other extreme, Lorna was not conditioned until Experiment 4 after receiving 16 sessions with up to 15 prompts per session. Three subjects were never conditioned.

Some of this variability was likely due to reinforcer preferences which varied considerably. Four different stimulus combinations were required to achieve conditioning amongst six subjects. Pictures were present in the reinforcer for all six subjects who conditioned, music was present for four subjects, and vibration for three subjects. Vibration and music appeared to be aversive to one subject, Niki.

The finding of considerable variability in reinforcer preference is consistent with the results of some other studies. For example, Griffin et al. (1975) found that vibration was an effective positive reinforcer for one subject and a negative reinforcer for another subject. Remington et al. (1977) tested the effectiveness of several types of rhymes and music as potential reinforcers and found that for two subjects nursery rhymes were effective; whereas, for a third subject country blues music proved to be reinforcing. A fourth subject displayed slight response rate changes to all types of music. Rice and McDaniel (1966) found a variety of idiosyncratic reinforcer preferences including one subject who would only respond to one particular Tommy Dorsey record.

The acquisition curves for the subjects took two forms. In the case of three subjects, Donna, Mona, and Sheila, the curves were very gradual with rates of responding increasing steadily across from seven to nine sessions. The extinction curves of these subjects also changed in a gradual fashion, with response rates falling to baseline rates only after several sessions in the reversal condition. The other three subjects, Tim, Lorna, and Niki displayed abrupt, large changes in rate of responding during acquisition. The latter three subjects displayed the highest maximum response rates and great variability in response rate from session to session. These three subjects also displayed an abrupt decline in response rate at the beginning of the reversal phase. There was no evidence of Rice's (1968) finding of "spontaneous extinction" amongst any of the subjects.

It is difficult to compare these findings directly with the results of other studies both because of procedural differences and because other studies have used so few subjects. Nonetheless, examples of both types of acquisition curve can be found in past research. For example, Fuller's (1949) subject increased his response rate gradually across four days, from .67 r/min to 1.67 r/min. By contrast in Bailey and Meyerson's (1969) study, the subject began responding at a high rate (mean=1000r/day) almost immediately upon exposure to the reinforcement contingency.

An examination of the characteristics of the individuals who served in the experiments did not provide a basis for explaining inter-subject variability in terms of subject characteristics. There was no apparent relationship between performance and the type or number of medically diagnosed conditions, or the administration of drugs. There was a marginal relationship between the subjects' sensorimotor test results (see Appendix B) and the results of the conditioning procedures. The three high scoring subjects on the sensorimotor test all conditioned; whereas, of the six low scoring subjects, three conditioned and three did not.

Implications for Research and Treatment of NPMR Individuals

The results of these experiments and those of other researchers indicate that many NPMR individuals are responsive to operant conditioning procedures, but they also indicate that a great deal of flexibility and patience are required for work with this population. There are two predominant factors which may explain the relative difficulty in conditioning NPMR subjects. The first is the severe neurological impairment suffered by these subjects and the second is the impoverished psychological environment in which they live.

The precise relationship between neurological factors and conditioning is still poorly understood and, in any event, largely beyond the control of a psychologist. One might expect a relationship between damage to sensory systems and reinforcer preference. However, the evidence of Friedlander and his colleagues (1974; 1973) that blind severely retarded children find changes in light intensity to be reinforcing, or that deaf children find sound to be reinforcing, indicates that knowledge of sensory system damage is probably of little predictive value in determining potential reinforcers for NPMR subjects.

On the other hand, there is an increasing interest in the relationship between the institutional environment and the behavior of institutionalized individuals. The passivity and unresponsiveness of NPMR subjects is likely due, at least to a large degree, to the severe lack of contingent experiences in the environment, and to the fact that most NPMR individuals have spent much of their lives in such environments.

It has become a well accepted premise in psychology that a lack of adequate and appropriate stimulation during the developing years of a child may be a cause of retarded development (Yarrow, Rubenstein, Pederson, & Jankowski, 1972). Yet, while the training of higher level retardates has certainly improved in recent years, studies suggest that the attention given to the most severely handicapped is still minimal (Repp & Barton, 1980; Whiteley & Dewson, Note 2). Ohwaki and Stayton (1978) found that after controlling for mental age and chronological age, the performance of profoundly retarded individuals on items from the Cattell Infant Intelligence Scale was negatively correlated with length of institutionalization. Ohwaki et al.'s results are quite consistent with those of several similar studies and suggest that the institutional environment is often linked to declining psychological functioning.

One theoretical model of how the institutional environment may cause such declines in functioning has been reviewed by DeVellis (1977). He has pointed out that many of the characteristics of institutionalized people (passivity, submissiveness and learning difficulty) resemble the symptoms of learned helplessness. According to the learned helplessness model, developed by Seligman (1975), when an organism is exposed to many experiences (or a few experiences of sufficient intensity) which are unrelated to the organism's behavior, it will become psychologically "helpless". Seligman hypothesized that noncontingent experiences may produce several deficits in an organism including passivity, i.e., reduction of behavioral initiation, and learning deficits.

In the present studies, many of the subjects did show two of the characteristics of learned helplessness, that is, passivity and slow learning. It has been shown (Whiteley & Dewson, Note 2) that the environment of these subjects is lacking in contingent experiences, and would therefore be conducive to the development of learned helplessness. Seligman, Maier, and Geer (1968) have also found that prompting is the most effective method of overcoming learned helplessness in dogs. Similarly, the most successful conditioning procedures were those employed in Experiment 4 which included systematic prompting of the subjects.

The application of the learned helplessness model to the treatment and study of the NPMR individual suggests that researchers must provide subjects with a great deal of prompting and experience with contingent events. Furthermore, it suggests that institutions should provide contingent experiences to all their residents as a means of arresting and reversing the decline in functioning which typically follows any long period of institutionalization.

The provision of simple manipulanda, such as padded crib levers which produce sensory reinforcement, might greatly improve the well-being of residents. It has already been demonstrated that sensory reinforcement can reduce or eliminate self-injurious behavior (Meyerson et al., 1967) and stereotyped behaviors (Murphy, Nunes, & Hutchings-Ruprecht, 1977) in profoundly retarded residents.

One area of institutional care which would benefit considerably from the introduction of conditioning techniques is physiotherapy. Theoretically, the use of operant conditioning could both counteract the learned helplessness set of the residents and also improve the efficiency and efficacity of physiotherapy programs.

Sensory assessment of NPMR individuals is extremely difficult, and in fact, may often be overlooked for this reason (see Appendix A). Procedures such as those of Macht (1971) or Friedlander and his colleagues (1974; 1973; 1967) should, with suitable modifications for the NPMR population, provide useful tools for sensory assessment. The results of the experiments described in this thesis indicate that in modifying these procedures, the head turning response could be employed with many NPMR individuals.

Future research with NPMR subjects will probably require a more long-term approach than has been the case to date. An example of the value of long-term approaches to conditioning human infants may be found in the work of Sheppard (1969). As researchers turn to the investigation of problems such as discrimination, more complex schedules of reinforcement, and the shaping of more complex behaviors, the long term, single organism research design will likely become increasingly common.

Summary and Conclusions

The subjects who served in these experiments were found to differ considerably, particularly in the areas of reinforcer preference and conditionability. The results of the experiments indicate, above all else, that the operant conditioning of NPMR individuals requires the use of procedures which optimize the probability of bringing the subject's behavior under the control of a reinforcer. The use of a low effort response (head turning), prompting, and the systematic variation of contingent stimulation probably facilitated operant conditioning in Experiment 4, and these variables should receive consideration in future studies with NPMR individuals.

The procedures developed in the fourth experiment suggest that it would be relatively simple and inexpensive to provide NPMR individuals with activities based on the use of sensory reinforcement. The use of such operant procedures may help to offset the effects of the often unstimulating environment in which NPMR individuals live. They may also prove to be useful in the field of physiotherapy by providing a means for motivating subjects to actively participate in their own therapy.

APPENDIX A

Subject Descriptions

The subjects who served in the various phases of this research program were all residents of Parkhaven Ward at the Manitoba School for Retardates, Portage la Prairie, Manitoba. Parkhaven Ward served the most severely handicapped individuals in the adolescent age group. The subjects for this research all came from one section of Parkhaven which cared for patients who were nonambulatory, profoundly retarded, and required total nursing care.

Physical Characteristics

There were three boys and seven girls who were available for research purposes. Their ages ranged from 11 years, 3 months to 29 years, 2 months with a mean age of 15 years, 10 months. The weights of only six subjects were known and they ranged from 14 to 21 kg. These figures provide some indication of the severity of the subjects' physical disabilities when compared with normal mean weights of 32 to 70 kg for individuals in the same age range as these patients. Details of subject characteristics are shown in Table 7.

Table 7

Summary of Subjects' Medical Reports

NAME	SEX	AGE[a]	WEIGHT[b]	DIAGNOSES	MOTOR	SENSORY	MEDICATIONS	PSYCHOLOGICAL
Cindy	F	29:02	20	Encephalopathy Cebebral Palsy	Contracture Deformities (Major Joints)	Maybe Optic atrophy		VSMS[c] 1 mo Unresponsive
Donna	F	13:10		Encephalopathy Spastic Athetoid C.P.	Spastic Quadriplegic	Peripheral Visual Damage	Valium	VSMS 2 mo Responsive
Geoff	M	14:03		Encephalopathy Cerebral Palsy Epileptic Scoliosis	Ataxic Diplegia Can Walk Few Steps When Held		Phenobarb Mysoline Nembutol	Untestable
Jean	F	14:07	20	Microcephaly Cerebral Palsy	Quadriplegic Hypertonic Hypereflexive	Visual Damage		VSMS 3 mo
Lorna	F	16:04		Diffuse cere- bral atrophy Epileptic	Scoliosis, Hip Dislocation	Can see and hear well	Mysoline	Untestable
Mona	F	18:05	21	Encephalopathy (Rubella)	Scoliosis	Left Eye cataract		VSMS < 5 mo

Table 7 (Cont'd)

NAME	SEX	AGE[a]	WEIGHT[b]	DIAGNOSES	MOTOR	SENSORY	MEDICATION	PSYCHOLOGICAL
Niki	F	11:03	21	Microcephaly Epilepsy Cerebral Hypogenesis	Quadriplegic			VSMS 11 mo
Roy	M	23:00		Cerebral Palsy	Athetoid Quadr plegic			VSMS 4 mo
Sheila	F	12:00	14	Microcephaly	Scoliosis Spasticity Dislocation of Right Hip		Valium	VSMS < 3 mo
Tim	M	17:00	15	Microcephaly Epileptic	Quadriplegic	Probably Blind	Dilantin Phenobarb Gravol	Inactive Unresponsive

[a] Age at beginning of experiments in years : months

[b] Weight in kilograms

[c] Vineland Social Maturity Scale

Medical Assessments

As can be seen in Table 7, all of the subjects were diagnosed as suffering from one or more of the major CNS pathologies; the most common diagnoses were encephalopathy, microcephaly, cerebral palsy, and epilepsy. All ten subjects also suffered from severe anatomical and functional abnormalities, including scoliosis, quadriplegia, dislocations, and spasticity. Thorough sensory assessments had not been done on most subjects; however, medical reports suggested that several subjects had some visual impairment and one was probably blind.

Five of the ten subjects received regular medication in the form of Phenobarb (2 subjects), Mysoline (2 subjects), Valium (2 subjects), Dilantin (1 subject), Nembutal (1 subject), or Gravol (1 subject).

Psychological Assessments

The psychological testing of the subjects was limited to the Vineland Social Maturity Scale (VSMS). Nine of the ten subjects were scored in the range untestable to 5 months, and one subject scored 11 months (Niki). All of the subjects were labeled as profoundly retarded. It should be pointed out that the type of psychological testing used for these individuals seems quite inappropriate. Examination of test forms showed that subjects had often been scored for items that were probably beyond their control. For example, scores were given for having a clean face or being dressed properly.

The author's sensorimotor test results appear in Appendix B. The results of these tests correspond to some extent with the VSMS results. For example, Niki scored highest on both the VSMS and the sensorimotor test; whereas, the scores of the three subjects labeled untestable on the VSMS were amongst the four lowest scores on the sensorimotor test. The sensorimotor test results were distinctly bimodal, with three subjects scoring above 12 and the remainder below 5.

Subject Environment

The subjects' environment was almost entirely restricted to two rooms. Typically, subjects spent about twelve hours a day in a crib in a communal bedroom and the remaining twelve hours in a nearby day-room. In the day-room, subjects either lay on mats on the floor or were tied into a wheel chair. All feeding, changing and toileting activities were carried out in the day-room. A few stuffed toys were placed near some residents on the mats. A radio was usually playing in the room.

An ecological study of this environment (Whiteley & Dewson, Note 2) indicated that the level of stimulation was very low outside of feeding and changing times. It was unusual for a subject to be approached by a caretaker, or to receive verbal or tactile stimulation. Similarly, there was very little mutual stimulation amongst the subjects due in part to their lack of mobility. The analysis also showed that there were few contingent relations amongst subject behaviors and environmental events.

A few of the subjects received physiotherapy treatments on a somewhat erratic schedule. Occasionally, during the summer, the subjects were moved to a gazebo outside their ward for a few hours.

Summary

The subjects of this study clearly fall into the lowest categories of human motor and mental development. Although they are quite heterogeneous in terms of the specific deficits they suffer, the subjects all have the three major characteristics which indicate use of the label "nonambulatory profoundly mentally retarded"

(Landesman-Dwyer & Sackett, 1978): (a) they are incapable of moving through space, (b) they are totally lacking in adaptive behavior skills, and (c) they are extremely small for their chronological age.

APPENDIX B

Sensorimotor Test

Several test items were administered to the subjects in an attempt to assess their sensory and sensorimotor abilities. The items were derived from Cattell's (1940) test of infant intelligence and a procedure developed by White, Castle, and Held (1964). They were slightly modified to suit the characteristics of the subjects and their environment.

The tests were administered when the subject was awake, with eyes open, in no obvious state of distress or seizure, and usually about one hour after the morning feeding. The items employed for assessing vision were: (a) fixating an object held over subject's headline (item 1.a); (b) following an object moving across subject's field of vision (item 1.b); (c) following a person (item 1.c). The items employed for assessing audition were: (a) response to a bell (item 2.a); (b) response to experimenter saying subject's name (item 2.b).

Method

Test Materials

There were two items used for testing, a bell and a visual stimulus object. The bell was of the mechanical type used on hotel or shop desks and it produced a single clear tone. The stimulus object was similar to the one described by White et al. (1964). It consisted of a cloth circle with six colored strips of material attached to the circumference. The object was suspended by a string on the end of a 1.3 m wooden rod in order that it could be presented to the subject without he or she seeing the experimenter's arm.

Procedure and Scoring

The test was administered by two experimenters; one acted as an observer while the other administered the test items. The subject was placed in a supine position in a crib with one side covered to prevent the subject seeing the experimenter. After verifying that the subject was awake with eyes open, the experimenter presented the stimulus object attached to the rod by placing it about .6 m directly above the subject's face.

If the subject did not fixate the object immediately, the experimenter jiggled the rod. After 5 sec of fixation, the object was slowly moved first to one side of the subject, then to the other. Four responses were observed and scored separately after the presentation of the stationary stimulus object (item 1.a): fixation of the stimulus for at least 5 sec, reaching, grasping, and changes in activity level. After presentation of the moving stimulus (item 1.b), the subject was scored separately for following the object visually to one side, following visually to the other side, reaching, grasping, and changes in activity level.

Following removal of the visual stimulus, the experimenter rang the bell (item 2.a). The subject was scored separately for turning eyes in the direction of the sound, and changing activity level. The experimenter then said the subject's name and the three responses of turning eyes, head, and changing activity level were noted. In each test, the sound source was located out of the subject's current direction of gaze.

The covering on the side of the crib was then removed, with the experimenter standing at the foot of the crib. The experimenter walked slowly along the crib, looking at the subject (item 1.c), and noted whether or not the subject followed him visually, and exhibited any changes in activity level. If the subject was not looking at the experimenter initially, the experimenter repeated the test starting from a point in the subject's current direction of gaze.

Success was scored 1 and failure 0 on prepared data collection sheets (see sample in Figure 20).

Results

The results of two test administrations appear in Tables 8 and 9 (see Figure 20 for item labels). These tests were given to the same 9 subjects twice with about a one year interval between testings. The correlation between the total scores on test 1 and test 2 was .90 (Pearson *r*).

S: ____________________ Date: ________________________

Time: ________________ Location: ____________________

Test Item

Test Item			SCORE (1 or 0)	COMMENTS
1. a)	i	Fixates		
	ii	Reaches		
	iii	Grasps		
	iv	Activity		
b)	i	Follows to one side		
	ii	Follows to other		
	iii	Reaches		
	iv	Grasps		
	v	Activity		
2. a)	i	Turns eyes		
	ii	Turns head		
	iii	Activity		
b)	i	Turns eyes		
	ii	Turns head		
	iii	Activity		
1. c)	i	Follows visually		
	ii	Activity		

Figure 20. Data collection form used in sensorimotor testing.

Table 8

Sensorimotor Test Scores on First Administration

ITEM	Cindy	Donna	Geoff	Jean	Lorna	Mona	Niki	Sheila	Tim
1. a) i	1	1		1		1	1	1	
ii								1	
iii									
iv									
b) i		1		1		1	1	1	
ii		1		1		1	1	1	
iii							1		
iv							1		
v							1		
2. a) i		1	1	1		1	1	1	
ii		1	1	1		1	1	1	
iii		1				1	1	1	
b) i		1		1		1	1	1	
ii		1		1			1	1	
iii							1	1	
1. c) i		1	1	1		1	1	1	
ii		1							
TOTALS	1	11	3	8	0	8	14	12	0

Table 9

Sensorimotor Test Scores on Second Administration

ITEM	Cindy	Donna	Geoff	Jean	Lorna	Mona	Niki	Sheila	Tim
1. a) i	1	1	1	1	1	1	1	1	
ii		1							
iii									
iv		1							
b) i	1	1		1	1	1	1	1	
ii		1				1	1	1	
iii		1					1		
iv							1		
v		1					1	1	
2. a) i		1			1		1	1	
ii		1						1	
iii		1					1	1	
b) i		1		1			1	1	
ii		1		1			1	1	
iii		1					1	1	
1. c) i		1		1		1	1	1	
ii		1							
TOTALS	2	15	1	5	3	4	15	12	0

APPENDIX C

Time-Series Analysis

In Experiment 4 there was considerable variation in the type of treatment and the number of sessions that different subjects received thus necessitating use of an analysis technique appropriate for single experimental units.

In a review of several proposed techniques for analyzing single organism research, Thoresen and Elashoff (1974) concluded that Time-Series Analysis was the only currently available technique suitable for analyzing repeated measures data on single experimental units. Glass, Willson, and Gottman (1975), whose statistical procedures were employed in analyzing data from this study, came to a similar conclusion in their reviews of the problems inherent in applying ANOVA-type models to single organism data. Jones, Vaught, and Weinrott (1978), in a study of the effects of serial dependency in data on the agreement of visual and statistical inferences concluded that Time-Series Analysis was a far more reliable tool for making inferences than the visual judgements of expert judges, and that Time-Series Analysis should be used as an important adjunct to visual inspection of data.

A time-series (Campbell & Stanley, 1966) is a collection of data points gathered in a periodic fashion from a single organism or group. A time-series experiment is a time-series into which some experimental change has been introduced. Typically, one examines such a time-series to determine if the level and/or slope of the time-series changed as a result of the experimental intervention. This type of design is generally highly resistant to internal sources of invalidity as described in Campbell and Stanley (1966).

The statistical analysis of the time-series data in the present study was based on the Auto-Regressive Integrated Moving Averages Model (ARIMA) of Glass et al. (1975). The analysis involves two phases. In the first phase, the data is analyzed through autocorrelation techniques to determine the most suitable mathematical model to describe the data. Based on this model, a least-squares type of analysis is computed in the second phase to determine if there is a significant change in level and/or slope of the series from pre- to post-intervention. The results are expressed in terms of t-statistics with N-2 degrees of freedom.

In the present study, there was an insufficient number of data points to carry out the model identification phase of the Glass et al. (1975) procedure in a systematic fashion. According to these authors, model identification can only be done in a highly reliable manner when the number of data points in each time-series (either pre- or post-intervention) ranges from 28 to 46 or more, and none of the time-series in Experiment 4 met either this requirement or the minimum requirements of the model identification computer program, CORREL.

Despite the absence of a quantitative model identification procedure, there were good grounds for assuming that the data fit the ARIMA (0,1,1) model. The description of the model given by Glass et al. (1975) is consistent with the types of data often encountered in behavioral studies. There are a number of other reasons for assuming the appropriateness of this model in the present study. Results of a survey of 116 time-series of behavioral and social indices by Glass et al. (1975) indicated that the ARIMA (0,1,1) model was the most common model identified. Gottman and Leiblum (1974) proposed the IMA (1,1) model (Integrated Moving Averages model, identical to ARIMA (0,1,1)), as the principal model to be used in the evaluation of behavioral time-series.

Glass et al. (1975) and Gottman and Leiblum (1974) indicate that this model is appropriate for time-series which contain trends and whose data points are not statistically independent. These two criteria appear to be met by the data in this study. Examination of Figures 14 to 19 indicates clearly the presence of trends in the data. Autocorrelations (lag 1) of the baseline data, the conditioning data, and of the extinction data for all of the subjects indicated that scores were not independent. The autocorrelations of baseline, conditioning, or extinction data from each subject ranged from .35 to .89 with a median of .67 (Pearson *r*).

Perhaps the most important justification for using the Time-Series Analysis despite the lack of a quantitative model identification procedure comes from a recent study by Padia (Note 4). Using Monte Carlo methods, Padia investigated the effects of model misidentification on the Type I error rates of Time-Series Analyses. Incorrect assignments of the values of *p* and *q* in the general ARIMA (*p*,*d*,*q*) model did not result in statistical output deviating materially from output based on the true model identification. The incorrect assignment of the value of *d* was found to have serious effects on error rate; underestimation producing excessively liberal error rates and overestimation producing excessively conservative error rates. In the present study, d can confidently be set at 1, reflecting the linear trends apparent in the data (see Figures 14 to 21).

In summary, the ARIMA (0,1,1) Model is probably very suitable for the data in Experiment 4, and in the worst case would err on the conservative side.

REFERENCE NOTES

1. Whiteley, J.H., & Dewson, M.R.J. Operant Conditioning with Profoundly Retarded, Nonambulatory Children. Paper presented to the American Psychological Association Meetings, Toronto, August, 1978.

2. Whiteley, J.H., & Dewson, M.R.J. An Ecological Study of the Profoundly Retarded, Non-ambulatory Child. Paper presented at the Third Biennial Conference of the International Society for the Study of Behavioural Development, Guildford, England, 1975.

3. Bower, C.P., Padia, W.L., & Glass, G.V. TMS: Two Fortran IV Programs for Analysis of Time-Series Experiments. Unpublished manual, University of Colorado, 1974.

4. Padia, W.L. The consequences of model misidentification in the interrupted time-series experiment. Paper presented to the American Educational Research Association, New York, 1977.

REFERENCES

Bailey, J., & Meyerson, L. Vibration as a reinforcer with a profoundly retarded child. Journal of Applied Behavior Analysis, 1969, 2, 135-137.

Butterfield, E.C. & Siperstein, G.N. Influence of contingent auditory stimulation upon non-nutritional suckle. In J.F. Bosma (Ed.), Oral sensation and perception. Springfield, Ill.: Charles C. Thomas, 1972.

Campbell, D.T., & Stanley, J.C. Experimental and Quasi-Experimental Designs for Research, Chicago: Rand McNally, 1966.

Caron, R.F. Visual reinforcement of head turning in young infants. Journal of Experimental Child Psychology, 1967, 5, 489-511.

Cattell, P. The Measurement of Intelligence of Infants and Young Children. New York: Johnson Reprint Corp., 1940.

Cleland, C.C., & Clark, C.M. Sensory deprivation and aberrant behavior among idiots. American Journal of Mental Deficiency, 1966, 74, 213-225.

DeVellis, R.F. Learned helplessness in institutions. Mental Retardation, 1977, 15, 10-13.

Eimas, P.D., Siqueland, E.R. Jusczyk, P., & Vigorito, J. Speech perception in infants. Science, 1971, 171, 303-306.

Friedlander, B.Z., & Knight, M.S. Brightness sensitivity and preference in deaf-blind retarded children. *American Journal of Mental Deficiency*, 1973, *78*, 323-330.

Friedlander, B., McCarthy, J., & Soforenko, A.Z. Automated psychological evaluation with severely retarded institutionalized infants. *American Journal of Mental Deficiency*, 1967, *71*, 909-919.

Friedlander, B.Z., Silva, D.A., & Knight, M.S. Selective preference for in-focus and out-of-focus visual displays by severely and profoundly retarded multihandicapped blind children. *Exceptional Children*, 1974, *41*, 121-124.

Fuller, P.R. Operant conditioning of a vegetative human organism. *American Journal of Psychology*, 1949, *62*, 587-590.

Glass, G.V., Willson, V.L., & Gottman, J.M. *Design & Analysis of Time-Series Experiments*. Boulder, Colorado: Colorado Assoc. Univ. Press, 1975.

Gottman, J.M., & Leiblum, S.R. *How to do Psychotherapy and How to Evaluate it*. New York: Holt, Rinehart and Winston, 1974.

Griffin, J.C., Patterson, E.T., Locke, B.J., & Landers, W.F. Toward automated physical therapy with the non-ambulatory profoundly retarded via operant conditioning. Behavioral Engineering, 1975, 2, 72-75.

Haskett, J., & Hollar, W.D. Sensory reinforcement and contingency awareness of profoundly retarded children. American Journal of Mental Deficiency, 1978, 83, 60-68.

Hulsebus, R.C. Operant conditioning of infant behavior: A Review. In H.W. Reese (Ed.), Advances in Child Development and Behavior (Vol. 8). New York: Academic Press, 1973.

Jones, R.R., Vaught, R.S., & Weinrott, M. Time-series analysis on operant research. Journal of Applied Behavior Analysis, 1977, 10, 151-166.

Kish, G.B. Studies of sensory reinforcement. In W.K. Honig (Ed.), Operant Behavior: Areas of Research and Application. New York: Appleton-Century-Crofts, 1966.

Lancioni, G.E. Infant conditioning and its implications for early intervention. Psychological Bulletin, 1980, 88, 516-534.

Landesman-Dwyer, S., & Sackett, G.P. Behavioral changes in nonambulatory, profoundly retarded individuals. In C.E. Meyers (Ed.), Quality of Life in Severely and Profoundly Retarded People: Research Foundations for Improvement. Washington, D.C.: American Association on Mental Deficiency Monograph #3, 1978.

Macht, J. Operant measurement of subjective visual acuity in non-verbal children. _Journal of Applied Behavior Analysis_, 1971, _4_, 23-36.

Meyerson, L., Kerr, N., & Michael, J.L. Behavior modification in rehabilitation. In S.W. Bijou & D.M. Baer (Eds.), _Child Development: Readings in Experimental Analysis._ New York: Appleton-Century-Crofts, 1967.

Millar, W.S. Operant acquisition of social behaviors in infancy: Basic problems and constraints. In H.W. Reese (Ed.), _Advances in Child Development and Behavior_ (Vol. 11). New York: Academic Press, 1976.

Murphy, R.J., & Doughty, N.R. Establishment of controlled arm movements in profoundly retarded students using response contingent vibratory stimulation. _American Journal of Mental Deficiency_, 1977, _82_, 212-216.

Murphy, R.J., Nunes, D.L., & Hutchings-Ruprecht, M. Reduction of stereotyped behavior in profoundly retarded individuals. _American Journal of Mental Deficiency_, 1977, _82_, 238-245.

Ohwaki, S., & Stayton, S.E. The relation of length of institutionalization to the intellectual functioning of the profoundly retarded. _Child Development_, 1978, _49_, 105-109.

Piper, T.J., & MacKinnon, R.C. Operant conditioning of a profoundly retarded individual reinforced via a stomach fistula. American Journal of Mental Deficiency, 1969, 73, 627-630.

Remington, R.E., Foxen, T., & Hogg, J. Auditory reinforcement in profoundly retarded multiply handicapped children. American Journal of Mental Deficiency, 1977, 82, 299-304.

Repp, A.C., & Barton, L.E. Naturalistic observations of institutionalized retarded persons: A comparison of licensure decisions and behavioral observations. Journal of Applied Behavior Analysis, 1980, 13, 333-342.

Repp, A.C., Deitz, S.M., & Deitz, D.E.D. Reducing inappropriate behaviors in classrooms and in individual sessions through DRO schedules of reinforcement. Mental Retardation, 1976, 14, 11-15.

Rice, H.K. Operant behavior in vegetative patients III: Methodological considerations. Psychological Record, 1968, 18, 297-302.

Rice, H.K., & McDaniel, M.W. Operant conditioning in vegetative patients. Psychological Record, 1966, 16, 279-281.

Rice, H.K., McDaniel, M.W., Stallings, V.D., & Gatz, M.J. Operant behavior in vegetative patients II. Psychological Record, 1967, 17, 449-460.

Robinson, N.M., & Robinson, H.B. The Mentally Retarded

Child. New York: McGraw-Hill, 1976.

Sameroff, A.J. Learning and adaptation in infancy: A Comparison of models. In H.W. Reese (Ed.), *Advances in Child Development and Behavior* (Vol. 7). New York: Academic Press, 1972. 169-214.

Seligman, M.E.P. *Helplessness: On Depression, Development and Death*. San Francisco: Freeman, 1975.

Seligman, M.E.P., Maier, S.F., & Geer, J.H. Alleviation of learned helplessness in the dog. *Journal of Abnormal Psychology*, 1968, *73*, 256-262.

Sheppard, W.C. Operant control of infant vocal and motor behavior. *Journal of Experimental Child Psychology*, 1969, *7*, 36-51.

Siqueland, E.R., & DeLucia, C.A. Visual reinforcement of non-nutritive sucking in human infants. *Science*, 1969, *165*, 1144-1146.

Stevens, H.A., & Heber, R. *Mental Retardation*. Chicago: University of Chicago Press, 1964.

Thoresen, C.E.,& Elashoff, J.D. An analysis of variance model for intra-subject design: Some additional comments. *Journal of Applied Behavior Analysis*, 1974, *7*, 639-641.

Webb, R.C., & Koller, J.R. Effects of sensorimotor training on intellectual and adaptive skills of profoundly retarded adults. *American Journal of*

Mental Deficiency, 1979, *83*, 490-496.

Weisberg, P. Operant procedures with retardates: An overview of laboratory research. In N.R. Ellis (Ed.), *International Review of Research in Mental Retardation* (Vol. 5). New York: Academic Press, 1971.

White, B.L., Castle, P., & Held, R. Observations on the development of visually directed reaching. *Child Development*, 1964, *35*, 349-364.

Yarrow, L.J., Rubenstein, J.L., Pedersen, F.A., & Jankowski, J.J. Dimensions of early stimulation and their differential effects on infant development. *Merrill-Palmer Quarterly*, 1972, *18*, 205-218.