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CLINICAL EVALUATION OF THE SELF-INJURIOUS BEHAVIOR INHIBITING SYSTEM (SIBIS)

THOMAS R. LINSCHEID

OHIO STATE UNIVERSITY AND CHILDREN'S HOSPITAL, COLUMBUS

BRIAN A. IWATA

UNIVERSITY OF FLORIDA

ROBERT W. RICKETTS

ABILENE STATE SCHOOL, ABILENE, TEXAS

DON E. WILLIAMS

RICHMOND STATE SCHOOL, RICHMOND, TEXAS

AND

JAMES C. GRIFFIN

MANAGEMENT AND PROGRAM ANALYSIS SERVICES, CHESTER, CONNECTICUT

Five cases involving the treatment of longstanding, severe, and previously unmanageable self-injurious behavior are presented. In each case, the behavior was forceful contact with the head or face, and treatment consisted of mild and brief contingent electrical stimulation, delivered automatically or by a therapist, via the Self-Injurious Behavior Inhibiting System. Results of reversal and/or multiple baseline designs, in which sessions ranged in duration from 10 min to all day across a variety of settings, showed that the effects of the system were immediate and produced almost complete elimination of the self-injurious behavior. Controlled and anecdotal follow-up data for four of the five cases suggest continuing benefits and the absence of detrimental side effects associated with treatment. Potential applications of the device, as well as extensions and limitations, are discussed.

DESCRIPTORS: self-injurious behavior, electrical stimulation, punishment

Self-injurious behavior (SIB) is a chronic and potentially life-threatening disorder whose prevalence is estimated to be from 8% to 14% among institutionalized individuals with developmental disabilities (Griffin, Williams, Stark, Altmeyer, & Mason, 1986; Maisto, Baumeister, & Maisto, 1978; Schroeder, Schroeder, Smith, & Dalldorf, 1978). Over the past 20 years, numerous etiological models have been proposed (e.g., see reviews by Carr, 1977; Cataldo & Harris, 1982), and hundreds of case reports and clinical studies have appeared in the

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The SIBIS device is available commercially through Human Technologies, Inc., 300 3rd Avenue North, St. Petersburg, Florida 33701.

Requests for reprints should be addressed to Thomas R. Linscheid, Ohio State University, Department of Pediatrics, Children's Hospital, 700 Children's Drive, Columbus, Ohio 43205, or Brian A. Iwata, Department of Psychology, University of Florida, Gainesville, Florida 32611.

literature (for reviews, see Johnson & Baumeister, 1978; Schroeder, Schroeder, Rojahn, & Mulick, 1981). Although interventions based on the application of operant conditioning principles are considered to be the most effective, no specific form of behavioral treatment has produced consistently positive results either generally or within response topography or diagnostic category.

Recent advances in the experimental analysis of behavioral function for disorders such as aggression (Carr, Newsom, & Binkoff, 1980), pica (Mace & Knight, 1986), SIB (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982), and multiple behavior problems (Sturmey, Carlsen, Crisp, & Newton, 1988) suggest the possibility of matching the operational features of intervention with the motivational aspects of behavior, thereby increasing the likelihood of obtaining positive clinical outcome (e.g., Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990; Repp, Felce, & Barton, 1988; Steege, Wacker, Berg, Cigrand, & Cooper, 1989). Based on promising data reported by these and other researchers, some observers (e.g., LaVigna & Donnellan, 1986) have argued that this functional analysis model renders unnecessary the use of interventions involving punishment or aversive events. Curtailment and eventual elimination of aversive therapeutic procedures are highly desirable for a number of reasons. Nevertheless, there is no experimental evidence indicating that behavioral assessment based on functional analyses reliably results in the selection of interventions that are either exclusively nonaversive or consistently effective. For example, extinction of behavior maintained by negative reinforcement requires the presentation of aversive stimuli and the prevention of escape. Similarly, differential reinforcement of other or incompatible behavior (DRO, DRI) applied to an extremely high-rate behavior exhibited by an individual for whom few events serve as positive reinforcers may be impossible to implement practically or may require the creation of rather severe deprivation states.

SIB has been particularly resistant to treatment through solely nonaversive means. For example, the Association for Advancement of Behavior Therapy (AABT), Task Force of Self-Injurious Behavior, noted in their review of the scientific literature that differential reinforcement has produced inconsistent results at best when used as a single intervention for SIB (Favell et al., 1982). Most studies in which reinforcement was used also included timeout, restraint, or punishment. Favell et al. also concluded that punishment is the most effective treatment for SIB and recommended its use when other procedures have failed or when the SIB is extremely severe. Since the publication of the AABT Task Force Report, other reviews of the literature on punishment (e.g., Axelrod & Apsche, 1983; Guess, Helmstetter, Turnbull, & Knowlton, 1987; Matson & DiLorenzo, 1984) and SIB (e.g., Romanczyk, 1986) have not produced different conclusions about the relative effectiveness of punishment versus reinforcement in decreasing behavior.

Given that procedures based on the use of positive reinforcement alone have not always resulted in clinically significant reductions of severe behavior disorders, it is not surprising that applied and clinical researchers often include one or more aversive components in the treatment of problems such as SIB (Lennox, Miltenberger, Spengler, & Erfanian, 1988; Lundervold & Bourland, 1988). Thus, data from both scientific reviews and surveys of current clinical practice suggest that there remains a need for a technology of behavior change based on aversive events, even though the uses of that technology may be extremely limited. Therefore, in addition to continued research and development in the area of nonaversive interventions, similar efforts in the area of aversive interventions seem warranted at the present time (Iwata, 1988).

Although considered by many to be one of the most intrusive behavioral interventions, response-contingent electrical stimulation is potentially superior to and safer than a number of currently used punishment techniques in several respects. First, the technical parameters of shock, unlike those involving physical contact between therapist and client (e.g., contingent restraint, facial screening, overcorrection), can be precisely quantified and regulated, thereby eliminating the use of subjective criteria in defining the appropriate level of stimulation or its upper limits. Second, shock can be delivered quickly and sometimes remotely, reducing the likelihood that the punishing event will be delayed (e.g., as in the application of aversive tastes), or that treatment will be compromised through inadvertent pairing of punishment with reinforcement in the form of social interaction between therapist and client (e.g., as in applying overcorrection or physically struggling with clients to put them in time-out). Third, the procedure does not interfere with the client's ongoing activities, a problem associated with restraint and certain forms of time-out. Fourth, electrical stimulation is a highly discrete event that does not pose problems associated with other stimuli (e.g., tabasco sauce, lemon juice, water mist, etc.) that linger for an unknown amount of time after the behavior has ceased. Finally, because the properties and physiological effects of electrical stimulation are well known, it is possible to select a level of stimulation that poses no physical risk.

In spite of its potential advantages, there are numerous concerns regarding the propriety of electrical stimulation, even as a treatment for high-risk and intractable SIB. Questions about side effects, maintenance, generalization, and unauthorized use are highly pertinent, but no more so for electrical stimulation than for other forms of punishment. A more valid concern with the specific use of electrical stimulation is the issue of safety, because most devices used for administering response-contingent shock (e.g., cattle prods, dog shockers) were not designed for therapeutic use with humans. By contrast, cutaneous stimulators used in the treatment of pain and bruxism were developed for specific applications and subsequently have met with few criticisms. Both types of devices deliver response-contingent electrical stimulation and are purchased as a means of controlling an unwanted symptom or behavior. Similar advances have been made in the technology for delivering response-contingent electrical stimulation in the treatment of behavior disorders; our study describes the application of a fully or semiautomated electrical stimulator designed specifically for treating SIB.

GENERAL INFORMATION

Apparatus

The Self-Injurious Behavior Inhibiting System (SIBIS) was developed through collaborative work by a group of advocacy, engineering, medical manufacturing, and research organizations.[1] The original design of SIBIS (see General Discussion for a brief description of later components) used in this study served three functions: automatic detection of potentially self-injurious blows to the head, response-contingent delivery of electrical stimulation to the arm or leg, and automatic recording of stimulus delivery. Figure 1 shows the basic components of SIBIS used in this study.

The sensor module (worn on the head) contains a pezioelectric velocity (impact) detector, a radio transmitter, and a common 9-V battery. The sensitivity of the impact detector can be adjusted; based on preliminary testing, it was set at approximately 1.5 G for this study (this level is sufficient to detect a forceful slap when the hand is held in a starting position within 6 in. from the body). The stimulus module (worn on an arm or leg) contains a radio receiver, microelectric circuitry for the generation and timing of the electrical stimulus, and a 9-V battery. The insulated electrode, also contained in the stimulus module, is configured in a concentric circle (diameter = 1.0 in.) to ensure that current is localized at the site of the electrode. This design eliminates the risk that current will pass through the body cavity and into the heart (i.e., there is no

[1] Two of the authors (Linscheid and Iwata) served as unpaid technical consultants to the Johns Hopkins Applied Physics Laboratory (who developed the prototype device) and to Human Technologies, Inc. (who adapted the prototype and developed the final working model) on several aspects of the SIBIS design (i.e., counters, cueing tones, DRO/time-out component). None of the authors have any financial interest in the design, manufacture, marketing, or distribution of SIBIS.

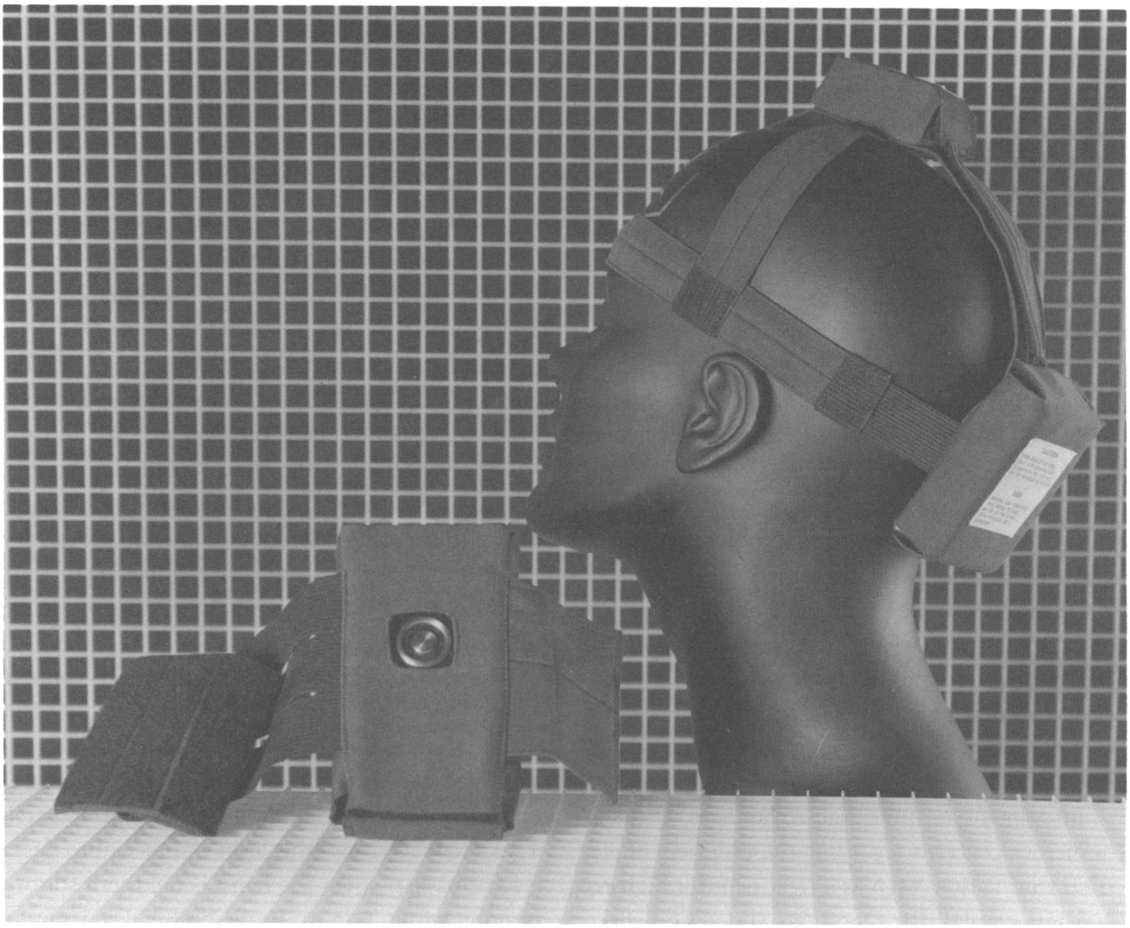


Figure 1. Basic SIBIS configuration. Above-threshold blows to the head or face trip the impact detector, which activates a coded signal transmitter. The transmitter then activates the stimulus unit (worn on the arm or leg), which produces a tone followed by electrical stimulation for 0.08 s. (See text for additional details.)

possibility of transthoracic current). Finally, the stimulus module has an internal counter that records the number of shocks delivered. This feature provides automatic data on stimulus delivery independent of the therapist and can be used as a check on accidental or unauthorized use of the device.

When a blow of sufficient intensity to activate the impact detector occurs, a coded radio signal is sent from the sensor module to the stimulus module. Alternatively, the therapist can activate a transmitter that fits in the palm of a hand (not shown in Figure 1), which also sends a radio signal to the stimulus module. To reduce the likelihood of accidental stimulus delivery, the transmitter does not operate unless two buttons are pressed simultaneously. During each application (via radio signal from the sensor module or the hand-held transmitter), the stimulus module emits a brief tone and delivers an 84-V, 3.5-mA electrical stimulus to the skin at an energy level of 0.007 W/s. The stimulus is delivered in 16 pulses for 0.005 s each over 0.2 s, so that stimulation is present at the electrode for only 0.08 s. Subjectively, the experience has been described at its extremes as imperceptible (low) and similar to having a rubber band snapped on the arm (high).

To compare the parameters of SIBIS with those of similar devices, we examined published recommendations (Butterfield, 1975) on safety factors for devices used in aversive conditioning (e.g., for SIB and related behavioral disorders in the devel-

Table 1

Comparison of Shock Specifications for SIBIS and Those from Other Studies Against Standards Proposed by Butterfield (1975)[a]

Article	Device	Power source	V	kΩ	mA	s
Butterfield (1975)	N/A	Battery	—[b]	—[c]	5.0	—[d]
Linscheid et al. (1990)	SIBIS	9-V Battery (1)	84	24	3.5	0.08
Birnbrauer (1968)	Sears	Battery[e]	500	500	5.0	—
Ball et al. (1975)	Lab built	Battery[e]	—	—	—	—
Corte et al. (1971)	1) Lab built	House current	150	—	5.0	—
	2) Hot shot	Battery[e]	300	—	1.0	—
Cunningham and Linscheid (1976)	Lehigh Valley	House current	—	—	4.5	0.5
Foxx et al. (1986)	1) Tri-tronics	Battery[e]	2,400	—	15.0	—
	2) Hot shot	Battery[e]	5,000	—	18.5	—
Lang and Melamed (1969)	Lab built	House current	—	—	—	1.0
Lovaas and Simmons (1969)	Hot shot	1.5-V battery (5)	1,400	50		1.0
Risley (1968)	Hot shot	1.5-V battery (7)	1,000	—	—	—
Romanczyk and Goren (1975)	1) Hot shot	Battery[e]	500	—	15.0	0.3
	2) Sci prototype	House current	—	—	12.0	—
Tate and Baroff (1966)	Sears	D-cell battery (7)	130	—	—	0.5
Young and Wincze (1974)	Lehigh Valley	Battery[e]	700	—	—	0.5

[a] V = volts, Ω = ohms body resistance, mA = current amplitude in milliamperes, s = duration. Lower values for each measure generally produce safer and lower levels of stimulation.

[b] No value specified or reported.

[c] A value of 1 kΩ is reported for body resistance (combined internal and skin resistance) for transthoracic current. No value is specified for nonthoracic current.

[d] A value of 0.01 s is reported for transthoracic current. No value is reported for nonthoracic current.

[e] Type and number of batteries not specified.

opmentally disabled, as well as for problems treated in the general population, such as drinking, smoking, stuttering, etc.). Much of the information presented by Butterfield was not reducible to absolute numbers, because many of the safety features are of a qualitative nature (e.g., protection against transthoracic current, grounding, etc., with which SIBIS complies fully). Furthermore, with respect to the quantitative parameters of shock, variations in one parameter must be considered relative to other parameters. For example, although higher voltages per se result in a higher current flow, the effects of a given voltage are reduced by the body's assumed resistance (measured in ohms). Thus, the best general indicator of the strength of electrical stimulation is current amplitude (amperage). Finally, most of the minimal values proposed by Butterfield assume the possibility of transthoracic current, which was prevented in the design of SIBIS.

In addition to the above considerations, the technical details provided in studies using shock are often incomplete. Nevertheless, we obtained these details from published studies on the treatment of SIB and compared them to Butterfield's (1975) recommendations and the parameters of SIBIS. As can be seen in Table 1, the SIBIS specification for current (mA)—the only comparable figure from Butterfield—is below that recommended by Butterfield, and the other SIBIS specifications compare favorably with those of previous devices used in the treatment of SIB.

Subject Selection

Three general criteria were used in selecting individuals for participation in the study: (a) chronic SIB involving forceful contact with the head (i.e., face hitting, head hitting, head banging) that produced obvious tissue damage; (b) a history of treatment failure, including the previous use of interventions for which formal approval is required (i.e., overcorrection, restraint, drugs, or aversive stimulation other than shock); and (c) currently uncontrollable SIB necessitating the use of protective equipment, restraint, and/or drugs. SIB meeting these criteria was severe and had already been judged by an independent body to warrant intrusive intervention. Indeed, it was apparent that each individual's SIB would cause further and potentially more serious trama, that the individual would remain restrained and/or sedated for the foreseeable future, or that programs more intrusive than those previously attempted would be implemented in order to prevent the first two outcomes. In our opinion, these subject characteristics justified the use of response-contingent electrical stimulation as described in this study. Additional details are presented separately under each of the case studies.

Human Subjects Review and Experimenter Qualifications

Prior to entry into the study, each case was reviewed and approved by the appropriate oversight committees for research and the use of intrusive procedures (i.e., Institutional Human Subjects Review Board, Peer Review Committee, Human Rights Committee, and State Behavior Modification Committee). Written informed consent was obtained from the parent or guardian of each subject.

Treatment was supervised directly by at least one psychologist who had extensive experience in the management of SIB (one or more of the authors), and all experimental sessions were conducted by one of the authors or by another experienced psychologist. The primary treatment sites were as follows: Cases 1 through 3, Children's Hospital; Case 4, Abilene State School; and Case 5, Richmond State School. Follow-up sessions and long-term maintenance and generalization programs, when conducted by other individuals (e.g., teachers), were preceded by training done by a supervising psychologist.

Comments on Experimental Design

SIBIS was not designed to serve as an initial treatment for SIB, nor was the aversive stimulation component designed to be used in isolation from other procedures. In general application, SIBIS should be used only within the context of a comprehensive program that includes positive reinforcement for establishing and strengthening appropriate behavior. The primary purpose of this study, however, was to determine the effects of SIBIS per se on SIB and not to determine its additive or relative effects when combined with or compared to other forms of treatment. When studying these primary effects, the simultaneous inclusion of other treatments would have weakened conclusions about the active role played by SIBIS. To conduct a rigorous evaluation, it was necessary to use methodology that eliminated potential sources of confounding between the effects of SIBIS and those of other independent variables, regardless of whether those other variables were parceled out via component analyses. Therefore, for the purposes of the present study only, SIBIS was the sole form of therapy delivered during treatment conditions unless noted otherwise. A number of interventions that included the use of positive reinforcement were incorporated into each subject's overall program following the completion of the study, but these were not subjected to experimental (i.e., controlled) evaluation.

Similarly, the cases reported here do not include data from a treatment condition preceding the use of SIBIS, in which alternative interventions were demonstrated to be ineffective. Such interventions were implemented prior to the study using similar methods of clinical supervision and data collection and had been judged to be technically adequate by an independent review group (see above). Therefore, we could not justify, as part of this study, the inclusion of pre-SIBIS conditions (other than necessary controls) merely to verify what had already been demonstrated.

The resulting experimental designs for each subject included at least two types of control conditions and at least one type of experimental (treatment) condition. The baseline condition was conducted as a no-treatment control (all subjects). Although data from such a condition do not permit conclusions about the relative effects of SIBIS versus some other intervention, we decided to use a no-treatment baseline because it would provide the best comparison when examining the singular effects of SI-

BIS. A second control condition (SIBIS inactive) separated the effects of response-contingent electrical stimulation, delivered within the context of wearing SIBIS, from any potential stimulus control exerted over the behavior merely as a function of wearing the inactive apparatus (all subjects). A third control condition (helmet) was included only if a subject routinely wore a helmet for protection and if it reportedly produced a decrease in SIB (2 subjects). During the experimental conditions, the SIBIS stimulus module was worn and was activated either automatically via the sensor module (all subjects) or via therapist operation of the hand-held transmitter (2 subjects).

CASE 1

METHOD

Subject

Marie was a 16-year-old female with diagnoses of profound mental retardation, hypertension, and dislocated hips. She was nonambulatory but could move her wheelchair. She could feed herself, but she was not toilet trained, nor did she have any language skills. Marie was institutionalized at the age of 2 and later transferred to a group home, where she had resided for the past 6 years.

Marie had a 12-year history of SIB, which included head hitting, banging her head against objects, self-biting, hair pulling, and pinching herself on the chest and thighs. The frequency of her SIB reportedly was higher at school (35 to 60 episodes per hour), but it occurred across all settings and while she was alone. Numerous interventions, including DRO, overcorrection, and physical restraint, that were designed and monitored by behavior management specialists, had been implemented both at school and in her group home to reduce the SIB. All of these attempts had been unsuccessful, to the point where Marie was required to wear a hockey helmet on an as-needed basis at school and at home to minimize the damage from her head banging.

An independent evaluation conducted by behavioral psychologists at a university-affiliated program (UAP) clinic recommended the use of aversive stimulation as part of Marie's ongoing treatment program. Subsequently, she was referred for evaluation and possible inclusion in this study by her physician, who continued to monitor her progress throughout the study. At the time of admission, the back of her head was bald as a result of hair pulling, and it was swollen and bruised in several areas as a result of head banging.

Response Measurement and Reliability

Head banging (any forcible contact between hand and head or between head and object) was Marie's most frequent and serious SIB, and it served as the primary dependent variable. Data also were taken on hair pulling (grasping hair between the fingers and pulling it away from the head), pinching (exerting forcible pressure on the skin between thumb and forefinger), biting (closure of teeth on any part of the body), and hits to chair (forcible contact of arm or hand on any part of Marie's wheelchair). All behaviors were scored as frequency counts.

During 19% of the Phase 1 sessions (across all conditions), a second observer independently counted head hits. Agreement ranged from 81.8% to 100%, with a mean of 94.1%. Session durations during Phase 2 were both extended and variable, and reliability observations during this phase were conducted during 30-min blocks on 4 of 20 days (3% of the total time for Phase 2). Comparison of observers' records from these sessions yielded no instances of disagreement.

Phase 1

The effects of SIBIS were evaluated in a combined reversal and multiple baseline across settings design. Sessions were conducted in a hospital treatment room and in Marie's bedroom, while she was seated in her wheelchair without wearing her helmet. Marie's nurse was present during initial treatment sessions, and physicians were immediately available if needed throughout treatment. The experimenter was present but did not interact with Marie during these sessions, nor was any attempt made to block self-injurious responses. Each session

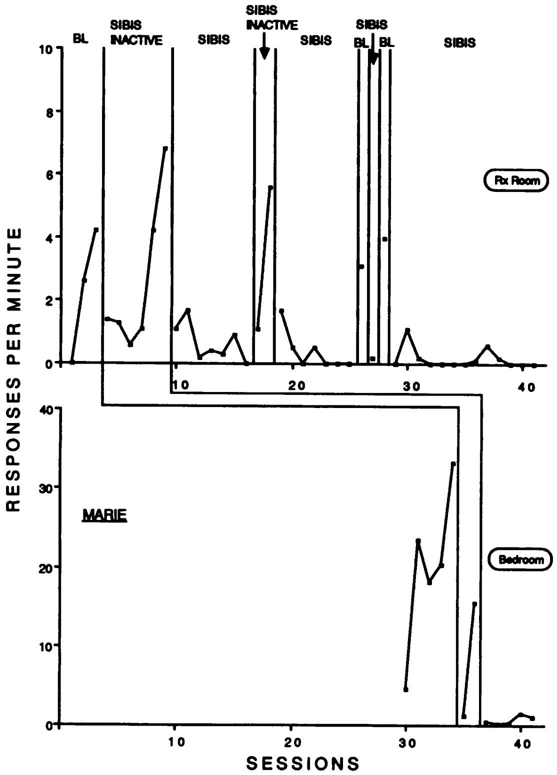


Figure 2. Head hits exhibited by Marie during Phase 1 of her treatment program (experimental evaluation).

lasted for 10 min or until Marie struck herself 25 times, whichever occurred first. The decision to terminate a session following 25 responses provided a means of protecting Marie from unacceptable risk associated with the behavior.

Baseline. No treatment was in effect during this condition.

SIBIS inactive. Prior to each session, the sensor and stimulus modules were placed on Marie, but the stimulus module was inoperative.

SIBIS. Prior to each session, the sensor and active SIBIS modules were placed on Marie, so that head hits produced electrical stimulation as described previously.

Phase 2

Following the completion of Phase 1, Marie was observed while wearing the active SIBIS device from 1 to 7.5 hr each day (M = 3.75 hr) on the hospital ward, and data were collected on all of her self-injurious behaviors. Session duration was determined by therapist availability. During these sessions, Marie was seated in her wheelchair without her helmet and interacted with staff in an unrestricted manner. Most of her time was spent sitting at the nurses' station (a preferred location), seated in the hallway, or in her room with the TV on.

Results

Phase 1

Figure 2 shows the results of Phase 1. Marie's head hitting averaged 2.3 responses per minute during the initial baseline in the treatment room, with an increasing trend evident. The first four sessions of the SIBIS-inactive condition were associated with a decrease in responding; thereafter, head hits increased to above-baseline levels (M = 2.6 per minute). Head hits decreased again during the first SIBIS condition and reached zero by the seventh treatment session (M = 0.6 per minute). During these seven sessions, Marie received 24 electrical stimulations totaling less than 2 s. Subsequent reversals produced rapid and large response reductions during each SIBIS condition and increases during either baseline or SIBIS-inactive conditions.

Marie's head hitting during baseline in her bedroom was similar to that observed in the treatment room, although she struck herself at a higher rate (M = 19.8 per minute). Head hitting decreased sharply during the first SIBIS-inactive session but recovered by the second session (M = 8.4 per minute) and decreased again and remained low during the SIBIS condition (M = 0.6 per minute). Across all similar conditions in both settings, Marie's mean rates of head hitting (responses per minute) were as follows: baseline, 11.2 (range, 0 to 33.3); SIBIS inactive, 3.8 (range, 0.6 to 15.6); and SIBIS, 0.4 (range, 0 to 1.7). These means are conservative estimates, because upward trends generally were evident during baseline and SIBIS-inactive conditions, whereas the reverse was true during SIBIS conditions. Nevertheless, the difference between 0.4 (overall SIBIS mean) and 11.2 (overall baseline mean) represents a 94.6% decrease in head hitting.

The percentages of sessions terminated early due

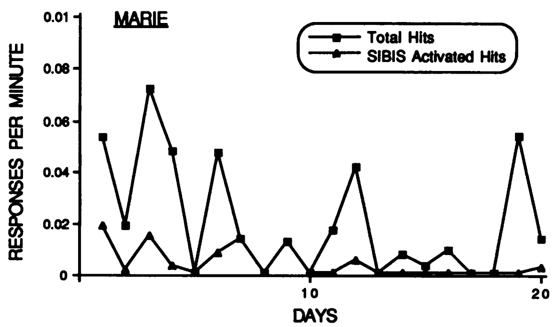


Figure 3. Head hits exhibited by Marie during Phase 2 of her treatment (extended therapy sessions).

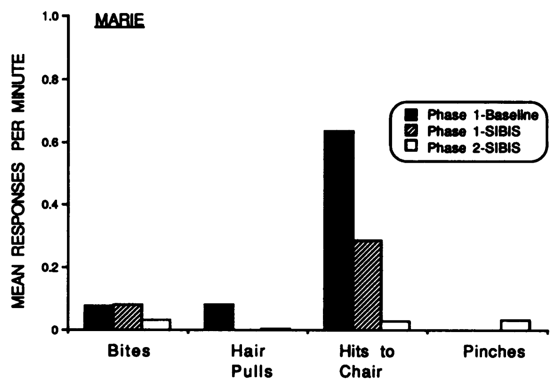


Figure 4. Other self-injurious behaviors exhibited by Marie during Phases 1 and 2.

to risk, across conditions and settings, were: baseline, 80%; SIBIS inactive, 40%; SIBIS, 0.

Phase 2

Figure 3 shows total head hits recorded by the observer, as well as those of sufficient intensity to activate the SIBIS module. During the 20-day condition, total head hits averaged 0.02 per minute, and potentially injurious (SIBIS-activating) responses averaged only 0.003 per minute. These rates compare favorably to Marie's head hitting during the baseline conditions of Phase 1 and represent almost complete suppression of that self-injurious behavior.

SIBIS was not applied to Marie's other forms of SIB because they were felt to pose little or no health risk; data were taken on these behaviors to determine whether punishment of one self-injurious topography (head hitting) might lead to increases in other untreated topographies (bites, hair pulls, pinches, hits to chair). Figure 4 shows the mean responses per minute for these four behaviors across sessions during Phase 1 (baseline and SIBIS inactive vs. SIBIS conditions) and Phase 2 (SIBIS). Three of the behaviors—bites, hair pulls, and hits to chair—showed a reduction associated with treatment (Phases 1 and 2), whereas pinches increased during Phase 2. Marie's school personnel reported that pinching was not a new behavior but was sporadic in nature (i.e., it occurred for several days and then disappeared for as long as several weeks). Thus, in Marie's case, it appeared that SIBIS applied to one response did not have detrimental effects on three of the four untreated but potentially self-injurious responses, which actually decreased. During the 20 days over which this phase was conducted, her SIB was virtually eliminated, her scalp wounds healed almost completely, and her hair was beginning to grow back.

Follow-Up

Phase 2 of Marie's treatment was terminated when she underwent surgery for longstanding gastrointestinal problems unrelated to her SIB. Upon recovery, she was immediately transferred to an institution to await placement in a group home for nonambulatory patients. Institutional administrators decided not to reinstate treatment with SIBIS. One year after Marie's admission to the institution, no request to reinstate treatment with SIBIS has been received, despite the failure of two newly developed nonintrusive programs and the fact that Marie is required to wear a helmet almost continuously to prevent damage from head banging. Although several potential group-home placements were located for her during this time, her continued SIB and need for restraint (helmet) precluded transfer from the institution.

CASE 2

Method

Subject

Johnny was an 11-year-old male diagnosed as severely retarded and autistic. His self-injurious head hitting reportedly began before the age of 2. He lived at home with his parents until age 6, when he was admitted to a group home, where he had remained for the past 5 years while attending a day school program. Johnny had no speech, although he displayed a few signs (e.g., eat, drink, help, sit). Differential reinforcement (both DRO and DRI), physical restraint, overcorrection, required relaxation, and gentle teaching had been used at home and at school to treat his SIB; none of these procedures was effective. These programs had been designed and implemented by school system behavior specialists and group home staff, both under the supervision of professionals with training in behavior analysis. Data from school records indicated that head hitting ranged from 300 to 720 responses per hour during the previous 3 school years.

During the school year preceding Johnny's inclusion in the study, a gentle teaching approach (McGee, 1985) had been used extensively. During that time, Johnny averaged approximately 1,800 head hits per school day, and he wore a hockey helmet most of the time to protect his head and face. Because the rate of his SIB was so high, he spent over 50% of the school day sitting in a bean bag chair, refusing to participate in educational sessions. He was unable to leave his classroom during the day to attend other activities (e.g., music, gym, lunch), and teachers could not take him on any community field trips. Despite the gradual removal of apparently aversive tasks over the course of the year and Johnny's ability to communicate needs through signing, his rate of SIB remained extremely high.

As Johnny grew larger and stronger, group home staff found it more difficult to restrain him during episodes of excessive head hitting and were considering placement in a more restrictive residential facility. Johnny was admitted into the project based on a joint referral from his group home and school programs, with full approval from his parents. At the time of his admission, he wore the hockey helmet almost continuously, although he was still able to injure himself. The areas around his temples and cheek bones were swollen and discolored, with open wounds in these locations, as well as on his neck and chin.

Response Measurement and Reliability

The number of times that Johnny forcefully struck his head was recorded during each session. A second observer independently recorded data during 7% of the sessions across all conditions, and interobserver agreement ranged from 92.8% to 100%, with a mean of 99.3%. Additional data were collected to assess Johnny's affective response to treatment. It was noted informally that Johnny became more relaxed and content during treatment with SIBIS. In order to document this more objectively, his group home staff were asked to note behaviors they observed when Johnny appeared to be "content" and "relaxed." These included: hand posturing (staring at one or both hands held in front of the face with fingers spread), rocking (rhythmic movement of the upper body backward and forward while seated), and panting (audible, deep breathing). Two additional behaviors were noted by the experimenters: distressed vocalizations (any audible sound made by Johnny indicating a distressed state, such as crying, screaming, or yelling) and nondistressed vocalizations (any other audible sound made by Johnny, such as cooing, laughing, or babbling). It should be noted that these behaviors are not necessarily desirable or functional as behavioral replacements for SIB. Nevertheless, we felt that these behaviors provided an objective and socially valid index of Johnny's emotional state while undergoing treatment, which we thought important to document. The five behaviors were recorded from videotapes taken of 28 baseline and 55 treatment sessions, using a 10-s partial interval system of observation. Interobserver agreement, assessed during 15 of these sessions and calculated on an interval-by-interval basis by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100, yielded the following ranges and means (in parentheses): hand posturing, 83% to 100% (97.9%); rocking, 84% to 100% (96.2%); panting, 94% to 100% (99.3%); distressed vocalizations, 100%; and nondistressed vocalizations, 89% to 100% (97.8%).

Procedures

The effects of SIBIS on Johnny's head hitting were evaluated in a combined reversal and multiple baseline across settings design. Baseline and treatment conditions were implemented in three types of situations. During alone sessions, Johnny was seated in a chair in a room where observers were present but did not interact with him. During demand sessions, Johnny and a staff member from his group home sat at a table, and Johnny was directed through a sequence of table tasks (e.g., blocks, pegs, etc.). During play sessions, Johnny was seated alone at the same table with materials available. During the demand and play sessions, no contingencies were in effect for SIB other than those described below. Sessions lasted for 10 min or until Johnny had struck himself 20 times, whichever occurred first.

Baseline. Johnny was observed without his helmet and while no treatment procedures were in effect.

Helmet baseline. This condition was identical to baseline, except that Johnny wore his hockey helmet throughout each session.

SIBIS inactive. Instead of the helmet, Johnny wore the SIBIS device, with the stimulus module inoperative.

SIBIS. Johnny wore the active SIBIS device, which delivered electrical stimulation contingent on head hitting as described previously.

Results

Figure 5 shows Johnny's rate of head hitting across conditions and settings. In the first baseline condition (alone, upper panel), Johnny's head hitting exceeded 100 responses per minute (extrapolated) during each of five sessions. Subsequent conditions involving the use of his protective hockey helmet and inactive SIBIS device were associated with a high degree of variability; Johnny's head hitting during the helmet and SIBIS-inactive conditions ranged from 0 to 134 and 0 to 122 responses per minute, respectively. Large, immediate, and sustained decreases in head hitting were observed upon introduction of SIBIS. Recovery of baseline levels of head hitting was observed within one to three sessions during brief reversals to previous conditions (baseline and SIBIS inactive), and near-zero levels of hitting were observed during two subsequent SIBIS conditions, one of which lasted for 41 sessions. Johnny received 13 electrical stimulations during the 55 SIBIS sessions in the alone setting, totaling 1.04 s of aversive stimulation.

Results in the demand and play settings (lower two panels of Figure 5) were similar to those obtained in the alone setting. High and variable rates of head hitting were observed during baseline, followed by complete elimination of the behavior within nine and three sessions during demand and play, respectively, when SIBIS was used. Johnny's mean rates of head hitting (responses per minute) across similar conditions in the three settings were: baseline, 66.9 (range, 0 to 122); helmet, 42.0 (range, 0 to 134); SIBIS inactive, 55.6 (range, 0 to 127); and SIBIS, 0.2 (range, 0 to 4.2). The mean rate obtained during the SIBIS conditions represents a 99.7% reduction from baseline. The percentages of sessions terminated early due to risk, across conditions and settings, were: baseline, 63%; helmet, 80%; SIBIS inactive, 83%; SIBIS, 0.

Figure 6 presents data collected on behaviors that reportedly reflected Johnny's affective state. Compared to baseline, the SIBIS condition was associated with increases in behaviors suggestive of relaxation (hand posture, rocking, and panting) and a decrease in distressed vocalizations. A decrease in nondistressed vocalizations was also observed. Thus, it did not appear that the use of aversive stimulation produced any untoward emotional reactions; instead, Johnny seemed less agitated and much calmer while wearing SIBIS.

Follow-Up

When the controlled evaluation of SIBIS was completed, Johnny began wearing the device in his group home. This provided another opportunity to assess the effects of SIBIS under more naturalistic conditions, the results of which are shown in the upper panel of Figure 7. During a baseline in the group home (with helmet), Johnny's rates of head hitting were 3.9, 7.9, and 7.5 responses per minute, respectively, during 2-hr sessions on each of 3 suc-

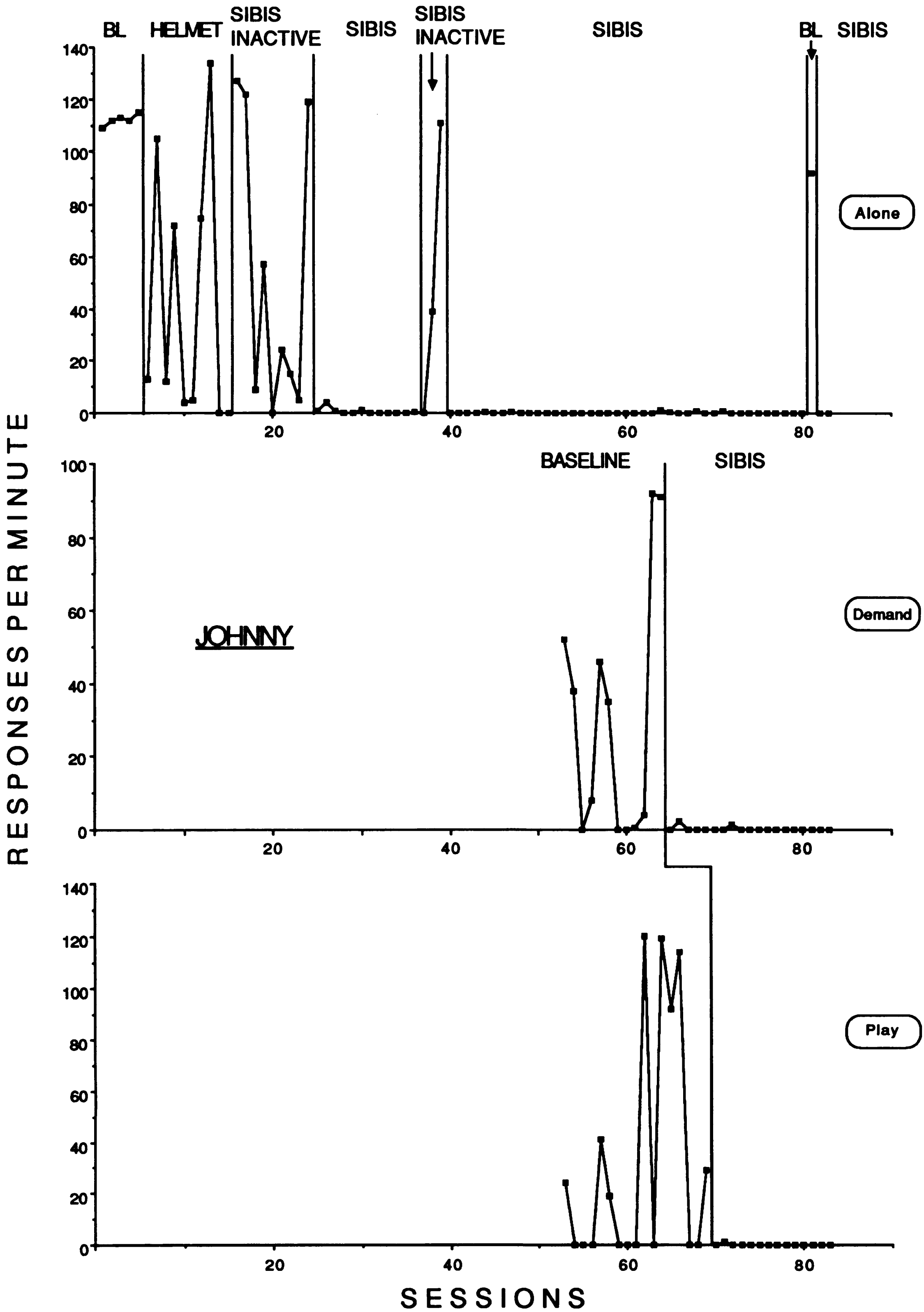


Figure 5. Head hits exhibited by Johnny during the experimental phase of his program.

cessive days. These rates were much lower than those obtained during in-clinic baseline sessions; this may have been due to (a) his greater familiarity with the environment and staff at the group home or (b) the fact that sessions were conducted over a much longer period of time, during which there was greater variation in his moment-to-moment rate of SIB. Following the baseline session on Day 3, SIBIS was placed on Johnny, and no hits occurred during the next 60 min. SIBIS was then removed for 10 min, during which Johnny struck himself 69 times. SIBIS was reapplied, and no hits occurred during the ensuing 50 min. Johnny again wore SIBIS on Days 4, 5, and 6 during routine training and leisure activities; one head hit occurred over the 6 hr distributed across 3 days. At this point, Johnny was allowed to wear SIBIS in his group home except when bathing or sleeping, and the group home staff continued to monitor his behavior carefully for 4 months. Johnny's head hitting reportedly remained well below 1% of his baseline level.

When school began in September, Johnny did not wear SIBIS during school hours for the first full day. SIBIS was worn during the morning of Day 2, removed in the afternoon, and worn for all of Day 3. Data (response frequency) were collected by his teacher, a behavior specialist at the school, and an experimenter. The results obtained during this in-school evaluation are shown in the bottom panel of Figure 7. Over 5,000 hits were recorded during the full- and half-day baselines (Days 1 and 2). No hits occurred during the half-day treatment on Day 2, and two hits occurred during full-day treatment on Day 3. The rate observed on Day 3 represents a 99.9% reduction from Day 1. During the 6 months that SIBIS has been fully utilized in Johnny's school setting (in conjunction with positive reinforcement procedures—praise, edibles, work breaks, etc.—to strengthen compliance and task completion), he has averaged 6.3 hits per hour (data collected by Johnny's classroom teacher and the SIBIS internal counter). Most of these are very light and are not likely to produce any physical injury; hits of sufficient force to activate SIBIS have averaged 1.4 per hour. These results compare favorably with records supplied by Johnny's school

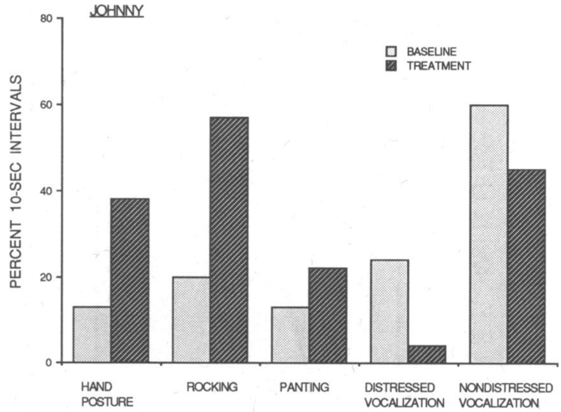


Figure 6. Johnny's behaviors indicative of affective state, recorded during baseline and SIBIS sessions.

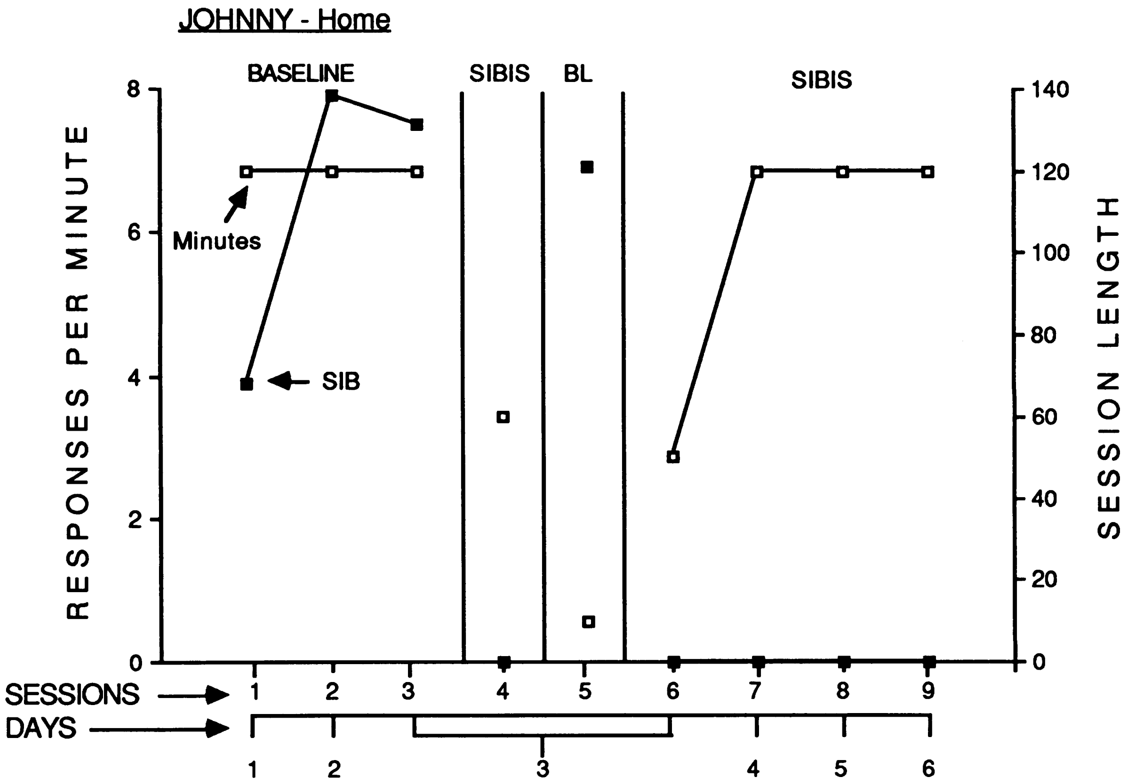
indicating that he averaged approximately 300 hits per hour during the previous year. During the current year, Johnny has made noticeable progress in a number of areas, has progressed from 1:1 to 1:3 teacher-to-student supervision during workshop activities, leaves his classroom for meals and other activities, and makes regular field trips in the community. Finally, because his SIB occurred at such a low rate and his behavior had improved so much generally, he was able to take an airplane trip to visit his parents in a distant state.

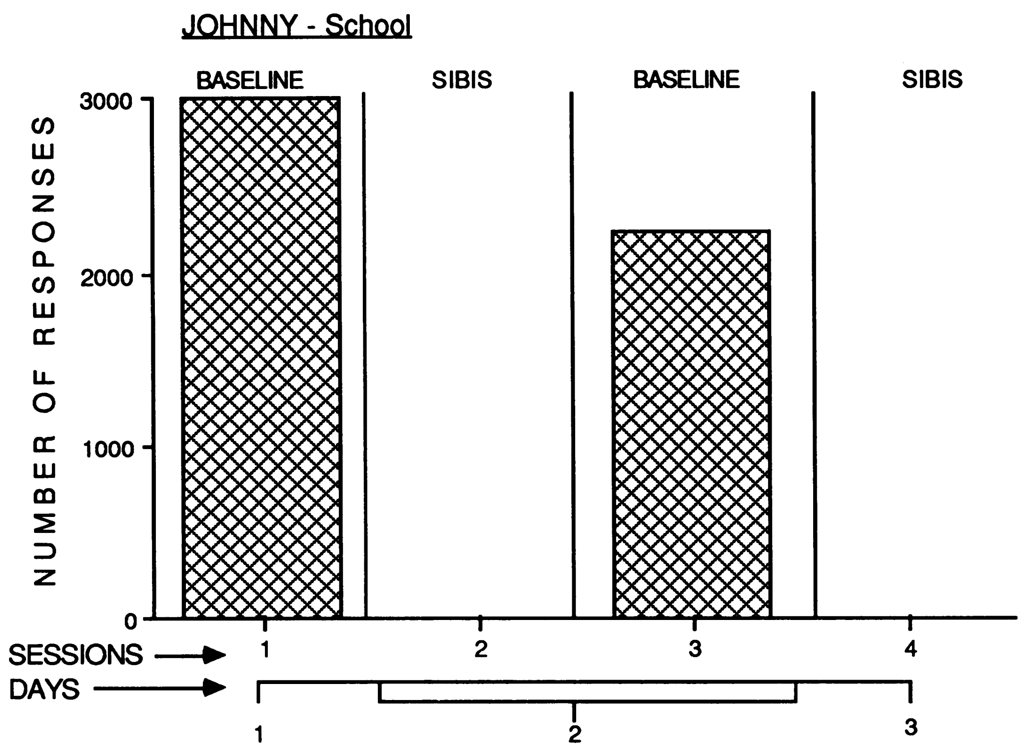
CASE 3

Method

Subject

Donna was a 17-year-old profoundly retarded female with no language, self-feeding, or independent toileting skills. She lived at home with her parents and attended a special school program. Donna's parents reported that her head hitting (which began more than 10 years ago) had produced numerous lesions on her face and head, particularly on the cheeks and ears. Donna's participation in the project was based on a joint referral from her parents and the school, both of whom indicated that many treatments, including differential reinforcement, gentle teaching and redirection, and response prevention, had been unsuccessful in reducing her SIB. For example, in order to prevent head hitting in bed, her parents had to


JOHNNY - Home
BASELINE
SIBIS
BL
SIBIS
RESPONSES PER MINUTE
SESSION LENGTH
Minutes
SIB
8
6
4
2
0
140
120
100
80
60
40
20
0
SESSIONS
1 2 3 4 5 6 7 8 9
DAYS
1 2 3 4 5 6


JOHNNY - School
BASELINE
SIBIS
BASELINE
SIBIS
NUMBER OF RESPONSES
3000
2000
1000
0
SESSIONS
1 2 3 4
DAYS
1 2 3

hold her arms each night until she fell asleep. This sometimes required 3 to 4 hr of undivided attention, which the parents felt they were unable to continue. At the time of the study, Donna, although ambulatory, spent most of her time during the day in a wheelchair, where her wrists were almost continually restrained to the arms of her chair in order to prevent SIB. When not in the wheelchair, she often was required to wear a helmet.

Response Measurement and Reliability

During each session, an observer recorded the number of times that Donna hit her head (defined as any forcible contact between hand and head or between head and object). A second observer conducted reliability checks during 17% of the sessions, and agreement ranged from 80% to 100%, with a mean of 95.5%.

Procedures

The effects of SIBIS were evaluated in a reversal design, in which Donna was exposed to baseline, SIBIS-inactive, and SIBIS conditions as described previously. During each session, Donna was seated in her wheelchair unrestrained in the presence of her parents, the observers, and the experimenter, although none interacted with her. Sessions lasted for 10 min or until she hit her head 25 times, whichever occurred first.

Results

Figure 8 shows the results obtained for Donna. In all but one session during the initial baseline and SIBIS-inactive conditions, Donna hit her head at least once per second (M = 68.1 and 70.2 responses per minute for these conditions, respectively). In contrast, her head hitting occurred 2.4 times per minute during the first session in which SIBIS was applied and decreased further on four subsequent sessions during this condition. Unlike the previous two cases, the next condition—a return

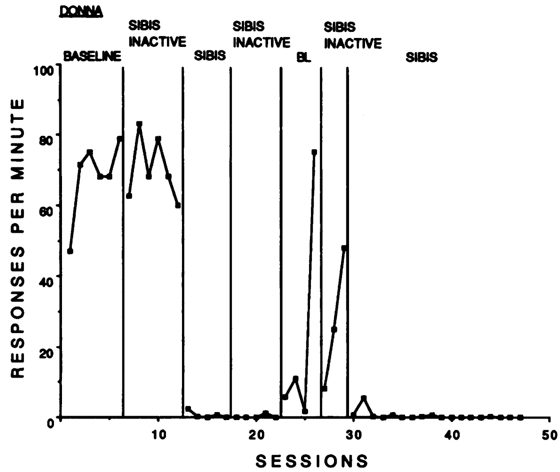


Figure 8. Head hits exhibited by Donna.

to SIBIS inactive—initially did not produce an increase in SIB. Baseline was then reinstated and was associated with an increase in Donna's head hitting to the original baseline level. Following this second baseline, SIBIS again was used in the inactive mode. Head hitting decreased during the first session of this condition but increased markedly during two subsequent sessions. During the final condition, Donna wore the operative SIBIS, and her head hitting quickly returned to a near-zero rate for 18 sessions. Her mean rates of head hitting (responses per minute) across similar conditions were: baseline, 50.2 (range, 1.7 to 78.9); SIBIS inactive, 32.5 (range, 0 to 48.0); and SIBIS, 0.5 (range, 0 to 5.6). Head hitting during the SIBIS conditions was reduced 98.9% from baseline; during these SIBIS conditions, Donna received 32 electrical stimulations lasting a total of 2.6 s. The percentages of sessions terminated early due to risk, across conditions, were: baseline, 100%; SIBIS inactive, 64%; and SIBIS, 0.

Follow-Up

Upon completion of treatment, SIBIS was used in Donna's school program. Prior to its introduction

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Figure 7. Head hits exhibited by Johnny during evaluations conducted in his group home (upper panel) and at his school (lower panel).

in this setting, data were taken during a brief baseline condition. Donna was released from her arm restraints; however, if she hit herself 40 times during any half hour, the restraints were reapplied until the beginning of the next half-hour interval. Using this procedure, a rate of 1.3 hits per minute was established over 1.5 days. On the first half-day treatment with SIBIS at school, Donna struck herself a total of 23 times in 2 hr and 40 min, resulting in a rate of 0.14 hits per minute. Of these 23 hits, only two were of sufficient intensity to produce stimulation, and Donna remained unrestrained for the entire time. On the first full day of treatment at school, Donna struck herself 94 times over 6 hr, but 89 of these responses were extremely light; they did not activate the SIBIS although they topographically met the definition of head hitting, and Donna remained out of restraint for the entire day. Only five of the hits produced stimulation, for an effective SIB rate of 0.01 per minute. Donna continued to wear SIBIS and remained out of restraint for the entire school year; during this time, her rate of SIB never exceeded 0.08 occurrences per minute.

In addition to the above data, anecdotal reports indicated that Donna's behavior improved greatly following treatment. The parents reported that she no longer had to be held in bed at night, and teachers reported general improvement in adaptive functioning. For example, the following quote is taken from progress notes made by Donna's teacher 6 weeks after Donna began to wear SIBIS in the classroom (these notes were made without knowledge that experimenters later would have access to them, so there is little reason to believe that the notes are biased):

> Since the introduction of SIBIS it is like we have a totally new girl in the classroom. Donna no longer has to have her hands restrained. She is walking around the classroom without the wrestling helmet or the cervical collar. She smiles more frequently and fusses a lot less. She pays more attention to what is going on in the classroom. She reaches out for objects and people more than she did.

CASE 4

Method

Subject

Michael was a 24-year-old profoundly retarded male with epilepsy. He was ambulatory but did not dress or toilet himself, use expressive speech, or respond to instructions or to his name. Michael fed himself only with assistance, often grabbing food and smashing it against his head. He also frequently refused edible reinforcement and resisted all attempts to teach him new behaviors by pushing therapists away or falling on the floor.

Mild head banging reportedly occurred as early as 3 years of age. Michael was admitted to an institution at age 9, and within a year his SIB of interest (head hitting and head banging) had produced noticeable bumps and scars. A comprehensive functional analysis of Michael's SIB (Iwata et al., 1982; Touchette, MacDonald, & Langer, 1985) was conducted in 1986, during which data were collected for over 45,000 10-s intervals distributed across time of day, activity, and location over a 2-week period. Results indicated that the only variable having any differential effect on the behavior was placement in his bed, which reduced the rate of SIB noticeably. All interventions based on this analysis, as well as all other attempts over the previous 5 years, were unsuccessful. Programs involving positive reinforcement failed for two reasons. First, Michael's high rates of SIB often yielded interresponse times shorter than 5 s, making it difficult to deliver any type of positive consequence without inadvertently reinforcing SIB. Second, no stimuli reliably served as positive reinforcers for his behavior, even though a wide variety of stimuli was assessed continually (Pace, Ivancic, Edwards, Iwata, & Page, 1985), ensuring that he experienced a number of social, activity, and sensory events.

During the year immediately prior to the study, programs consisting of noncontingent stimulation, sensory extinction, DRI, restraint, and overcorrection were implemented, and data were collected on SIB using a 10-s interval system. None of the programs produced a level of SIB lower than 38% of observed intervals.

At the time of this study, Michael had been wearing a protective helmet for 1 year. Visible damage from his SIB included multiple contusions and thickening of the skin on his forehead, ears, and hands and almost complete loss of hair on his head (which abated after he began wearing the helmet). Results of a medical consultation indicated that Michael's SIB probably was causing neurological damage. His inclusion in the study was based on a request from his mother and subsequent consultation with a psychiatrist and two psychologists.

Response Measurement and Reliability

During each session, an observer recorded the number of times that Michael hit his head (defined as any forcible contact between hand and head or between head and object). Independent observations were conducted during 32.5% of the sessions. During initial sessions, which lasted a maximum of 10 min (M = 8.8 min), interobserver agreement was assessed for the entire duration. Later, however (i.e., during the SIBIS-remote condition), session length was increased to up to 4 hr (M = 2.9 hr), and it was possible to have two observers present only during randomly selected portions of these sessions (M = 36.4 min per session). Agreement scores ranged from 74.6% to 100%, with a mean of 94.7%.

Procedures

Sessions were conducted in a classroom or on Michael's living unit, with his mother present during Sessions 51 through 119. The classroom was used to allow controlled observation with minimal distraction, whereas the living unit provided a context for naturalistic observation. These differences appeared to have no effect on Michael's behavior, and the results are not separated by setting. Sessions 1 through 18 were conducted on Michael's living unit, Sessions 19 through 142 were conducted in the classroom, and all subsequent sessions were conducted on the living unit. Sessions during the helmet baseline condition lasted for 10 min. Initially, sessions in which Michael did not wear a protective helmet lasted 10 min or until he hit himself 50 times, whichever came first. Beginning with Session 67, the 50-hit limit was discontinued, and beginning with Session 143, session length was gradually increased (based on experimenter availability) up to a maximum of 4 hr.

The effects of SIBIS were evaluated in a reversal design. Experimental conditions consisted of helmet baseline, baseline, SIBIS inactive, and SIBIS, as described previously. An additional condition (SIBIS remote) was included in which activation of the electrical stimulus was done by the therapist instead of the sensor module.

Results

Figure 9 shows the results obtained for Michael. The first three conditions—helmet baseline, baseline, and SIBIS inactive—produced similar results in that Michael's head hitting was quite variable and it occurred at high rates, with individual session values ranging from 0 to 201.5 (extrapolated) responses per minute (M = 44.3 per minute across the three conditions). His extremely high rates of hitting caused many sessions during these three conditions to be terminated before 10 min had elapsed; five sessions lasted for only 15 s. Introduction of the active SIBIS condition was associated with a noticeable reduction in the rate of Michael's hitting; however, some variability remained, and the overall rate during the beginning of this condition was still unacceptably high. Many of the hits were below the threshold for SIBIS, and it was felt that the continued occurrence of these hits in the absence of a contingency was sufficient to maintain more high-intensity hits as well. Therefore, beginning with Session 61, the SIBIS-remote system was used as an adjunct to the automated SIBIS. Subsequent to this change, Michael's hitting decreased further, and on Session 100, the remote was discontinued with little or no increase in SIB (M = 7.3 per minute for the entire condition; M = 1.0 per minute for the last 10 sessions). Reinstatement of the helmet baseline condition initially produced no change in Michael's hitting; after several sessions, however, the behavior increased noticeably, although not to its original baseline level (M = 7.0 per minute). Informally, it appeared that the helmet and the setting itself began to exert some stimulus control over Michael's SIB (e.g., his SIB decreased when he entered the treatment setting and increased after the session was over or when his helmet was removed briefly). Rather than extending the helmet baseline condition further or returning to a no-helmet baseline, a decision was made to continue treatment so that its effects could be evaluated over more extended periods of time. On Session 137, SIBIS was reintroduced, producing a delayed but eventual reduction in hitting to near-zero levels. During this condition, the occurrence of unintended shocks (i.e., false positives) was observed. For example, on several occasions it appeared that Michael accidentally hit the sensor module with sufficient intensity to trigger the device as he was about to scratch his head or when he pulled his shirt over his head. Because the elimination of all accidental sources of contact could not be eliminated from his living unit due to Michael's generally high level of motor activity, the sensor module was removed on Session 215 and only the SIBIS remote was used. Michael's hitting continued to decrease following this change in treatment and was virtually eliminated during most sessions. Because of the high degree of variability in Michael's previous data, the limited success of the initial reversal (helmet baseline), and the fact that treatment was no longer correlated with any device worn on the head, the helmet baseline was repeated beginning on Session 332 and was associated with a recovery of baseline levels of hitting. On Session 392, SIBIS remote was reintroduced and quickly eliminated the behavior. Michael's mean rates of head hitting across similar conditions of the study were: baseline, 47.5 (range, 0 to 200.0); helmet baseline, 27.3 (range, 0 to 214.2); SIBIS inactive, 58.1 (range, 0 to 188.0); SIBIS (including sessions in which SIBIS remote was used as an adjunct), 1.7 (range, 0 to 102.0); SIBIS remote, 0.1 (range, 0 to 1.0). The mean rate of SIB during the SIBIS-remote condition represents a 99.8% reduction from baseline.

During the initial conditions of this study (i.e., through Session 188), session length was limited to 10 min. Subsequent to implementation on Michael's living unit, session duration was increased such that, by the end of the formal data collection phase (SIBIS remote), session length averaged 214 min with most sessions lasting for 4 hr. The percentages of sessions terminated early due to risk are not available for all conditions because the 50-hit criterion for session termination did not apply to the initial helmet baseline and was eliminated completely during the first SIBIS condition. Sessions terminated early during the baseline and SIBIS-inactive conditions were 50% and 37.5%, respectively.

Unlike other subjects, Michael received a considerable number of shocks (3,640) during the course of treatment. It is important to note, however, that his rate of SIB prior to treatment was extremely high and that his experimental sessions were conducted within an extended time frame (total session time for all SIBIS conditions was 580 hr). Most of these shocks were delivered during early treatment conditions. For example, during the first SIBIS condition the mean rate of shock delivery was 2.9 per minute. By contrast, shock delivery averaged 0.01 per minute during the final SIBIS condition, and, on several occasions, Michael received no shocks over an entire 4-hr session.

Follow-Up

Once Michael's hitting was essentially eliminated, staff noted that he began attending to his physical surroundings and that he was much more responsive to social interaction and positive reinforcement; all of these represented significant changes in his behavior. As a result, he began to follow simple instructions, started sitting at a table to participate in training, stopped smashing food against his head during meals and began seeking out edible reinforcers, and acquired new self-help skills (e.g., pulling up his pants, independently drinking from a water fountain, feeding himself

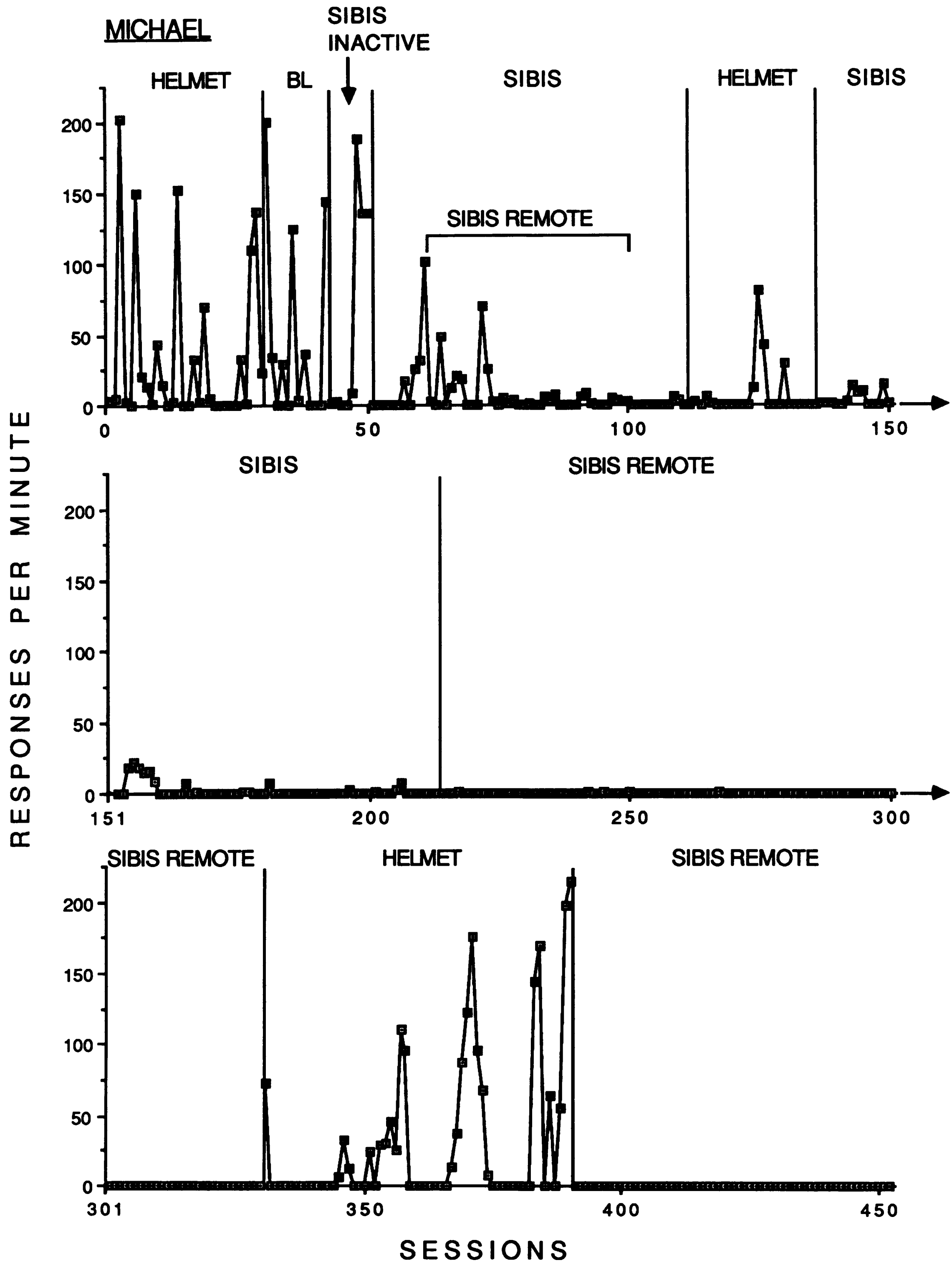

Figure 9. Head hits exhibited by Michael.

using proper utensils). In contrast, no negative side effects of treatment (e.g., withdrawal, increase in other inappropriate behaviors) were observed. These outcomes, although anecdotal, have been reported on numerous occasions by staff and can be found in his progress summaries.

Formal data (using methods described earlier) collected during the 14 months following termination of the study show continued maintenance of very low levels of SIB with SIBIS. For example, 25 sessions were conducted during June 1989, ranging in duration from 5.2 hr to 13.8 hr (M = 8.8 hr). During these sessions, Michael's SIB averaged 0.67 occurrences per hour. This rate can be contrasted with Michael's baseline rate of 2,849.4 hits per hour (extrapolated), resulting in an estimated prevention of over 25,000 hits during the average 8.8-hr session, or approximately 1,367,400 hits during a single 30-day period (assuming 16 hr per day). These extrapolated rates probably would not have been obtained in actuality, because Michael would have been restrained to prevent such excessive amounts of SIB. They are reported here, however, because they are reasonable predictions based on actual data, and they illustrate both the potential injury due to Michael's SIB as well as the reduction in SIB associated with SIBIS.

We are currently beginning to fade the electrical stimulation by establishing a conditioned stimulus and by moving from a continuous schedule of punishment to one involving differential punishment of high rates of SIB. The SIBIS unit has been modified to produce an audible tone each time it is activated, but electrical stimulation is delivered only if two or more activations occur with a 10-s interval.

CASE 5

Method

Subject

Diane was a 22-year-old female with diagnoses of severe retardation and autism. She was ambulatory, had adequate self-help skills, and could speak in simple phrases. Diane was admitted to an institution at the age of 8, and she had already begun to exhibit self-injurious head hitting and banging by that time. During her 13 years at the institution, she accumulated an extensive medical history of trauma to the head, face, and shoulders. Her head hitting and banging were of sufficient intensity to detach a retina and to produce cataracts that required surgical treatment. Also during that time, numerous drugs, including Lithium, Haloperidol, and other neuroleptic agents were administered in an attempt to reduce Diane's SIB. Only Loxitane (150 mg per day) was reported to be somewhat helpful, and she continued to receive it prior to and during this study. Other treatment approaches included stimulation activities (dance, music, and play therapy), noncontingent restraint, and behavioral programs (extinction of minor SIB, differential reinforcement, time-out, and contingent mechanical restraint). One program involving the use of DRI, time-out, and contingent restraint in a chair had resulted in some improvement prior to discharge from the hospital; however, Diane still spent a considerable amount of time in emergency restraint and exhibited over 70 episodes (extended bouts) of SIB per month.

Approximately 9 months prior to her participation in this study, Diane was transferred to a special unit of a mental retardation facility for intensive behavioral treatment. The unit provided a highly structured environment with all-day programming 7 days per week. A functional analysis (Iwata et al., 1982) indicated that more than 50% of Diane's SIB occurred in response to demands. Extinction of escape (Iwata et al., 1990) supplemented with response-contingent and brief (5 to 15 min) mechanical restraint (a belt with padded wrist cuffs) and differential reinforcement produced a 47% decrease in Diane's SIB; however, the procedure did not reduce head hitting and banging to a clinically acceptable level (i.e., episodes still occurred at a rate of 21 per month). This program with slight modifications (e.g., extension of restraint from 5 to 15 min) had been in effect for several months prior to the initiation of treatment with SIBIS and continued throughout the maintenance (post-SIBIS) period. Other forms of treatment involving physical intervention by a therapist (e.g., physical restraint) were ruled out because she had an extensive history of self-restraint and because her aggressive behavior (head butting) posed a danger to staff. The decision to include Diane as a subject in this study was made by her interdisciplinary team (including a physician), who felt that her continued SIB would produce loss of vision.

Response Measurement and Reliability

The frequency of SIB (defined as forceful contact between the hand or a held object and the head, or between the head and a stationary object) was recorded during continuous 15-s intervals. Independent observations were conducted during 48% of the sessions. Agreement percentages were calculated by dividing the number of agreements by the sum of agreements plus disagreements and multiplying by 100. Mean overall agreement was 99% (range, 90% to 100%), mean occurrence agreement was 81% (range, 64% to 100%), and mean nonoccurrence agreement was 99% (range, 88% to 100%).

Procedures

Sessions were conducted in a dayroom of the living unit. Diane was seated alone at a table, and no one else was present in the room except the experimenter and observers. As a safety precaution, sessions were terminated when 50 hits occurred.

The effects of SIBIS were evaluated in a reversal design. Conditions consisted of baseline, SIBIS inactive, SIBIS, and SIBIS remote, as previously described, with one exception. As part of a plan to promote maintenance and generalization of the treatment program, at least one staff member who worked regularly with Diane was present during the SIBIS remote sessions. These individuals intermittently delivered either edible items or praise on a DRO 30-s schedule. Additionally, the staff member delivered reprimands (e.g., "No hitting, Diane") contingent on the occurrence of SIB.

Results

Figure 10 shows the results obtained for Diane. Her SIB during the initial baseline ranged from 6.9 to 50 responses per minute, averaging 30.4.

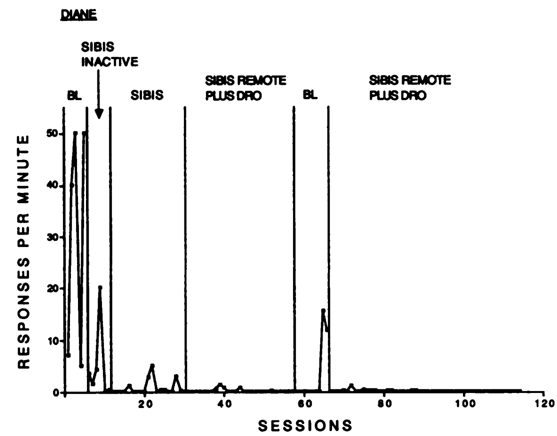

Figure 10. Head hits exhibited by Diane.

A reduction in both the variability and frequency of SIB was observed during the SIBIS-inactive condition (range, 0 to 20; $M = 4.9$). This decrease suggests the possibility of some stimulus control exerted by merely wearing the apparatus. The sensor module was worn under a baseball cap to make the device less conspicuous, and Diane had a history of wearing hats and caps as reinforcers. During this condition, Diane periodically touched and tapped the baseball cap and exhibited an increased frequency of stereotypic behaviors, all of which competed somewhat with SIB. Nevertheless, she still engaged in forceful head and face hitting. The introduction of SIBIS was associated with a further decrease in SIB. Toward the latter part of this condition, however, it appeared that some of Diane's potentially injurious hits were not detected by the sensor (false negatives). This was particularly true for responses involving striking the nose from the front, which may have afforded a cushion that reduced the force of the response at the site of the sensor (on the head). Because forceful hits to the nose were not always detected, and because the sensor module could not be calibrated to be differentially sensitive, the therapist-activated SIBIS remote plus DRO condition was initiated. Throughout this condition, SIB remained at near-zero rates. A delayed increase in SIB was observed during a return to the baseline condition, followed by immediate and sustained suppression during the final SIBIS remote plus DRO condition. Diane's mean rates of SIB (responses per minute) across similar conditions were: baseline, 16.6 (range, 0 to 50.0); SIBIS inactive, 4.9 (range, 0 to 20.0); SIBIS, 0.7 (range, 0 to 5.0); and SIBIS remote + DRO, 0.1 (range, 0 to 1.3). The level of SIB observed during her final treatment condition represented a 99.4% reduction from baseline.

Diane received a total of 37 shocks during treatment (all SIBIS conditions). The percentages of sessions terminated early due to risk were: baseline, 42.9%; SIBIS inactive, 0; SIBIS (including remote), 0. During the final condition of the study, Diane's psychiatrist felt that the reduction in her SIB produced by SIBIS eliminated the need for continued high dosages of medication. Therefore, her prescription for Loxitane was reduced from 150 mg to 100 mg on Session 89 and to 50 mg on Session 109.

Follow-Up

Since the completion of Diane's evaluation, the SIBIS remote has been used on a regular basis in her classroom and on her living unit, although application has been limited to situations in which a psychologist is present. This limited use, nevertheless, has had beneficial effects. During 459 10-min follow-up sessions conducted on her living unit and in her classrooms, Diane's mean rate of SIB has been 0.06 responses per minute.

During the 7 months prior to Diane's SIBIS program, she engaged in 142 episodes of SIB requiring the use of restraint. In the 17 months since the last evaluation session depicted in Figure 10, Diane has exhibited only 61 such episodes at times when SIBIS is not worn, resulting in a reduction of restraint use from 20.3 episodes per month (pre-SIBIS) to 3.3 per month (post-SIBIS). This reduction in SIB cannot be attributed to the presence of SIBIS per se or to Diane's behavioral treatment program (described earlier), which is implemented during both SIBIS and non-SIBIS portions of the day, because the behavior change has occurred during non-SIBIS times and the program was implemented prior to the use of SIBIS. Thus, there appears to have been a generalization of treatment effects to times when SIBIS is not worn.

Based on Diane's rate of SIB and the intrusive methods necessary to prevent serious injuries prior to the study, the beneficial effects of SIBIS include (a) greater than 99% reduction in SIB from baseline, (b) a reduction in drugs by over 51,000 mg over the past 17 months, (c) the prevention of 290 emergency restraint episodes during the same period, and (d) a reduction in injury-producing SIB from 2.2 per month (pre-SIBIS) to 0.7 per month (post-SIBIS). Finally, staff reported that, following treatment with SIBIS, noticeable improvements have been seen in Diane's response to instruction, in her ability to sit along for brief amounts of time without engaging in any SIB (e.g., waiting for meals), and in her general level of social interaction. Based on these improvements in Diane's behavior and the reductions in SIB and the need for restraint, she has been able to participate in community activities that were precluded prior to the use of SIBIS.

GENERAL DISCUSSION

Results obtained in the present study indicated that brief and relatively mild electrical stimulation produced rapid and large decreases in severe, longstanding, and previously untreatable SIB. Additionally, formal and anecdotal data indicated a general absence of negative side effects associated with treatment, whereas a number of positive side effects were observed. We do not suggest that similar results would be obtained in all cases; however, the varying conditions under which treatment was delivered (e.g., across clients, experimenters, activities, and settings) lend some degree of generality to the findings reported here.

The clients who participated in this study were considered appropriate for inclusion only because their SIB was severe and had not been successfully treated after many years of intervention. Nevertheless, their SIB responded very quickly to the administration of SIBIS, such that the actual duration of electrical stimulation needed to virtually eliminate the behavior amounted to no more than a few seconds for 4 of the 5 subjects. The relative merits of electrical stimulation versus other aversive stimuli should be considered in light of these results.

Shock is certainly an intrusive procedure, and its use typically is justified only when other aversive procedures have failed and the alternative outcome is potentially irreversible injury. However, our experience with SIBIS, as well as that of others who have worn the device briefly, suggests that certain types of electrical stimulation may be the treatment of choice even if other supposedly less intrusive inventions might be effective. For example, most individuals who have received a shock from SIBIS indicated that they consider the procedure less aversive than tastes (e.g., lemon juice and tabasco sauce), ammonia, overcorrection, or restraint. The continued categorization of procedures as more or less aversive as a class, therefore, does not seem warranted given the wide degree of within-class variation that exists. It is probably assumed that electrical stimulation is both highly effective and intrusive because it is more painful than other punishing stimuli. Intensity, however, is not the only variable contributing to the effectiveness of a punishing stimulus. Immediacy of delivery, inability of the subject to avoid or escape from the punishing stimulus, the temporal separation between punishing and potentially reinforcing stimuli, and a number of other characteristics may affect the outcome of punishment (Azrin & Holz, 1966). The apparatus used in this study delivered immediate, inescapable, remotely applied, and precisely quantified stimulation. Therefore, although there are no data with humans on response suppression under varying shock parameters, it is quite possible that stimulus intensity can be decreased if other parameters are maximized.

In addition to the major issue of intrusiveness and effectiveness, questions regarding generalization, maintenance, and potential for misuse are important when considering the use of punishment and have been addressed partially in the present study. With respect to response generalization, the only potentially negative side effect was a slight increase in noninjurious pinching in 1 subject (Marie). In contrast, all 5 subjects appeared more calm while wearing SIBIS (this was measured quantitatively for Johnny) and began to exhibit a number of positive behaviors (e.g., increased sociability, responsivity to reinforcement, cooperation during instruction, and acquisition of new behaviors) as their SIB decreased. In spite of continuing concerns over the potential negative side effects of punishment, our findings are consistent with previous reviews of the literature indicating that positive side effects generally outnumber negative side effects (Lichstein & Schreibman, 1976; Newsom, Favell, & Rincover, 1983).

Stimulus generalization—whether or not SIBIS could be removed or faded while maintaining a therapeutic effect—was not addressed systematically. Our failure to obtain either immediate or complete reversals during several control conditions (i.e., the second SIBIS-inactive condition for Donna, the second and third helmet conditions for Michael, and the return to baseline for Diane) suggests that some generalization may have occurred; however, continuation of these conditions or subsequent repetitions were associated with near-baseline levels of SIB. On the other hand, programmed efforts at stimulus fading or establishing conditioned punishment effects seem possible and would be aided by a particular feature built into the design of SIBIS. Concurrent with the delivery of electrical stimulation, the stimulus module emits a tone audible to the client. As noted previously, the relationship between the occurrence of SIB, the tone, and shock can be programmed according to different schedules. Thus, it is possible that the tone or some other event (e.g., verbal reprimand, as was used with Diane) could acquire punishing properties, thereby allowing eventual delivery of the shock on a highly intermittent schedule or perhaps even its complete discontinuation. This approach was not taken in the present study because, in three of the four cases in which SIBIS was continued after formal data collection, there was no desire on the part of parents or guardians to eliminate SIBIS. Other approaches that might be considered include use of the SIBIS remote and stimulus fading, which has been used with other forms of mechanical restraints (Pace, Iwata, Edwards, & McCosh, 1986).

Follow-up data for 4 of the 5 subjects indicate that the suppressive effects of SIBIS are enduring in that no habituation to the stimulus has been observed months after the initiation of treatment. Because the stimulus is relatively mild, one might expect it to lose its aversive properties over time. It is not clear why the chronic SIB of clients in this study did not show any relapse; perhaps it is due to some combination of stimulus specificity, limited exposure, and other factors (i.e, immediacy, inescapability) noted earlier.

Electrical stimulation, like all forms of both punishment and positive reinforcement, is subject to misuse and should be carefully regulated. Because SIBIS poses no physical risk, the consequences of misuse are probably no greater than those for other interventions. In addition, the independent counter contained in SIBIS makes unauthorized use of the device readily detectable, because it allows a comparison between the number of stimulations recorded by staff and those recorded by the device itself.

Although the data presented in this study indicate that SIBIS was extremely effective, the device contains some limitations that should be mentioned. Most seriously, false positives (shocks following the nonoccurrence of SIB) may result from several sources. Accidental but forceful bumping, extremely rapid head movement, and aggressive blows to the head delivered by another may be of sufficient intensity to trigger the device. A number of calibrations were conducted during the development of SIBIS, including its use by tennis players who did not experience shocks during the normal course of play. It was impossible, however, to control for all sources of accidental contact, and these should be monitored closely. Ordinarily, altering the sensitivity of the impact detector should be satisfactory; if not (as was the case with Michael), automated stimulus delivery should be abandoned in favor of remote application. A related problem occurs when the impact detector fails to recognize a potentially self-injurious response (false negatives). This is certainly true for all forms of SIB that do not involve forceful contact (e.g., biting, scratching, etc.), but may also apply to banging and hitting under certain conditions. For example, it was noted that Diane's nose punching appeared to cushion the impact; a similar situation might arise in the rare event that an individual held his or her head against a stationary object (e.g., wall or floor) while hitting. In either case, the automated use of SIBIS does not permit consistent detection of the response and subsequent delivery of the punishing stimulus, and the remote method of application should be used. A third problem arises if clients attempt to remove the apparatus during treatment. Although subjects in this study were observed to touch the stimulus module periodically, they never attempted to remove it in response to receiving a shock (Diane attempted to remove the device twice after periods of extended wear but not after being shocked, and she did not succeed in taking the device off). A straightforward interpretation suggests that the stimulus was sufficiently aversive to punish SIB but not to produce escape behavior. Alternatively, perhaps the subjects did not know how to remove the device. The latter explanation, although perhaps more appealing, is inconsistent with the fact that the subjects did not exhibit any other escape behaviors during treatment. Nevertheless, it is possible that some individuals might attempt to remove the apparatus; this can be made more difficult by placing the devices under clothing or other equipment.

Although SIBIS was originally conceptualized as an electrical stimulator, subsequent efforts have been aimed at using the same technology to improve the manner in which positive reinforcement is delivered. In its current form, SIBIS has the capability of programming DRO intervals from 1 to 999 s in duration according to either fixed- or variable-time schedules, to monitor whether or not SIB has occurred during an interval, to cue the therapist to deliver reinforcement at the end of an interval, to record successfully completed intervals, and to deliver automated reinforcement via radio signal to an electrical device (e.g., stereo, television, food dispenser, etc.). SIBIS also can be used in a time-out mode to terminate ongoing events (e.g., television) contingent on the occurrence of SIB. These positive reinforcement and time-out components can be used in conjunction with or completely independent of the punishment component. Thus, in addition to examining issues such as stimulus fading and conditioned punishment, future research should determine whether improved delivery of positive reinforcement might increase its relative effectiveness when applied as the sole treatment for serious behavioral disorders such as SIB. For example, a significant practical limitation in treating high-rate SIB with DRO lies in the use of short-duration intervals (e.g., 10 s or less), which make it extremely difficult to deliver reinforcement in a precise and consistent manner. Automated interval programming and reinforcement delivery might make the use of such reinforcement schedules more feasible.

In closing, we emphasize again that SIBIS is not intended to be used as the first or the only means of treating SIB. Indeed, the aversive components of SIBIS may be appropriate only as a default technology, to be used with a small percentage of cases involving the treatment of severe self-injurious or aggressive behavior (Iwata, 1988). SIBIS should not be considered as a replacement for comprehensive assessment and treatment, independent of positive reinforcement programs aimed at increasing appropriate behavior, or in the absence of close professional supervision. In addition, compliance with regulations on the use of restrictive or aversive behavioral treatment must be ensured prior to using SIBIS. These aspects are of paramount importance in the treatment of problems such as SIB, and they are among a client's basic rights to effective behavioral treatment (see Van Houten et al., 1988). Nevertheless, given that legal, professional, and scientific standards are maintained, data from the present studies indicate that SIBIS (and, more generally, contingent electrical stimulation) can be a very effective and safe intervention whose limited use should not be abandoned. Accordingly, under certain conditions, access to carefully evaluated technologies of aversive stimulation is also one of a client's rights to effective treatment.

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