OPERANT TREATMENT OF OROFACIAL DYSFUNCTION IN NEUROMUSCULAR DISORDERS

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The popularity and reported success of biofeedback treatment for neuromuscular disorders has occurred despite a lack of research identifying the critical variables responsible for therapeutic gain. In this study, we assessed the degree to which severe neurological dysfunction could be improved by using one of the components present in all biofeedback treatment, contingency management. Three cases of orofacial dysfunction were treated by reinforcing specific improvements reliably detectable without the use of biofeedback equipment. The results showed that contingency management procedures alone were sufficient to improve overt motor responses but, unlike biofeedback treatment, did not produce decreases in the hypertonic muscle groups associated with the trained motor behavior. The findings suggest that sophisticated, expensive biofeedback equipment may not be necessary in treating some neuromuscular disorders and that important clinical gains may be achieved by redesigning the patient's daily environment to be contingently therapeutic, rather than only accommodating the disabilities of the physically handicapped.

DESCRIPTORS: neuromuscular disorders, orofacial dysfunction, behavioral medicine, electromyography, rehabilitation medicine, contingency management

Neuromuscular disorders include a wide variety of progressive and nonprogressive conditions with differing symptomatology, prognoses, and etiologies. The common feature of each of these disorders is reduced function and aberrant movement or posturing due to upper motor neuron, lower motor neuron, or muscular impairment.

Therapeutic modalities for neuromuscular disorders have included physical therapy, pharmaco-

logical interventions, and neurosurgical procedures. Physical therapies utilize a variety of motor training and learning models in an attempt to teach patients to achieve maximum function with whatever central nervous system (CNS) motor control the particular disorders will allow (Bobath & Bobath, 1972; Potter & Harryman, 1973). Pharmacological treatments attempt to rectify presumed CNS biochemical abnormalities (Calne, 1975; Fahn, 1976; Yahr & Duvoisin, 1968). Neurosurgical procedures attempt to lesion or block neuronal impulses from CNS areas producing abnormal activity in motor systems (Cooper, 1961, 1969; Gornall, Hitchcock, & Kirkland, 1975), or to stimulate the cerebellum, effectively blocking abnormal motor activity from reaching motor cortex (Cooper, Amin, Riklan, Walz, & Poon, 1976; Penn & Etzel, 1977; Upton & Cooper, 1976). In spite of increasing understanding of movement disorders and reported improvements in all therapeutic modalities, the benefits of these treatments continue to be controversial, largely because the

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literature lacks documentation of the biological mechanisms for specific neuromuscular disorders and because of the lack of well-designed research studies on treatment effects.

Within the past 10 years, electromyographic (EMG) feedback has been developed and frequently used as an alternative or adjunctive therapy for neuromuscular disorders (Basmajian, Gowland, Brandstater, Swanson, & Trotter, 1982; Bird & Cataldo, 1978; Brudny *et al.*, 1976; Cataldo, Bird, & Cunningham, 1978; Finley, Niman, Standley, & Ender, 1976; Inman, 1979; Martin, 1981; Ortega, 1978; Prevo, Visser, & Vogelaar, 1982; Wolf, Baker, & Kelly, 1980; Wolf & Binder-MacLeod, 1983). Operant conditioning procedures not using biofeedback equipment, although frequently applied to other problems, have not often been used to improve motor control of the physically handicapped, despite reports in the literature of a few successfully treated cases (Ball, McCrady, & Hart, 1975; Block, 1978; Garber, 1971; Martin & Sachs, 1973; Sachs & Mayhall, 1971; Thompson, Iwata, & Poynter, 1979). The final goal of both EMG feedback and operant conditioning alone is to improve motor skills. However, the procedures used and the type of response selected for training differ. Biofeedback provides patients with information representative of *muscle activity* in an effort to teach improved motor control. For example, it is generally assumed that feedback-assisted relaxation, in the hypertonic patient, will facilitate more adequate functional responses. Whereas, operant conditioning procedures without feedback equipment typically reinforce an observable *motor response* without directly training muscle control.

Results of biofeedback training have shown changes in the targeted EMG response that generalize to untrained motor skills (e.g., gait, grasp-release, feeding). Operant conditioning studies have shown rapid acquisition of a trained motor skill with unknown effects at the muscle site, because collateral changes in muscular responses have never been measured.

Examination of neuromuscular disorders within an operant paradigm is important for at least two reasons. First, traditional physical therapies as well

as EMG feedback commonly use operant conditioning principles in their treatments but rarely study their effects in isolation of other components. Indeed, although not developed from extensive basic research studies, biofeedback techniques can best be explained as a form of operant conditioning using equipment to provide immediate and precise information about the target response. Thus, biofeedback can best be conceptualized, not as dichotomous to operant conditioning, but as part of a continuum of operant techniques. Such a continuum ranges from procedures using precise information about very specific biological functioning in combination with differential reinforcement (biofeedback) to procedures that only differentially manage environmental consequences contingent on more gross performance outcomes (contingency management). Studies that elucidate this continuum from simple contingency management to sophisticated biofeedback will aid in their differential use and more successful application. The second reason for studying neuromuscular disorders within an operant analysis is that neuromuscular disorders are characterized as "involuntary" by neurologists (Lemieux, Wright, & Swaiman, 1982) and therefore often assumed to be unaffected by environmental consequences contingent on motor activity. Investigations that demonstrate the functional relationship between consequences and behavior (in this case behavior affected by neurological disorder) can contribute to a better understanding of neurological dysfunction, and ultimately alter treatment approaches for patients with neuromuscular disorders.

This study was conducted to determine whether behaviors secondary to severe neuromuscular disorders would be responsive to environmental contingencies. Contingency management procedures were used with three patients having different orofacial disorders. Treatment procedures in all three cases were assessed within a multiple-baseline design across stimulus conditions. An EMG measure of muscle activity was monitored in two patients to determine whether successful operant conditioning of a motor response would change the general levels of hypertonic muscle activity.

CASE 1

METHOD

Case 1 represents a severe type of orofacial dysfunction characterized by extremely high muscle tone. This patient was initially trained in a laboratory setting to ensure greater control of the environmental stimuli. To assess for stimulus generalization, measures were obtained in a setting in which no training occurred. Additionally, EMG recordings were obtained from the masseter muscle group simultaneously with performance data to determine whether changes in facial behavior were correlated with decreases in electrical activity of these facial muscles.

Patient and Setting

All participants were inpatients from The John F. Kennedy Institute. Rae was a 24-year-old female of normal intelligence diagnosed as having a severe neurological deficit secondary to cardiorespiratory arrest. The arrest had occurred 5 years prior to this hospital admission. Her disorder was characterized by asymmetric spastic quadriplegia and expressive aphasia. Rae was referred for treatment of frequent jaw dislocations, which occurred following rapid and forceful opening of the mouth. Possible risks of continued jaw dislocations were documented to be permanent bone damage of the jaw and arthritis.

Previous treatments included diazepam. Rae was maintained on a constant dosage of this medication throughout the study. The study was conducted in the electromyography laboratory, in a busy hospital lobby, and in Rae's bedroom, which was shared by three other patients and was located on the general inpatient unit.

Apparatus

Electromyographic recordings were obtained from Beckman silver-silver chloride miniature disk electrodes. Raw EMG activity was amplified by two Biofeedback Systems, Inc. (BSI), model PA-2M preamplifiers with low and high pass filters set at 10 and 1,000 Hz, respectively, and a gain setting at 1,000. Preamplifiers were each interfaced with a BSI Model B-1 integrator, which converted

analogue EMG to digital pulses. An Intel 80/10 microcomputer counted pulses and produced printouts on a Decwriter II printer of cumulative EMG pulses for each 20-s period.

Conventional electromechanical programming equipment was used to deliver reinforcers to the patient in the form of light flashes in the lab and lobby settings. A panel of red lights was placed 1.6 m from the patient at approximately eye level. The observer used a hand held microswitch to activate delivery of reinforcers. The number of delivered reinforcers cumulated on a standard electromechanical counter, which was located in the observation room, out of the patient's view.

Recording and Reliability

Target behavior. Jaw dislocations were defined as mouth openings accompanied by a visible rapid movement at the temporomandibular joint.

Observations. An observer recorded the occurrence of jaw dislocations using a 20-s whole interval coding procedure. Occurrence or nonoccurrence was recorded for 10 consecutive intervals for each baseline and reinforcement session.

Reliability procedures. Reliability checks were made during 32% of the total sessions with a range of 1 to 12 checks per experimental condition. Interobserver agreement was calculated using occurrence and nonoccurrence intervals. Agreements were divided by agreements plus disagreements and multiplied by 100. The mean reliability for jaw dislocation was 92% with a range of 89% to 100% across experimental conditions.

EMG measure. An EMG measure of right masseter activity was obtained throughout the study. The skin was prepared with alcohol and Brasisol skin cleanser. Surface electrodes were filled with Beckman conductive paste and attached with adhesive electrode collars. Two active electrodes, separated by a grounded reference, were placed 13 mm apart over the masseter muscle group. The cumulative EMG activity in microvolts per 20-s observation period was obtained for 10 consecutive intervals. EMG values obtained for each block of 10 intervals were averaged to produce a mean EMG value per session.

Experimental Design

A multiple-baseline across two settings was used in combination with the subsequent implementation of a time-out procedure across both settings. Data were recorded in a third setting to assess for generalization.

Procedures

Sessions were conducted daily, 5 days a week. During each session, Rae was observed in the lab setting. Observational probes were conducted in the lobby every 3 to 4 days and in the bedroom every 6 to 7 days. In the lab setting, Rae was observed while seated in front of a two-way mirror through which observers could view her behavior. In the lobby and bedroom settings, observers were in the same room as the patient. The study lasted a total of 86 sessions over a period of 9 weeks.

Baseline. During baseline the patient was instructed to keep her mouth closed to prevent jaw dislocations. One prompt occurred at the beginning of each session. This instruction was included in baseline to ensure that the problem of jaw control could not be resolved by a simple prompt. The staff did not reprimand or otherwise attend to jaw dislocations. Twelve baseline sessions were conducted in the lab, 12 in the lobby, and 10 in the bedroom. Instruction to the patient to close her mouth was extended to all sessions in all experimental settings.

Reinforcement of mouth closure. Training of mouth closure consisted of rewarding the patient with a light flash and praise for increasing lengths of mouth closure. Reinforcement initially occurred following 5 s of mouth closure, after which the interval for reinforcement was extended to 10 and then to 15 s. The criterion for lengthening the interval was 4 consecutive sessions in which the patient earned at least 80% of the possible reinforcers. Rae was alone throughout this condition. An observer viewed the patient through a two-way mirror and delivered light flashes by closing a microswitch contingent on mouth closure for the duration of the interval. The interval was reinitiated following jaw dislocation. Because these cases were designed to maximize experimental control in con-

trast with applied technique, reinforcement was delivered electromechanically in all training environments to standardize the procedure. Criterion mouth closures were praised at the end of each session. A large graph was posted in the lab, and the percentage of reinforcers earned per session for mouth closure was plotted, allowing the patient to monitor her progress. This reinforcement procedure was chosen because the individual was a young adult for whom clinical improvement appeared to be very important. The percentage of reinforcers earned per session was calculated by dividing the number of reinforcers earned by the number of reinforcement opportunities.

Following 29 training sessions in the lab, training began in the lobby. In this setting, one or two observers were present throughout training. The reinforcement procedures were identical to those in the lab. Reinforcement was contingent on 5 and then 10 s of mouth closure. No reinforcement procedure was implemented in the bedroom setting.

Reinforcement of mouth closure plus time-out. Following 42 training sessions in the lab and 19 sessions in the lobby, a 5-s time-out procedure was added in an attempt to decrease jaw dislocations. Every jaw dislocation resulted in a time-out period, during which time the reinitiation of the specified interval of mouth closure was unavailable for 5 s (no differential consequences occurred for any of the individual's behavior). This procedure was implemented because observation of the behavior indicated that jaw dislocations were primarily occurring within 5 s following reinforcement.

RESULTS AND DISCUSSION

Figure 1 shows the occurrence of jaw dislocation for the lab, lobby, and bedroom settings. During baseline, the mean number of intervals of jaw dislocations observed in the lab was 38% and 49% in the lobby. Introduction of reinforcement procedures in the lab substantially reduced jaw dislocations ($M = 15\%$). Subsequent introduction of the same reinforcement procedure in the lobby also resulted in a decrease from a mean of 55% during baseline to a mean of 35% during reinforcement. Following the introduction of the time-out proce-

Figure 1. Percent occurrence of jaw dislocations observed in the EMG lab, the hospital lobby and the patient's bedroom during baseline and reinforcement conditions for Case 1.

Figure 2. Right masseter EMG (microvolts) activity obtained in the EMG lab during baseline and reinforcement conditions for Case 1. Instructions and reinforcement of mouth closure began on sessions 13 and 44 in the lab and lobby settings, respectively. Instructions and reinforcement and time-out were initiated during session 67 simultaneously for lab and lobby settings.

ture, near zero levels of dislocations were observed in the lab and lobby. There was a gradual decrease in jaw dislocations measured in the bedroom; however, jaw dislocations were still occurring during 20% of the observed intervals during the last two treatment sessions. Reinforcement procedures were not introduced in the bedroom setting due to an early hospital discharge.

Figure 2 displays the mean EMG activity in microvolts obtained in the lab from the right masseter muscle group. No consistent EMG changes were noted across baseline and treatment conditions. These data suggest that the decrease in jaw dislocations was not achieved by muscular relaxation of the jaw.

Results of this case demonstrate control over an orofacial neuromuscular response using an operant conditioning intervention. Unfortunately, the experimental design was not adequate to assess the functional relationship between the initiation of the time-out procedure and the observed decrease in

jaw dislocations. Results of Case 1 suggest that the treatment effects may be specific to the training setting and to the trained response. A decrease in the EMG measure was not observed throughout training for this patient. Additional experimental controls were used in Case 2 to correct some of the design problems noted in Case 1. All training for Case 2 was conducted in the lab setting to ensure environmental control. The manipulated stimulus dimension was the presence or absence of specific people in the training environment. Blind reliability checks were included to assess observer drift, and the patient's hospital stay was extended to allow for the completion of the multiple-baseline design.

CASE 2

Patient and Setting

Sheryl was a 26-year-old female with an IQ of 56. She was diagnosed as having congenital spastic

quadriplegia with dystonic posturing. Sheryl was aphonic but compliance to requests indicated good receptive language. She had a history of jaw hyperextension manifested by an open mouth posture. Previous unsuccessful pharmacological treatments for the jaw hypertonicity included haloperidol, dantrolene, carbamazepine and trihexyphenidyl. Sheryl was maintained on 60 mg/day of diazepam throughout the course of the study.

Experimental sessions took place in a sound-attenuated room in The John F. Kennedy Institute. The patient was seated in a lounge chair facing a two-way mirror, through which observations were made.

Apparatus

Apparatus was identical to that used for Case 1.

Recording and Reliability

Target behaviors. Two types of mouth closure were selected for measurement. Inappropriate mouth closure was defined as the visible contact of the upper and lower teeth with the tongue. This type of mouth closure was inappropriate because it did not permit chewing. Appropriate mouth closure was defined as any contact of upper and lower teeth. This type of closure was considered a more functional and socially appropriate response.

Observation. An observer recorded the occurrence of inappropriate and appropriate mouth closure using a 20-s whole interval coding procedure. Occurrence of each response was recorded for 10 consecutive intervals for each baseline and training session.

Reliability procedures. Interobserver reliability was obtained by comparing the independent records of two observers; on some occasions one of the observers was blind as to the experimental conditions. Observers designated as blind to experimental procedures were unfamiliar with the patients and unaware of the experimental conditions and general design of the study. Reliability checks were made during 52% of the total sessions with a range of 3 to 23 checks per experimental condition. Blind observers were not available during baseline for the alone condition nor during treat-

ment for the mother present condition. Blind observations were made during at least 10% of all observations taken in the other experimental conditions. Interobserver agreement was calculated using occurrence and non-occurrence intervals. Agreements were divided by agreements plus disagreements and multiplied by 100. Mean reliability for appropriate mouth closure ranged from 68% to 100% per condition for all observations. The total mean reliability for all observations for appropriate mouth closure was 91%.

Reliability of appropriate mouth closure data taken during the treatment phase of the therapist present condition was considerably lower than during other phases of this study. This may have been due to the fact that the patient reoriented her head and body position in the presence of the therapist and thereby changed the angle of the observer's view of her mouth. Mean reliability for inappropriate mouth closure ranged from 96% to 100% for blind observations and from 90% to 100% per condition for all other observations with a total mean reliability of 96%.

EMG measure. An EMG measure of right masseter activity was obtained throughout the study. Procedures for skin preparation, electrode application, and EMG data summarization were identical to those described for Case 1.

Experimental Design

A multiple-baseline design across stimulus conditions was used (Baer, Wolf, & Risley, 1968). Reinforcement of 5 and then 10 consecutive seconds of appropriate mouth closure was initiated in the alone condition only. Reinforcement of 20 consecutive seconds of appropriate mouth closure was then implemented sequentially across all three stimulus conditions.

Procedures

Sessions were conducted daily, 5 days a week. During each session, Sheryl was observed in each stimulus setting: alone, with therapist present, and with mother present. Sessions were 28.6 min in length and divided into five trials. Each trial consisted of (a) a 200-s data collection period or a

Figure 3. Percent occurrence of appropriate and inappropriate mouth closures obtained across alone, therapist present, and mother present conditions for Case 2.

data collection *and* training period, and (b) a subsequent 180-s rest period. Initially, three trials were in the alone setting, and one trial was in each of the other two settings. Each trial is represented as a point on Figure 3. When appropriate mouth closure was established, the number of trials in that setting was decreased to one; and three trials using contingency procedures were begun in the next setting. Reinforcement contingencies during the 200-s training periods were based on the patient's performance during either 5-, 10-, or 20-s intervals, thus establishing 40, 20, or 10 occasions for reinforcement, respectively, during each of those periods. When Sheryl was in the alone condition, she was seated in a chair facing a two-way mirror in

the training room. During the therapist present and mother present conditions, the therapist or mother entered the training room and sat in a chair approximately 3 ft from Sheryl. During all conditions, the patient was asked to keep her mouth closed with her lower teeth touching her upper teeth. No further verbal interaction occurred during the observation. The study lasted a total of 36 sessions over a period of 6 weeks.

Baseline. Five baseline sessions were conducted prior to intervention in the alone condition.

Reinforcement of appropriate mouth closure. Following collection of baseline data, Sheryl was reinforced for each 5-s interval of appropriate mouth closure in the alone condition. Reinforce-

ment consisted of a light flash. The number of light flashes was cumulated on a electromechanical counter located in the observation room, providing a total point count for each session. This procedure was followed for 12 sessions. For the next three sessions, the required response duration for the delivery of reinforcement was increased to 10 s. Reinforcement for 20-s appropriate mouth closure was then sequentially implemented across alone, therapist present, and mother present conditions. Reinforcement was delivered by a staff member who was located in a room adjacent to the patient's room and viewed her performance through a two-way mirror. Point counts were exchangeable at the end of each session for social events with staff, trips to the gift store, or money.

RESULTS AND DISCUSSION

The percentage of intervals of appropriate and inappropriate mouth closure across the alone, therapist present, and mother present conditions is presented in Figure 3. During baseline sessions for the alone condition, inappropriate mouth closure occurred in 50% to 100% of the intervals and appropriate mouth closures never occurred. Following the initiation of reinforcement in the alone condition, inappropriate mouth closures occurred at near zero levels and appropriate closures increased. Appropriate responding continued as the criterion for reinforcement was lengthened to 10 s and then to 20 s. Appropriate mouth closures increased and inappropriate mouth closures decreased with the sequential implementation of reinforcement in the therapist present and mother present conditions. The initiation of reinforcement in the mother present condition produced an immediate increase in appropriate mouth closure from zero to 100% and an immediate decrease in inappropriate mouth closure from 80% to zero. Following intervention, occurrence of appropriate mouth closure was more variable in the therapist present and mother present conditions than in the alone condition.

Right masseter EMG (microvolts) data obtained in sessions in the alone, therapist present, and mother present conditions are presented in

Figure 4. EMG activity was noted to be highest toward the end of the alone condition, whereas an increase in EMG was observed in the therapist present and mother present conditions following the introduction of reinforcement for appropriate mouth closure. These EMG findings are supportive of EMG data obtained for Case 1 in that hypertoncity did not decrease during treatment as would be expected with a biofeedback intervention. However, data from this patient differ from those of Case 1 in that EMG activity increased with the initiation of two of the intervention conditions, suggesting that appropriate mouth closure was achieved by increasing muscle activity.

CASE 3

Patient and Setting

Tim, an 11-year-old male, was diagnosed as having severe choreoathetoid cerebral palsy (CP) and mild mental retardation (IQ of 67). He was nonambulatory and nonverbal, communicating with the use of a word board. Gross motor functions were noted by pediatrics and physical therapy to be at the 6–7 month level. Tim had an 11-year history of tongue protrusion secondary to choreoathetoid CP. Previous unsuccessful pharmacological treatments for the choreoathetosis included dantrolene sodium, diazepam, haloperidol and levodopa plus carbidopa. Physical therapies had also been unsuccessful in improving the tongue protrusion. Tongue protrusion was a significant problem because it disrupted eating and interfered with social interaction.

Measures for Case 3 were obtained in the living area of the inpatient unit and in the playroom. The living area of the unit was a large social area shared by five other children and used for treatment, recreation, and meals. The playroom was used for individual or group recreational activities and was occupied by 5–15 other inpatients at any one time.

Recording and Reliability

Target behavior. Tongue protrusion was defined as the tongue in view and the tip of the

Figure 4. Right masseter EMG activity obtained during alone, therapist present, and mother present conditions for Case 2. Instructions plus reinforcement of mouth closure began on sessions 6, 25, and 30 in the alone, therapist present, and mother present conditions, respectively.

tongue protruding forward with the tongue resting on or beyond the crest of the lower lip.

Observations. An observer recorded the occurrence of tongue protrusion in continuous 15-s intervals. An occurrence was recorded if tongue protrusion occurred during any portion of the observation interval.

Reliability procedures. Interobserver agreement was assessed by comparing the independent records of two observers who simultaneously recorded the behavior. Reliability checks were made during 27% of the total sessions (6 of 22 sessions) with a minimum of one check per experimental condition. Interobserver agreement was calculated for the occurrence of tongue protrusion by dividing the number of occurrence agreements by the total

number of intervals in which either or both observers recorded the behavior. Reliability of occurrence percentages for tongue protrusion was 99.5%.

Experimental Design

A multiple-baseline across settings design was used. Baseline data, in the form of percentage of intervals of tongue protrusion, were taken a minimum of two times in each setting. Prompts were introduced in the playroom setting only, followed by prompts plus a fixed differential reinforcement of other behavior (DRO) schedule of reinforcement. A fixed DRO without prompts was then introduced in the living area. Finally, a variable DRO procedure was implemented across the playroom and living area settings.

Procedures

Sessions were conducted twice daily, 5 days a week. The first daily session was conducted during the early morning in the living area of the inpatient unit; the second, in the late morning in the playroom. Sessions lasted 15–60 min (mean duration 32 min). Throughout the study, the duration of the two daily sessions was matched. The study lasted a total of 22 sessions over a period of 7 weeks.

Baseline. During baseline, toys and games were made freely available to all the children present in both settings. Activity involvement was occasionally prompted by staff, particularly when Tim ceased involvement for approximately 1 min. The staff did not mention, reprimand, or otherwise attend to tongue protrusion. Two baseline sessions were conducted in the playroom and eight in the living area.

Prompts. Prompts were provided in the living area only. The staff member serving as primary observer made verbal prompts to the patient regarding tongue protrusion control by saying, "Be sure to keep your tongue in." A prompt was given once every 2 min on the average, whether or not tongue protrusion was observed.

Prompts plus fixed DRO. Prompts plus praise were delivered according to a DRO contingency. When a specified interval elapsed without any occurrence of tongue protrusion (the response-free interval), praise was given. Occurrence of protrusion terminated timing of the interval. When the tongue was no longer protruding, timing of the response-free interval was reinitiated. Initially, the praise used was very specific, that is, "It's good that you're keeping your tongue in." Later in this intervention less specific praise was used, that is, "You're really doing well." Prompts and praise were provided while Tim was engaged in the recreational activities described previously. The response-free interval was initially set at 5 s, slightly briefer than the baseline average interresponse time. The prompts plus fixed DRO procedure was used in the playroom for eight sessions.

Fixed DRO. A fixed DRO procedure without

prompts was introduced for seven sessions in the living area. In this setting the response-free interval was extended following five consecutive reinforcements. The sequence of interval values was 5, 10, 15, 20, 30, 40, 60, 90, 120, and 180 s.

Variable DRO. Following 3 consecutive minutes without tongue protrusion, a 3-min variable DRO contingency was initiated. The variable DRO contingency involved varying the duration of the response-free interval required for a particular reinforcement through a specified range of values with an average value of 3 min. The specified values were 0.25, 0.5, 2.0, 3.0, 4.0, 5.5, and 5.75 min. The sequence of response-free interval values in this study was randomized within sessions with the limitation that the first one used be one of the three shortest values. Eight variable DRO sessions were conducted.

RESULTS AND DISCUSSION

The percentage of intervals of tongue protrusion in the playroom and living area is presented in Figure 5. These data indicate that initially tongue protrusion was high in both settings, averaging 75% and 72% in the playroom and living area, respectively. The introduction of the prompts only condition in the playroom resulted in a transient decrease in tongue protrusion. Addition of the fixed DRO contingencies to the prompts resulted in a sizable and sustained decrease. Likewise, in the living area, the percentage of intervals of tongue protrusion remained high until the introduction of the DRO contingencies without prompts. Tongue protrusion became more variable with the introduction of the variable DRO schedule in the playroom. In the living area, the level of performance obtained during the fixed DRO condition was maintained during the variable DRO condition.

In summary, the prompts only condition was not sufficient to produce the desired decrease in tongue protrusion. The addition of the DRO procedure in the playroom and the introduction of a DRO schedule without prompts in the living area were successful in decreasing the levels of tongue protrusion in both settings; however, zero levels of the behavior were never obtained. This may have

Figure 5. Percent occurrence of tongue protrusion observed in the playroom and living area during baseline, prompts only, prompts + DRO, and DRO conditions for Case 3.

been due to the natural environment of the training setting that provided many distractions and did not permit a high degree of experimental control.

Results of this case indicated that a simple contingency management procedure could successfully decrease a component response associated with a neurological disorder. These findings are particularly interesting in that an environmental manipulation could control a neurological deficit when both pharmacological and physical therapies were reportedly ineffective.

GENERAL DISCUSSION

This study provided an experimental demonstration of the effectiveness of contingency man-

agement procedures in modifying dysfunctional motor behavior secondary to neuromuscular disorders. Operant procedures were implemented in an attempt to demonstrate improved orofacial control in three cases with severe orofacial dysfunction. Procedures differed across cases and included contingent reinforcement of the targeted response, DRO, and time-out. Interventions were evaluated within a multiple-baseline across stimulus conditions design for each case. The stimulus dimensions differed for each case. Cases 1 and 3 were evaluated across environments and Case 2 across people. Case 2 was assessed across people so as to obtain a higher degree of experimental control, possible only in the laboratory setting, while still examining a socially relevant stimulus variable. Experimental designs for Cases 1 and 2 proceeded from less to more elegant with an attempt to rectify experimental deficiencies of Case 1. Case 3 was conducted in the individual's daily hospital living setting rather than the laboratory to obtain data on functional changes using the contingency management procedures.

Interpretation of the results of these case studies must be appropriately qualified by design weaknesses. Perhaps the greatest weakness in design occurred in Case 1 in which a functional relationship between the time-out procedures and a decrease in jaw dislocations was not assessed. However, the general trend and decrease in variability in these data are supported by the experimentally validated findings from Cases 2 and 3.

Improvements in orofacial control were observed in all cases following implementation of the treatment procedures. Because this was designed to be a basic study of contingency management procedures under highly controlled conditions, extensions of the intervention were not made to additional referring problems (e.g., speech, eating) nor were interventions extended to obtain generalization to nonexperimental settings (e.g., home, school). Follow-up data as well as the experimental study of treatment generalization must be the subject of future investigation to better understand and achieve enduring clinical outcomes.

The data in this study suggest that neuromus-

cular disorders can be investigated within an operant paradigm and are not characterized by a set of behaviors that are unresponsive to the environment. It is significant to note that behavior change occurred across cases treated with three different procedures within three sets of stimulus conditions. This consistent behavior change, observed across a variety of experimental conditions, types of orofacial disorders, levels of intellectual functioning, and diagnostic categories, indicates a robust treatment effect. These data do not imply a nonorganic etiology but, rather, suggest that behaviors displayed by individuals with these neuromuscular disorders may be mitigated or exacerbated by environmental events.

The relationship between environmental contingencies and motor performance has important implications, not only for the design of treatment procedures but also for an understanding of the biobehavioral development of functional deficits secondary to neuromuscular pathophysiology. That is, in addition to the effects of central and peripheral biological abnormalities, the degree of functional impairment will very likely depend on the manner in which the environment responds to an individual's motor responses. This simple principle about the relationship between behavior and the environment, demonstrated repeatedly to be relevant to a variety of problem areas (Rimm & Masters, 1979; Russo & Varni, 1982), has been largely overlooked in designing treatment interventions for motor impaired patients. That this principle has been demonstrated by the recent use of biofeedback procedures should encourage extensions of operant approaches beyond that limited by biological feedback equipment. For example, as contingent parental behavior has been shown to affect most aspects of children's behavior, parents' response to their neuromuscularly impaired child's motor activity could alter the level of function eventually achieved. Consistently applying basic operant principles to a motor problem as it occurs in the child's daily living environments (e.g., as in Case 3) is likely to have a more profound impact on behavior change and maintenance than brief, periodic clinic visits. Further, the notion that motor

performance is in part a function of the individual's operant history relative to that motor activity challenges current approaches in neurology. Neurological assessment strategies permit conclusions about neurological competence based on a clinical examination of patient performance in response to instruction (Brown, Sher, & Wright, 1982). The same performance assessed long enough to permit observation and measurement under reinforcement rather than instructional control could result in quite different levels of performance and, therefore, result in different conclusions about the extent of functional deficit.

An EMG measure of muscle activity was monitored in the first two cases to determine whether changes in muscle activity would accompany changes in overt behavior. Contingency management effects were specific to the trained motor response, and over the course of the study, a small increase in EMG recordings was noted for one patient (Case 1) and a greater increase in EMG for a second patient (Case 2). With regard to Case 2, the increases in EMG accompanied the intervention procedures. However, in these two cases the change in EMG was not experimentally manipulated; and in the absence of normative data on what level of EMG constitutes an abnormal or pathological state, it is unclear whether the observed increase in EMG represented a negative outcome. These results are to be contrasted with EMG feedback treatment that produces changes in motor activity by targeting first the level or coordination of muscle electrical activity. In the hypertonic patient, an EMG feedback goal would be an initial reduction in the overall level of electrical activity and then, with this accomplished, an improvement in functional movement. The results of this study suggest that such a reduction in muscle activity is not a prerequisite or an essential ingredient for training a functional improvement (i.e., mouth closures). Presumably, patients who change function in response to environmental contingencies may do so with or without concomitant reductions in levels of muscle activity. However, the results do not suggest that establishing such a reduction wouldn't be desirable. Operant research on re-

sponse requirement (Hefferline & Keenan, 1961) suggests that functional gains achieved with the lowest possible effort to the neuromuscular system would be the most enduring. Therefore, contingency management procedures for neuromuscular problems should be used in conjunction with other measures (e.g., EMG) and treatments (e.g., biofeedback), if such a combined approach will maximize outcome for the patient. The use of an operant procedure such as contingency management in combination with more traditional medical measures and other treatments would represent a behavioral medicine approach to neuromuscular problems.

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