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THE FUNCTIONS OF SELF-INJURIOUS BEHAVIOR: AN EXPERIMENTAL-EPIDEMIOLOGICAL ANALYSIS

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Data are summarized from 152 single-subject analyses of the reinforcing functions of self-injurious behavior (SIB). Individuals with developmental disabilities referred for assessment and/or treatment over an 11-year period were exposed to a series of conditions in which the effects of antecedent and consequent events on SIB were examined systematically by way of multielement, reversal, or combined designs. Data were collected during approximately 4,000 experimental sessions (1,000 hr), with the length of assessment for individuals ranging from 8 to 66 sessions (M = 26.2) conducted over 2 to 16.5 hr (M = 6.5). Differential or uniformly high responding was observed in 145 (95.4%) of the cases. Social–negative reinforcement (escape from task demands or other sources of aversive stimulation) accounted for 58 cases, which was the largest proportion of the sample (38.1%). Social–positive reinforcement (either attention or access to food or materials) accounted for 40 (26.3%) of the cases, automatic (sensory) reinforcement accounted for 39 (25.7%), and multiple controlling variables accounted for 8 (5.3%). Seven sets of data (4.6%) showed either cyclical or inconsistent patterns of responding that were uninterpretable. Overall results indicated that functional analysis methodologies are extremely effective in identifying the environmental determinants of SIB on an individual basis and, subsequently, in guiding the process of treatment selection. Furthermore, an accumulation of assessment data from such analyses across a large number of individuals provides perhaps the most rigorous approach to an epidemiological study of behavioral function.

DESCRIPTORS: epidemiology, functional analysis, self-injurious behavior

Self-injurious behavior (SIB), a debilitating disorder common among individuals with mental retardation and related disabilities, has been the subject of considerable research for over 20 years; progress toward finding more effective approaches to its management was a major focus of a consensus development conference sponsored by the National Institutes of Health in 1989 (U.S. Department of Health and Human Services, 1991). The consensus panel concluded that, although much is known about SIB at the present time, thorough understanding and eventual reduction in the frequency of SIB will require continued research on all aspects of the disorder, including prevalence, etiology, treatment, and prevention.

In an attempt to define the general parameters of SIB as a clinical disorder, a number of investigators have conducted group surveys using methods

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derived from the field of epidemiology, which focuses on the distribution and determinants of disease within the population (e.g., see Sackett, Haynes, Guyatt, & Tugwell, 1991). For example, the descriptive characteristics of SIB have been well established through a series of studies on incidence or prevalence. Johnson and Day (1992) recently examined data from 34 epidemiological surveys and summarized the findings along several dimensions, including overall frequency and distribution of SIB according to subject characteristics (e.g., gender, age, handicapping condition), response characteristics (e.g., topography, frequency), and other variables such as residential setting, frequency of drug administration, and so on.

Closer examination of these studies reveals that several attempts have been made to identify the functional characteristics of SIB (i.e., its environmental determinants), which have been of interest to clinicians and researchers for many years, but more so since the publication of Carr's (1977) theoretical analysis of the origins of SIB. Results of experimental research conducted both before and subsequent to Carr's review suggest that much of SIB is learned behavior, acquired through an individual's history of interaction with the social and/or physical environment. Thus, an analysis of the conditions that produce or maintain SIB may provide valuable information relevant to both treatment and prevention. If social interactions of a specific nature or other environmental arrangements account for significant proportions of SIB observed in a given population (i.e., having a high prevalence), steps may be taken to minimize their occurrence.

To date, almost all available data on environmental or other correlates of SIB in large subject samples have been collected by way of questionnaires. In studies of this type, those who worked with or cared for self-injurious individuals (usually staff members in institutions) were asked to identify events surrounding the occurrence of SIB. Although questions often were posed in terms of operant mechanisms such as positive reinforcement in the form of attention or negative reinforcement in the form of escape (e.g., Griffin, Williams, Stark, Altmeyer, & Mason, 1984), all such studies included antecedent variables that would be difficult to observe reliably and consequent events that often represented attempts to stop SIB rather than potential sources of reinforcement. For example, in the largest and most extensive study reported in the literature, Maurice and Trudel (1982) asked staff members to describe antecedent as well as consequent events related to the occurrence of SIB in 403 individuals residing in three Canadian institutions. Antecedent variables consisting of "frustration" (33.7%), "refusal" (32%), "no identifiable circumstances" (24.3%), "anger" (19.9%), and "agitation" (16.6%), and consequent events consisting of "verbal reprimand" (44.7%), "restraint" (20.6%), "isolation" (17.1%), and "other" (16.6%) were the events most frequently reported to be contiguous with SIB (i.e., each was identified for over 15% of the sample).

Observational analysis provides a more direct method for identifying environmental correlates of SIB; however, very few observational studies have been conducted due to the extensive amount of time required to collect such data. Moreover, the available results pose a number of interpretive problems, as illustrated in the three largest studies reported to date. Schroeder et al. (1982) conducted observations in a day-treatment program serving 15 self-injurious individuals living in a state residential facility. Their observation system permitted quantification of numerous aspects of both client and staff behavior, and their data presentation was extensive. However, the purpose of the study was to describe changes in behavior within the context of an ongoing treatment program; thus, the data did not characterize a typical environment in which SIB might occur or how staff might usually react to such behavior. As part of the Maurice and Trudel (1982) prevalence survey, naturalistic observations of 36 individuals were conducted at various times throughout the day to establish correlations between the occurrence of environmental events and SIB. No relevant events were identified for 12 subjects. For the remaining 24, the events were never described, and data were merely summarized as frequency of antecedent and consequent vari-

ables. Similar results were reported by Edelson, Taubman, and Lovaas (1983). After conducting 5-hr observations for each of 20 self-injurious residents of an institution, Edelson et al. found low correlations between SIB and staff interaction as a consequent event but high correlations between SIB and staff interaction as an antecedent event. However, the potential influence of antecedent staff interaction cannot be determined because topographical (and, most likely, functional) variations in staff interaction were collapsed in the data analysis. That is, the presentation of demands, removal of positive reinforcers, and delivery of reprimands were scored as the same class of interaction.

Finally, Wiesler, Hanson, Chamberlain, and Thompson (1985) used a combined approach in an attempt to identify the most common consequences for SIB among 23 individuals residing in one institution. After administering a questionnaire on which staff indicated the extent to which SIB was or was not followed by staff attention, escape from tasks, or no consequences, they conducted observations to verify these reports. Results indicated modest interobserver agreement on questionnaire responses (73%) and that the consequences attributed to SIB were about equally divided among the three possible choices.

Further refinements in the use of both interview and observational procedures might greatly enhance our understanding of the circumstances under which SIB occurs. At the same time, research on the experimental analysis of SIB has yielded another methodology for precisely identifying its reinforcing functions. Based on Carr's (1977) analysis and on research demonstrating the effects of both attention (Lovaas & Simmons, 1969) and escape (Carr, Newsom, & Binkoff, 1976) as reinforcing consequences, Iwata, Dorsey, Slifer, Bauman, and Richman (1982) described an experimental methodology for studying the operant function(s) of SIB. In the Iwata et al. study, individuals were exposed to a series of conditions in which establishing operations (the presence or absence of attention, leisure materials, or task demands) and reinforcement contingencies (attention or escape) were arranged in multielement designs. Differential responding was correlated with a particular test condition in 6 of the 9 subjects. These data suggested that assessment methodologies based on a functional (experimental) analysis of behavior might be useful in identifying the source(s) of reinforcement for SIB and, subsequently, in developing more effective treatment procedures designed specifically to eliminate or alter the contingency found to be responsible for maintenance of SIB.

Both the utility and generality of functional analysis procedures have been established in numerous studies that have examined the effects of a variety of variables across response topography, subject population, and setting (e.g., see Iwata, Vollmer, & Zarcone, 1990, and Mace, Lalli, & Lalli, 1991, for recent reviews). Although the focus of this research has been on assessment and treatment of individual behavior, a recent study by Derby et al. (1992) suggests another use for functional analysis methodologies. Derby et al. summarized data for 79 individuals referred to an outpatient clinic over a 3-year period for management of behavior problems such as SIB, aggression, stereotypy, and property destruction. As part of the evaluation process, brief observations (i.e., 90 min per subject) were conducted under environmental conditions similar to those described by Iwata et al. (1982). The primary focus of the study was on the extent to which their brief functional analyses produced outcomes leading to the development of effective treatment recommendations. However, the general approach used by Derby et al. suggests that an accumulation of experimental data over time across a large subject sample might provide the only means of conducting an epidemiological study of behavioral function, because such data would be impossible to collect over the short intervals of time usually devoted to studies of incidence or prevalence.

During the course of our research on SIB, we have routinely conducted functional analysis baselines as a means of selecting individuals for inclusion in studies on the relationship between various treatment procedures and specific maintaining contingencies. Thus, the outcomes of intervention reported in numerous studies provide some evidence of validity for our approach to identifying behav-

Table 1
Demographic Characteristics of Subject Sample (N = 152)

	Number	%
Sex		
female	65	42.8
male	87	57.2
Age		
1–10	39	25.7
11–20	39	25.7
21–30	29	19.1
31-40	32	21.0
41–50	11	7.2
51+	2	1.3
Degree of retardation		
mild/moderate	10	6.6
severe	37	24.3
profound	105	69.1
Sensory impairment		
visual	8	5.3
auditory	3	2.0
Genetic or medical conditions		
cerebral palsy	47	30.1
congenital rubella	1	1.3
Cornelia de Lange	2	1.3
Down	9	5.9
fetal alcohol	2	1.3
Hirschsprung	2	1.3
hydrocephalus	4	2.6
Lesch-Nyhan	1	0.7
PKU	2	1.3
Rett	3	2.0
seizures	22	14.5
Residence		
natural home	49	32.2
foster/group home	20	13.2
institution	83	54.6

ioral function. In order to establish an epidemiological data base on the reinforcement contingencies that maintain SIB, we present in this study the results from extended functional analyses of SIB for 152 individuals. In addition, a summary of treatment data is presented relating the effects of various interventions to behavioral function.

METHOD

Subjects, Settings, and Experimenters

Subjects consisted of all individuals referred for either evaluation or evaluation and treatment over an 11-year period (1982–1986 and 1988–1993). Of the 156 individuals who completed assessment, 4 were excluded from the sample (3 exhibited no SIB throughout the evaluation, and 1 exhibited a form of SIB [aerophagia] that could not be observed reliably). Data from all remaining cases (N = 152) were included in the present analysis. The demographic characteristics of this sample are summarized in Table 1.

The assessments were conducted while subjects were inpatients in a pediatric hospital or living in a state residential facility. Sessions were conducted two to eight times per day based on subject and experimenter availability, usually 5 days per week, in individual therapy rooms containing furniture and equipment necessary to run a particular type of condition (see below). All experimenters had prior training in the assessment and treatment of SIB under supervision of one of the first three authors, and all observers met a minimum criterion of 90% interobserver agreement prior to the collection of formal data. Educational backgrounds of experimenters and observers ranged from the BA to the PhD level.

Human Subjects Considerations

Assessment protocols were approved by institutional human subjects committees, and informed consent was obtained for participation. All subjects were deemed eligible for inclusion based on prior examination by either a physician or a nurse, through which it was determined that subjects could be allowed to engage in SIB for brief periods of time without being exposed to undue risk. As an additional protection from risk, sessions were not conducted or were terminated if subjects met one of several criteria defined by either extent of injury or number of responses. Less than 2% of all sessions were terminated due to risk, although on numerous occasions subjects' SIB produced wounds (such as contusions and small lacerations) that required either no treatment or minor wound care (cleaning and topical dressing).

Response Measurement and Reliability

Topographies of SIB and response definitions used by observers are listed in Table 2. Data were

Table 2
Response Topographies, Definitions, and Sample Distribution[a]

Topography	Definition	Number of subjects	%
Banging (body)[b]	audible or forceful contact of the body against a stationary object	10	6.6
Banging (head)	audible or forceful contact of the head against a stationary object	66	43.4
Biting	closure of upper and lower teeth on any part of the body	56	36.8
Choking (neck)	forceful closure of both hands around the neck	2	1.3
Hitting (body)[b]	audible or forceful contact of one body part against another	25	16.4
Hitting (head)	audible or forceful contact of a body part against head or face	88	57.9
Kicking (body)[b]	audible or forceful contact of foot against another body part	7	4.6
Kicking (head)	audible or forceful contact of foot or knee against head	2	1.3
Mouthing (hand)	contact of fingers or hand against lips or tongue	13	8.5
Pica	ingestion of a nonfood item	2	1.3
Pinching	forceful grasping of skin between fingers	11	7.2
Poking (ear)	forceful contact of a finger inside the ear	7	4.6
Poking (eye)	forceful contact of a finger within the ocular area	12	7.9
Pulling (hair)	closure of fingers on hair with a pulling motion	5	3.3
Scratching	raking the skin with fingernails or rubbing against objects	24	15.8
Self-restraint[c]	entanglement of limbs in each other, clothing, or other material	11	7.2

[a] Numbers and percentages do not correspond to the total sample size because many subjects exhibited more than one topography of SIB.
[b] Banging, hitting, and kicking the body excluded contact with the head.
[c] Included preference for wearing mechanical restraints.

collected using either paper and pencil during consecutive 10-s intervals cued by cassette tape or on a hand-held computer with an internal clock (Assistant Model AST102, Hewlett-Packard Model HP-71B, or Panasonic Model RL-H1800). All data were converted to percentage of 10-s intervals during which one or more SIBs occurred (different topographies were not counted separately in the present analysis). Data were also collected on a variety of other subject and experimenter behaviors for treatment or research purposes and are not presented here. Relevant to this study, measures were taken of experimenters' interactions with subjects as both antecedent and consequent events (e.g., delivery of instructions and attention); these data were used for training new experimenters and for assessing procedural consistency. Accuracy percentages for experimenter behavior ranged from 72% to 100% (M = 92.5%).

Interobserver agreement was assessed by having a second observer collect data simultaneous with but independent of the first observer. Agreement was calculated based on interval-by-interval comparison of observers' records, in which the number of scoring agreements was divided by the number of agreements plus disagreements and multiplied by 100%. The percentage of sessions during which agreement was assessed for individual subjects ranged from 2.9% to 79.6% (M = 34.7%) and in all but two cases exceeded 15% of the total sessions. Mean interobserver agreement for individual subjects ranged from 83.3% to 100% (M = 94.9% across subjects).

General Characteristics of Test and Control Conditions

Each subject was exposed repeatedly in 15-min sessions to a series of three to eight different test and control conditions that were designed to assess behavioral sensitivity to potential sources of reinforcement for SIB: social–positive reinforcement (attention or access to either food or leisure materials), social–negative reinforcement (escape from academic, work, or similar task demands), and automatic reinforcement (sensory stimulation directly produced by the response, independent of the social environment). The manner in which each condition was implemented remained fairly constant across subjects with only minor variations in procedure; however, the specific stimuli (e.g., lei-

sure materials, work tasks, etc.) used during a given condition varied considerably across subjects based on the outcome of informal observations conducted before the assessments began.

Each test condition contained three elements to increase the likelihood of responding, given that SIB was maintained by a given contingency: (a) an establishing operation (see Michael, 1982, 1993, for an extensive discussion) consisting of either deprivation or aversive stimulation, (b) one or more discriminative stimuli (experimenter, therapy room, etc.) correlated with reinforcement, and (c) a contingency for occurrences of SIB. By contrast, control conditions contained none of these characteristics. Subjects were initially exposed to two to three test conditions (attention, demand, and/or alone) and a control (play). Additional test or control conditions were added as necessary to isolate more clearly the effects of some unusual circumstances under which SIB would or would not occur. Rationales for using particular test and control conditions are presented below.

When the study began, experimenters were rotated randomly across conditions to minimize any potential influence of experimenter-specific effects. Examination of session-by-session data for those subjects revealed the absence of such effects. However, it appeared that this practice may have hindered some subjects' ability to discriminate among the different conditions. Thus, throughout most of the study, experimenters were uniquely paired with a specific condition for a given subject. Other procedures used occasionally to enhance subject discrimination included running different sessions in specific rooms, having experimenters wear different colored shirts, and sequencing test and control conditions in a specific order (see below under Experimental Designs).

Test Conditions for Social–Positive Reinforcement

Numerous terms have been used to describe this broad contingency, including *edible, material, social,* and *tangible.* The feature common to these reinforcing events is social interaction, because their availability is almost always confounded with attention (i.e., these items never appear from "nowhere"; they are given by individuals). Describing SIB as maintained by a different stimulus (e.g., food) seems reasonable only if it can be shown that food maintains SIB *independent* of the attention with which it is delivered. The contingency remains a social one, however, because reinforcement is mediated through another's actions (i.e., SIB does not directly produce food, and hence cannot be considered automatic reinforcement). Thus, in our basic test condition for social–positive reinforcement, only attention was used as the consequence for SIB, and additional conditions (food, materials) were not conducted if this test produced positive results.

Attention. The experimenter and subject were in a therapy room containing a variety of leisure materials conveniently located. At the beginning of the session, the experimenter either commenced a solitary activity (e.g., reading) immediately or first informed the subject that "I am here if you need me." Contingent on the occurrence of SIB, the experimenter briefly attended to the subject by expressing disapproval and concern (e.g., "Stop, don't do that. You'll hurt yourself") and providing physical contact in the form of response interruption, a pat on the shoulder, and so on. All other responses exhibited by the subject were ignored.

Food. At the beginning of the session, the experimenter either showed food to the subject or delivered a small portion noncontingently. Thereafter, the experimenter delivered food to the subject contingent on occurrences of SIB but ignored all other behaviors.

Materials. At the beginning of the session, the experimenter gave the subject one or more leisure materials noncontingently, allowed the subject to manipulate the items for 10 to 30 s, and then withdrew them (but kept them nearby). The items were re-presented to the subject contingent on occurrences of SIB, whereas all other behaviors were ignored.

Test Conditions for Social–Negative Reinforcement

This contingency involves escape from ongoing social stimulation, usually in the form of task demands. Recent data suggest that social interaction per se can sometimes provoke escape behavior (Tay-

lor & Carr, 1992), and occasionally we obtained results consistent with this finding (see Social Interaction below).

Demand. The experimenter and subject were in a therapy room containing task-related materials selected on the basis of (a) their similarity to tasks found in the subject's education or habilitation plan, and (b) previous data (formal or informal) suggesting that the subject was not likely to comply with the tasks. During the session, the experimenter presented learning trials to the subject, usually on a fixed-time (FT) 30-s schedule, using a graduated three-prompt procedure. After delivering an initial instruction, the experimenter repeated it and demonstrated the correct response if the subject did not initiate a response within 5 s. If the subject did not initiate a response within 5 s following the demonstration, the experimenter repeated the instruction again and physically prompted the subject to comply. The experimenter delivered praise contingent on a correct response following either the initial instruction or the demonstration. Contingent on the occurrence of SIB, the experimenter removed the instructional materials and turned away from and ignored the subject. Three variations of this "time-out" (escape) contingency were used: (a) The next instructional trial was initiated according to schedule, (b) the next trial was initiated following 30 s of escape, or (c) the next trial was initiated following 30 s of escape with the additional stipulation that no SIB occurred during the last 5 s.

Medical. This variation of the demand condition was used with only 1 subject whose SIB seemed to be occasioned by medical examinations or questions about his medical status (he had a history of numerous physical problems and was in need of eye surgery). The experimenter and subject were in a therapy room containing chairs and a couch. The experimenter asked questions to the subject (e.g., "Does your knee hurt?"), asked him to flex or extend extremities, and palpated various body parts. Periodic praise was delivered for compliance or tolerance. Contingent on the occurrence of SIB, the experimenter turned away from the subject for 30 s.

Social interaction. No specific test condition was developed to assess escape from social interaction as negative reinforcement. It was possible, however, to identify such a process through examination of a subject's overall pattern of responding during other conditions. Three of the basic assessment conditions (attention, demand, and play) included the presence of an experimenter as a salient stimulus, which may have been correlated with social interaction. No experimenter was present, however, during the alone condition. If the presence of an experimenter served as an aversive stimulus, consistently lower levels of SIB should have occurred in the alone condition relative to others.

Test Condition for Automatic Reinforcement

Unlike SIB maintained by contingent attention or escape, SIB that is not maintained by social reinforcement presents difficulty from the standpoint of both description and analysis. Such behavior has been referred to using a number of terms, including *stereotypy, self-stimulation, sensory reinforcement,* and so on, all of which have advantages as well as limitations. We have preferred the term *automatic* reinforcement as one that (a) describes a general contingency in which behavior directly produces reinforcement independent of the social environment, and thus complements *social* reinforcement; (b) is consistent with operant theory and terminology (Vaughan & Michael, 1982); and (c) leaves open the possibility that the contingency could involve either positive or negative reinforcement. Although the term is limited in its lack of specificity about the unique features of the reinforcing consequence, *social* reinforcement as a functional description is equally vague, because it does not specify the exact nature of the social interaction that serves as reinforcement (i.e., smiles or other gestures, conversation, physical contact).

Several approaches may be taken with respect to analysis. The first is to demonstrate a reinforcement effect, which ordinarily would be impossible because the consequence is a direct product of responding. A second approach is to show an extinction effect, which would require interrupting the stimulation produced by the response. For example, Dorsey, Iwata, Reid, and Davis (1982) demonstrated reductions in several topographies of

SIB when individuals wore devices that allowed responding to occur (or to be approximated) but attenuated the stimulation produced by the behaviors. However, recent data suggest that the effects of such manipulations could be a function of punishment or time-out in addition to or rather than extinction (Mazaleski, Iwata, Rodgers, Vollmer, & Zarcone, 1994). The third approach to analysis involves demonstration that the response in question is maintained in the absence of social contingencies. Having eliminated social reinforcement as a maintaining variable, one might then conduct further analyses in an attempt to isolate the specific source of automatic reinforcement. As an initial approach to assessment, the last method, although not ideal, is clearly the most practical and it is the one we have adopted.

Alone. The subject was alone in a therapy room that contained no extraneous materials. When observation could not be conducted from a separate room through a one-way window, the observer watched through a regular window, stood in the doorway, or stood in a corner of the room without interacting with the subject at any time during the session.

Control Conditions

The above test conditions were designed to increase responding given that SIB was maintained by a particular reinforcement contingency. As a basis for comparison, a control condition with several variations was designed so as to minimize the likelihood of occasioning or reinforcing SIB.

Play. The experimenter and subject were in a therapy room equipped with leisure materials, as in the attention condition. Throughout the session, the experimenter interacted with the subject in some way (e.g., delivered toys, patted the subject on the back, spoke friendly words, etc.) according to one of three schedules: (a) an FT 30-s schedule of noncontingent reinforcement in which the experimenter interacted with the subject independent of the subject's behavior, (b) an FT 10-s schedule in which the experimenter interacted with the subject almost continuously, or (c) a differential-reinforcement-of-other-behavior (DRO) 30-s schedule in which the experimenter interacted with the subject as long as the subject was not engaging in SIB (occurrences of SIB during the last 5 s of the DRO interval delayed the experimenter's interaction by another 5 s). The play condition served as a general control for the three test conditions because it eliminated (a) deprivation from attention and contingent attention for SIB (attention condition), (b) task demands and contingent escape for SIB (demand condition), and (c) a general state of deprivation (alone condition) while providing access to alternative activities.

Experimental Designs

The sequence of presentation for assessment conditions was arranged in one of three design formats. The first was a multielement design, described previously by Iwata et al. (1982) and used in a number of subsequent studies, in which one or two sessions of one condition were conducted, followed by another, and so on. When the study began, conditions were presented in semirandom, repeating cycles (i.e., the sequence was random except that no condition was run more than twice consecutively). Under current procedure, a fixed cycle (alone → attention → play → demand) is used to either reduce or take advantage of potential sequence effects during assessment. If SIB is maintained by attention, the alone condition (preceding attention) provides additional presession deprivation from attention, whereas noncontingent reinforcement delivered during the play condition (following attention) should prevent the occurrence of carryover effects resulting from an extinction burst (which might occur if the alone condition followed attention). If SIB is maintained by escape, the alone condition (following demand) should produce little or no carryover SIB due to the complete absence of demands and correlated stimuli (i.e., experimenter, tasks, etc.). Finally, if SIB is maintained by automatic reinforcement (sensory stimulation), the availability of leisure materials during the attention condition (following alone) might compete with SIB and thereby reduce carryover effects.

The second format was a reversal design (see Vollmer, Iwata, Duncan, & Lerman, 1993), in which sessions during a given condition continued until data appeared either stable or predictable, at

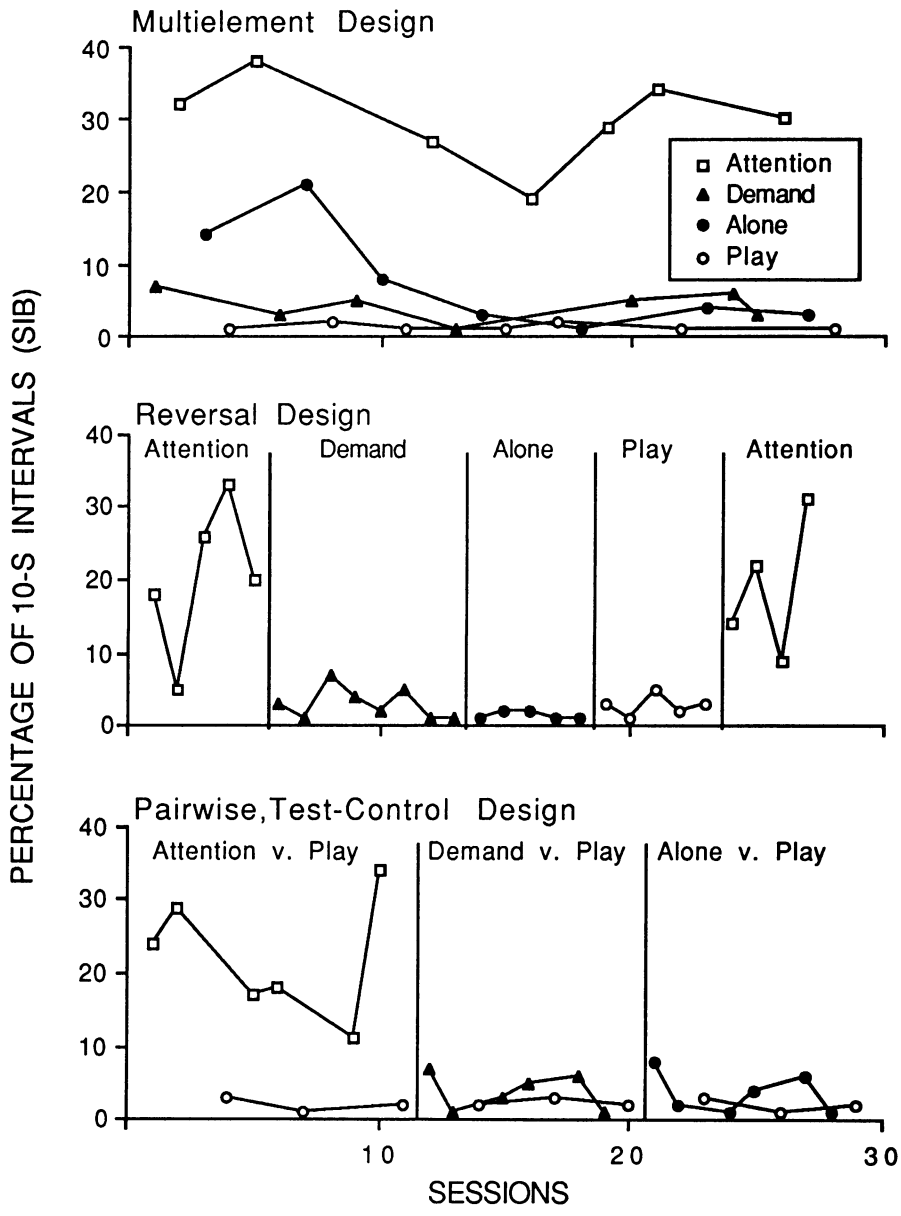

Figure 1. Examples of the experimental designs used in the study. Hypothetical data represent an individual whose SIB is maintained by contingent attention (social–positive reinforcement).

which time the next assessment condition was implemented. The third format combined features of the first two: Test conditions were arranged sequentially as in a reversal design, and each test condition alternated with the same continuous control in a multielement format (see Iwata, Duncan, Zarcone, Lerman, & Shore, in press). Because all data in the present study are summarized in an abbreviated form, each of the design variations is illustrated in Figure 1 with a hypothetical set of data.

Data Interpretation

Assessment data. All data were summarized in graphic form showing session-by-session values, as illustrated in Figure 1, and were reviewed daily by various members of the research team while data were being collected. For the present analysis, at

least four of the authors (including the first author in every case) but usually as many as 8 to 10 experimenters examined each data set at the conclusion of assessment and reached a consensus about the variable(s) maintaining a given subject's SIB or, alternatively, agreed that the data were uninterpretable. These decisions were based on examination of the data with respect to differing levels of SIB across assessment conditions as well as trends within conditions and are explained further in conjunction with the data presentation.

Treatment data. Although the primary focus of the study was on assessment, results obtained during treatment may lend further credibility to conclusions about behavioral function. That is, both the validity and utility of the assessment process are strengthened if it can be shown that relevant interventions—those explicitly designed to eliminate or alter an assumed maintaining contingency—are more effective in reducing SIB than irrelevant interventions. During assessment, some of the test and control conditions to which subjects were exposed actually contained elements of "treatment" as described in the literature. For example, both the noncontingent reinforcement and DRO components of the play condition were relevant treatments for SIB maintained by social–positive reinforcement, whereas the verbal reprimand and response interruption components of the attention condition were irrelevant treatments. Following assessment, 121 of the subjects also participated in formal treatment programs, during which the effects of relevant (and sometimes irrelevant) interventions were evaluated.[1] To summarize these outcomes, we categorized the independent variables (i.e., treatment components) to which subjects were exposed during either assessment or treatment. We then determined the extent to which SIB was effectively reduced by comparing the mean level of responding during the last five sessions of a given condition with the mean level during the last five sessions of the most appropriate baseline (all data were counted if a condition contained fewer than five sessions). Successful outcome for a given intervention was defined as a reduction in SIB to below 10% of its baseline level.[2] Although this criterion was arbitrary and perhaps overly stringent, it provided an objective basis for establishing "clinically significant" behavior change.

RESULTS

Assessment data were collected during 3,968 experimental sessions (approximately 1,000 hr of actual running time) over the course of the study. Length of individual assessments ranged from 8 to 66 sessions (M = 26.2) conducted over 2 to 16.5 hr (M = 6.5). Because it would be impossible to present all of the individual data, and because many of the data sets were quite similar, individuals whose results were either typical or atypical of a response pattern reflecting a given reinforcement contingency were selected for presentation.

Social–Positive Reinforcement

Figure 2 shows data for 9 subjects whose results were indicative of social–positive reinforcement as the maintaining contingency for their SIB. Subjects A40, A69, and A114 (top panel) all exhibited SIB almost exclusively during the attention condition. Subject A40's SIB occurred only during attention sessions, and Subjects A69 and A114 showed extremely high levels of SIB during attention sessions relative to others. The data for Subjects A3, A4, and A54 (middle panel) showed smaller relative differences between the attention condition and others; still, all 3 subjects exhibited SIB much more frequently during attention sessions. Thus, the six

[1] A complete description of the treatment process is beyond the scope of this study. In all cases, however, data collection and reliability procedures were similar to those described here, and treatment outcomes were evaluated by way of single-subject designs.

[2] Baseline was considered to be either the relevant test condition(s) during assessment or a subsequent baseline prior to treatment. Using this procedure, "baseline" and "treatment" were the same for some irrelevant interventions applied to some functions of SIB. For example, reprimands were in effect during the attention condition, which was the critical test condition (baseline) for attention-maintained SIB; thus, by definition, reprimands were ineffective as treatment for this behavioral function.

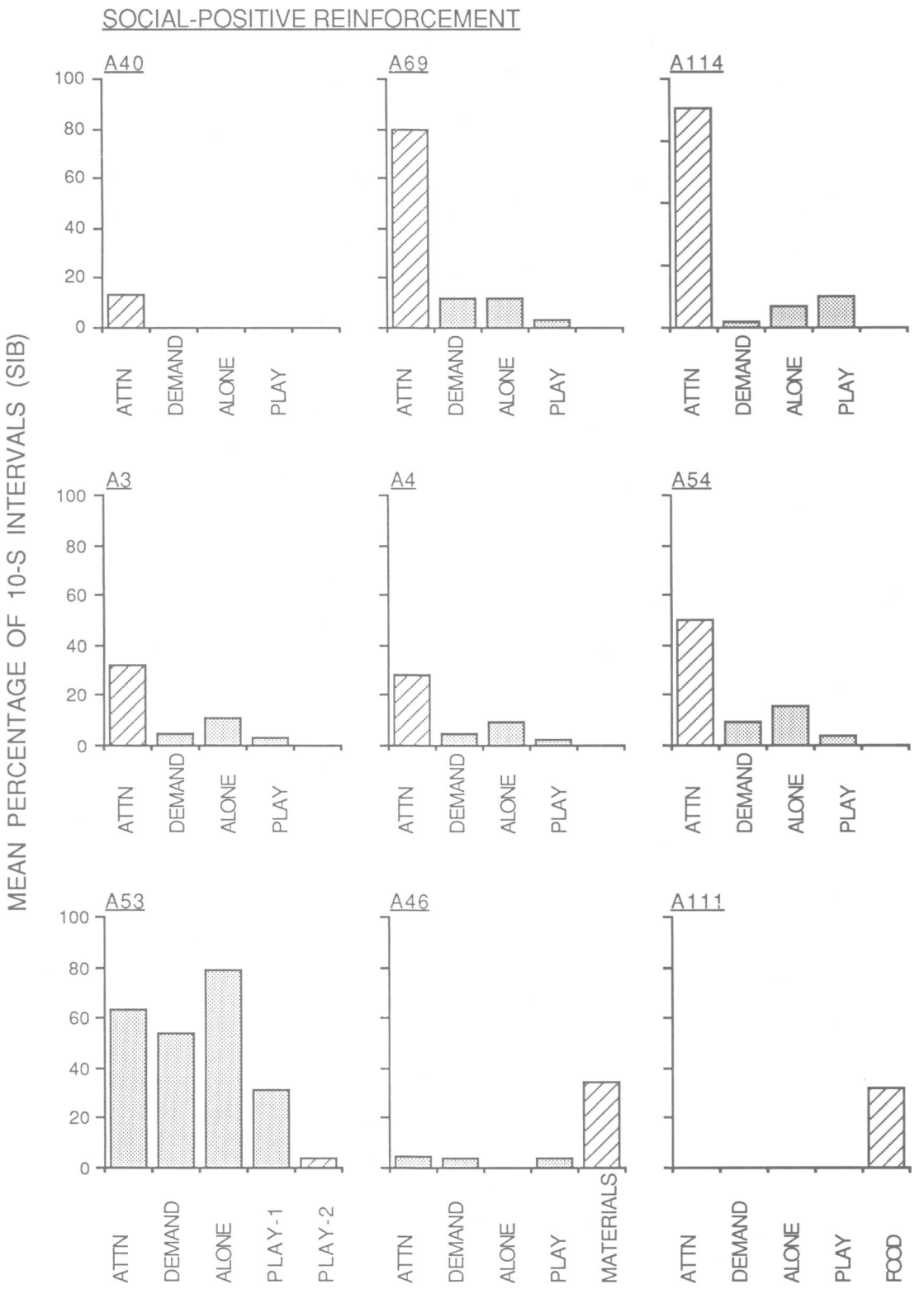

Figure 2. Selected summary of data across assessment conditions for subjects whose SIB was maintained by social–positive reinforcement. SIB occurring during critical test (or control) conditions is highlighted via striped bars.

data sets reveal clear sensitivity of SIB to contingent attention as a reinforcer.

Subject A53 (bottom panel, left) showed an atypical response pattern. His SIB occurred at relatively high levels during the attention, demand, and alone conditions, but occurred much less frequently in the condition labeled Play 1, which involved continuous access to materials and noncontingent attention delivered on an FT 30-s schedule. When exposed to a rich schedule (FT 10 s) of attention only (no materials available) during the Play 2 condition, his SIB decreased to almost zero. Data from recent research on the assessment and treatment of attention-maintained SIB (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993) indicate that rich schedules of noncontingent attention are effective in suppressing such behavior, and results obtained for Subject A53 were consistent with this finding. Subject A46 (bottom panel, middle) exhibited very little SIB except when access to materials (toys) was provided contingent on SIB. Similarly, Subject A111's SIB never occurred except when it was followed by the delivery of food. Because Subjects A46 and A111 showed little SIB during the attention condition, their data suggest that materials and food, respectively, served as reinforcing events independent of the delivery of attention.

Social–Negative Reinforcement

Figure 3 contains data representative of subjects whose SIB was maintained by social–negative reinforcement. Subjects D9, D12, and D56 (top panel) exhibited little or no SIB except during the demand condition, and the data for Subjects D2 (middle panel, left) and D39 (middle panel, middle) also showed large relative differences. This general pattern of responding in which much higher levels of SIB occurred during the demand condition was characteristic of a great majority of subjects for whom escape was identified as the maintaining reinforcer.

The data for Subject D145 (middle panel, right) were rather unusual. This individual exhibited very high levels of SIB during the attention, demand, and play conditions, all of which had in common the presence of an experimenter. This subject never played with any of the leisure materials during any play sessions (she, in fact, threw them at the experimenter on several occasions). Very little SIB, however, was observed when she was left alone. This type of response pattern suggests that either (a) the presence of adults had previously been predictive of an eventual request for this subject to do something, and her SIB served as an avoidance response; or (b) interaction with adults per se served as an aversive event (cf. Taylor & Carr, 1992). In either case, Subject D145's behavior was consistent with negative reinforcement as the maintaining contingency.

Data for Subjects D45, D51, and D117 (bottom panel) also indicate that their SIB was maintained by escape; however, the stimulus conditions serving as establishing operations were idiosyncratic. Typical task demands did not produce SIB in any of these subjects. Instead, medical examinations (D45, bottom panel, left), self-care routines such as changing clothes and washing (D51, bottom panel, middle), and ambient noise such as music playing nearby and even the telephone ringing (D117, bottom panel, right) seemed to constitute aversive stimulation.

Automatic Reinforcement

Figure 4 shows three distinct patterns of responding indicative of SIB that is not maintained by social contingencies. Subjects S82, S104, and S121 (top panel) exhibited SIB almost exclusively during the alone condition. During other conditions, they either played with the available leisure materials (attention and play conditions) or actively participated in learning trials (demand condition). Thus, SIB was suppressed almost completely when alternative sources of stimulation were available. Subjects S27, S62, and S119 (middle panel) also exhibited differentially high levels of SIB during the alone condition, but they also engaged in SIB during other conditions as well. For them, alternative activities competed with SIB only to a moderate degree.

The data for Subjects S32, S36, and S87 (bottom panel) were actually undifferentiated, in that extremely high levels of SIB occurred during all assessment conditions. Nevertheless, these results

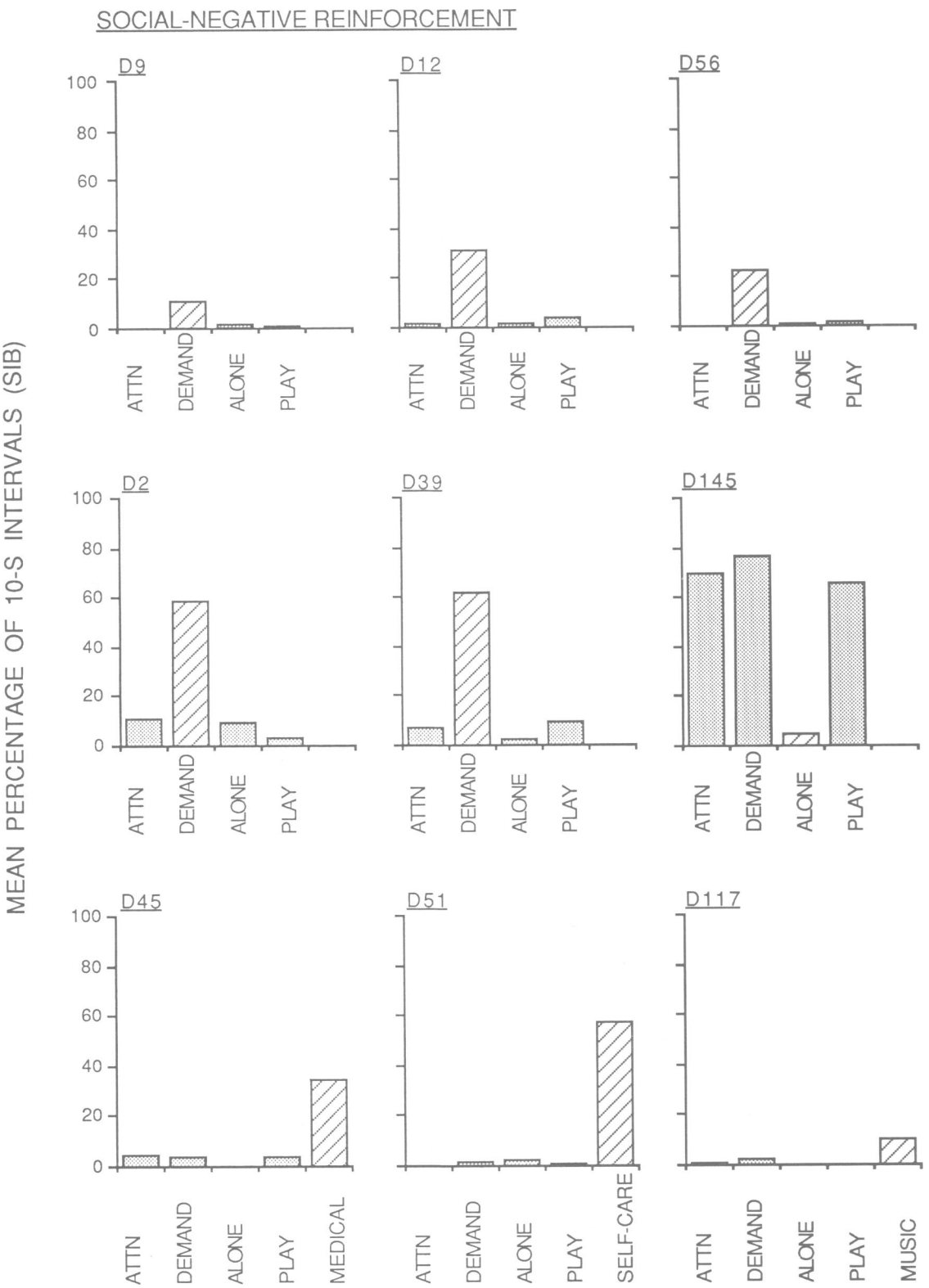

Figure 3. Selected summary of data across assessment conditions for subjects whose SIB was maintained by social–negative reinforcement. SIB occurring during critical test (or control) conditions is highlighted via striped bars.

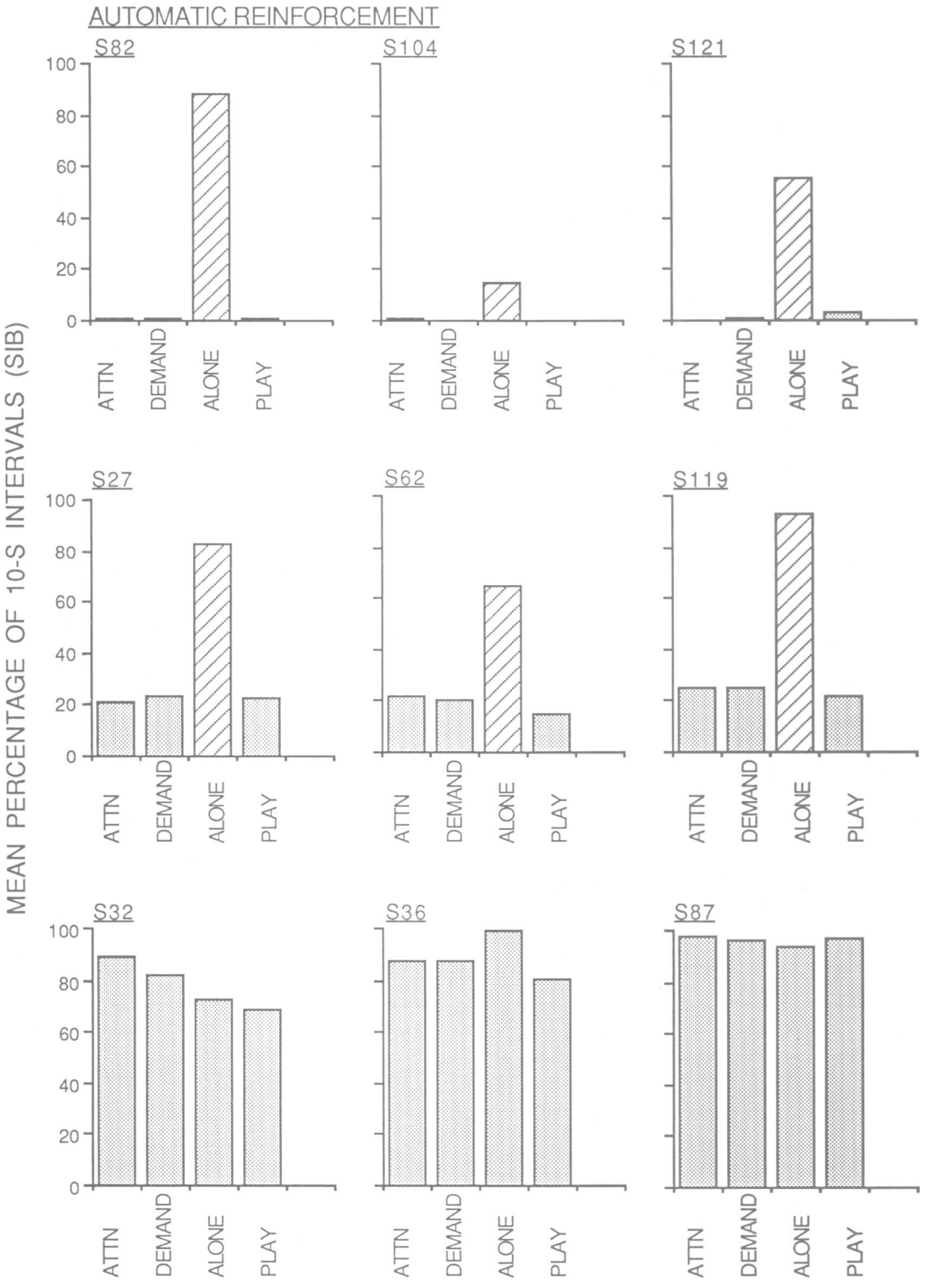

Figure 4. Selected summary of data across assessment conditions for subjects whose SIB was maintained by automatic reinforcement. SIB occurring during critical test (or control) conditions is highlighted via striped bars.

are highly consistent with those from other research in which assessment data were either presented (Mason & Iwata, 1990, see Kathy's data) or described (Reid, Parsons, Phillips, & Green, 1993; Van Houten, 1993) as being high and invariant across assessment conditions and therefore indicative that the SIB under study was self-stimulatory in nature. Thus, patterns of responding that closely matched those shown by Subjects S32, S36, and S87 suggest that none of the alternative activities available during other assessment conditions competed with the reinforcers maintaining SIB, and data for these subjects seem to most accurately reflect the influence of automatic reinforcement.

Multiple Controlling Variables

Figure 5 (top panel) shows results obtained for 3 subjects who exhibited their highest levels of SIB during two assessment conditions and little or no responding during other conditions. These data suggest that their SIB was maintained by multiple (and different) sources of reinforcement. Subject M42's SIB appeared to be maintained by two sources of social reinforcement, in that it occurred most often during the attention and demand conditions. By contrast, the data for Subjects M50 and M80 reflect both social and nonsocial components to their SIB. Subject M50 exhibited high levels of SIB during the attention and alone conditions. Although this pattern suggests that his SIB was maintained by both contingent attention and automatic reinforcement, an alternative interpretation is that his behavior was maintained only by attention, and that responding during the alone condition represented an extinction burst. However, because the alone condition (in which the experimenter was not present) was highly predictive of the absence of attention, one would expect rapid extinction of attention-maintained behavior, yet his SIB during the alone condition showed no decreasing trend across sessions. In fact, he exhibited more SIB during the alone condition than during the attention condition. Subject M80 exhibited high levels of SIB during the demand and alone conditions. Assuming that her SIB during the demand condition represented reinforced escape behavior, its continued occurrence in the alone condition would be highly unlikely due to the complete absence of both demands and the experimenter, which may have occasioned escape behavior. Thus, Subject M80's data suggest that her SIB contained a self-stimulatory as well as an escape component.

The problem of multiple control over SIB has been examined in very few studies (e.g., see Day, Rea, Schussler, Larsen, & Johnson, 1988; Heidorn & Jensen, 1984), and because the outcomes of a functional analysis for such behavior may be ambiguous, conclusions based on assessment data alone must be tentative. For example, Smith, Iwata, Vollmer, and Zarcone (1993) found that, for 3 subjects whose assessment results suggested multiple control, only two of these assessments were verified by way of treatment outcome. Nevertheless, when relatively clear control over SIB is shown by more than one variable, a working hypothesis based on multiple control seems to be reasonable for the purpose of developing treatment options.

Undifferentiated Results

The data for Subjects U140, U147, and U149 (Figure 5, bottom panel) were uninterpretable. Although it is clear that no single source of reinforcement accounted for their low to moderate levels of SIB across all conditions, the relative influence of multiple reinforcement contingencies compared to automatic reinforcement as the sole maintaining contingency cannot be determined. Unlike subjects whose SIB was uniformly high across conditions (Figure 4, bottom panel), Subjects U140, U147, and U149 all spent 50% or less of their time engaged in SIB. This finding does not rule out sensory consequences as maintaining reinforcers, but it does render such a conclusion tentative. Additional data taken on the behavior of these and other subjects whose assessment outcomes were unclear were not helpful in identifying the variables maintaining their SIB. During subsequent manipulations of the assessment parameters for Subject U140, her SIB disappeared and never reemerged, and she never received a formal treatment program. Subjects U147 and U149 both exhibited self-restraint in addition to SIB, and we were unable to determine

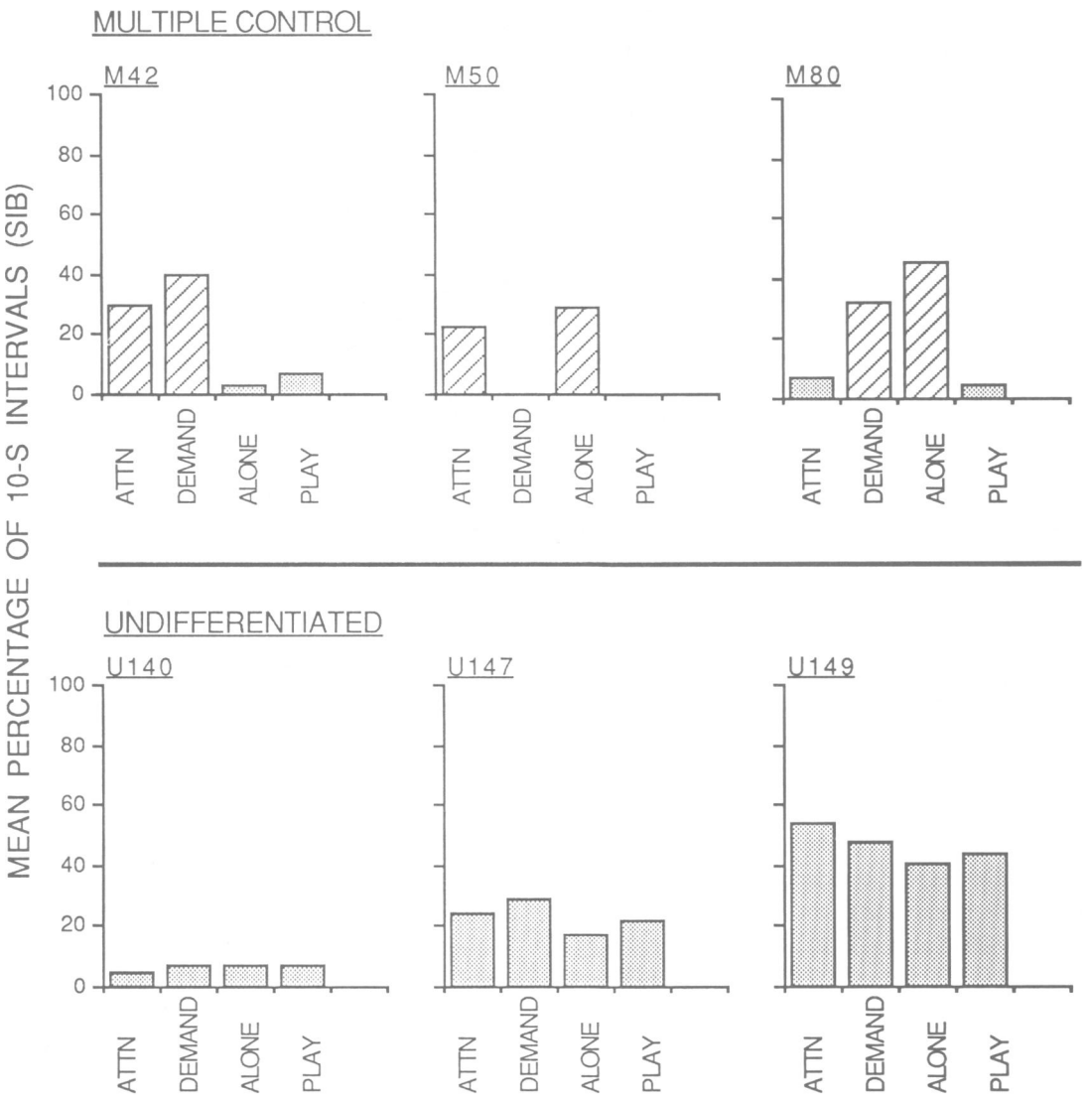

Figure 5. Selected summary of data across assessment conditions for subjects whose SIB was maintained by multiple controlling variables (top panel) or was undifferentiated (bottom panel). SIB occurring during critical test (or control) conditions is highlighted via striped bars.

what variables maintained either behavior. Their subsequent treatment programs therefore emphasized the development of basic play and instruction-following behaviors concurrent with a restraint-fading procedure.

Summary of Assessment Data

Using the logic illustrated above in evaluating the assessment data for each subject, it was possible to determine the proportion of the sample for whom SIB was maintained by a given source of reinforcement. Table 3 summarizes these results for all 152 subjects. Social–negative reinforcement (escape from varying sources of aversive stimulation) accounted for the largest proportion of SIB (38.1%), followed by roughly equal proportions maintained by social–positive reinforcement (attention or access to materials or food, 26.3%) and automatic reinforcement (sensory stimulation or pain attenuation, 25.7%). Multiple controlling variables were clearly

identified for 5.3% of the cases, and uncontrolled responding was observed in 4.6% of the cases. It is highly unlikely that the SIB of individuals in this last category (uncontrolled) could be attributed to a single source of social reinforcement (e.g., attention or escape); therefore, it is possible that the proportions of SIB maintained by automatic reinforcement or multiple control could be as high as 30% and 10%, respectively.

Assignment of data sets to subcategories under a given reinforcement contingency (e.g., attention, materials, or food under social–positive reinforcement) was empirically determined, with one exception. For SIB maintained by automatic reinforcement, it is often difficult (if not impossible) to identify the exact nature of the reinforcing stimulus because its delivery is not ordinarily subject to control by the experimenter.[3] We have recently begun work to isolate the reinforcing features for some topographies of SIB maintained by automatic reinforcement, and have applied it to a few cases in the present sample, but most of the data presented here were not collected in such a way as to allow retrospective analysis. Therefore, under the category of automatic reinforcement, all cases but two were attributed to sensory stimulation (positive reinforcement) of some unspecified type. The 2 individuals whose SIB was attributed to pain attenuation (negative reinforcement) both exhibited scratching as their predominant topography and both had histories of allergic and dermatologic problems, although it is not clear that the latter were any more a "cause" (establishing operation) than an effect of the SIB.

Table 3
Summary of Assessment Results

Behavioral function	Number of subjects	%
Social–positive reinforcement		
attention	35	23.0
materials only	3	2.0
food only	2	1.3
total:	40	26.3
Social–negative reinforcement		
escape from task demands	54	35.4
escape from social interaction	2	1.3
escape from physical examinations	1	0.7
escape from ambient stimulation (noise)	1	0.7
total:	58	38.1
Automatic reinforcement		
sensory stimulation (suspected)	30	19.7
pain attenuation (suspected)	2	1.3
undifferentiated high responding[a]	7	4.6
total:	39	25.7
Multiple controlling variables		
attention and escape	4	2.7
attention and sensory stimulation	2	1.3
escape and sensory stimulation	2	1.3
total:	8	5.3
Uncontrolled		
cyclical or unpredictable responding	7	4.6
total:	7	4.6

[a] Data for the 7 subjects whose SIB was high and undifferentiated were essentially "uncontrolled" because no particular condition was *differentially* associated with SIB. These results, however, are highly consistent with SIB maintained by automatic reinforcement (e.g., see Mason & Iwata, 1990). Therefore, these data sets were added to the "automatic reinforcement" category.

Summary of Treatment Data

Data summarized in Figure 6 show the extent to which various treatment components were successful in reducing SIB maintained by a given contingency to below 10% of its baseline level. In some cases, the data reflect comparisons between test and control conditions during assessment; in others, results are based on the outcome of a formal treatment program.

Social–positive reinforcement. Noncontingent attention (or access to materials or food), presented either in the play condition during assessment or during treatment, was highly effective in reducing SIB in most subjects, and extinction (EXT) (attention), differential reinforcement (either DRO or differential reinforcement of alternative behavior), and

[3] It is difficult to arrange conditions in which stimulation directly produced by a response can be delivered or blocked without introducing another source of influence, although see the exception reported by Rincover, Newsom, and Carr (1979).

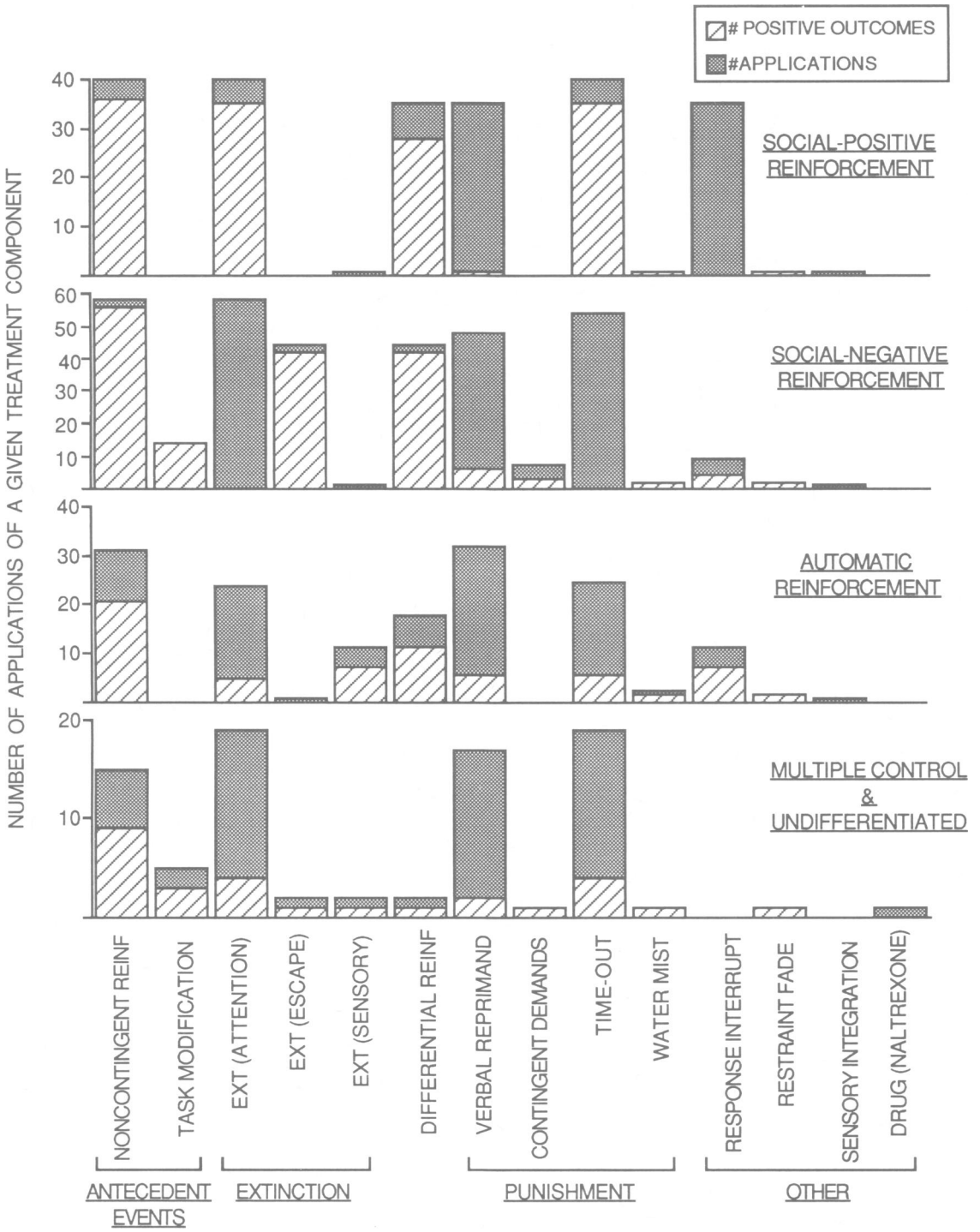

Figure 6. Summary of treatment effects, grouped by intervention and behavioral function, and expressed as number of successful outcomes compared to number of applications of a given treatment.

time-out (all implemented as treatments) produced similar results. By contrast, verbal reprimands and response interruption (both presented in the attention condition during assessment) were ineffective interventions.

Social–negative reinforcement. Noncontingent reinforcement for this function involved the removal of task demands or other aversive stimuli (e.g., noise); it was implemented in the alone condition during assessment and was associated with almost complete elimination of SIB. Other effective interventions included reducing the frequency of task presentation, EXT (escape), and differential reinforcement (either positive reinforcement for compliance or negative reinforcement in the form of escape contingent on appropriate behavior), all of which were implemented during treatment programs. EXT (attention) and time-out, implemented in the demand condition during assessment, had no effect and amounted to negative reinforcement (escape) for SIB. Other treatment procedures examined for several subjects included the presentation of additional demands contingent on SIB and response interruption, both of which had modest effects.

Automatic reinforcement. For behavior maintained by its own (sensory) consequences, noncontingent reinforcement consisted of continuous access to alternative sources of stimulation (e.g., leisure materials) presented either in the play condition during assessment or during treatment. Although the procedure was associated with large reductions in SIB, results were not as consistent as those observed when noncontingent reinforcement was applied to social functions, because the leisure materials were not effective substitutes for SIB with some subjects. EXT (sensory), differential reinforcement, and response interruption, implemented during treatment, produced generally positive outcomes. EXT (attention) and time-out, implemented in the demand condition during assessment, were usually ineffective; positive outcomes seemed to be a function of subjects' engagement in the available tasks.

Multiple control and undifferentiated assessments. These functional groupings were combined because of their low prevalence and because they represented the influence of more than one source of reinforcement. Noncontingent reinforcement consisted of access to one or more of several events (attention, escape, or leisure materials), and often was effective in reducing SIB. The ineffectiveness of EXT (attention), verbal reprimands, and time-our reflects their inability to reduce SIB during assessment conditions, and mixed findings for most other interventions were a function of selective influence on one but not all functions of SIB.

The data presented in Figure 6 depict results obtained with treatments that were both relevant and irrelevant to a given function of SIB. As such, they do not allow a determination of treatment effects when intervention is based on the outcome of assessment; instead, they reflect a somewhat arbitrary approach to treatment selection. However, because the reinforcing function of SIB was identified for all but a few subjects in the present study, it was possible to examine treatment outcome in a more selective manner by considering only those interventions having a reasonable likelihood of eliminating or altering a behavior's maintaining contingency.

Table 4 presents such an analysis for those interventions considered to be relevant to a given behavioral function (i.e., irrelevant applications of an intervention were deleted). Across all categories of intervention, restraint fading was the most effective, but its 100% success rate is misleading because it was always implemented in conjunction with another procedure. As single interventions, EXT (escape) had the highest success rate (93.5%); sensory integration and naltrexone had the lowest (0%), although each was based on results for only 1 subject. Of particular interest are the overall success rates obtained with antecedent interventions, extinction, differential reinforcement, and punishment. All of these interventions, when applied to the function of SIB for which they were designed, reduced behavior to below 10% of baseline in over 80% of the cases. More important, uniformly positive results were obtained in spite of the fact that reinforcement-based interventions were used two to three times more often than punishment. This ratio

Table 4
Overall Summary of Treatment Effects Obtained with Interventions Selected for Their Relevance to Behavioral Function

	Successful Outcomes	Applications	Effectiveness (%)
Antecedent interventions			
noncontingent reinforcement	127	152	83.6
task modification	17	19	89.5
total	144	171	84.2
Extinction			
EXT (attention)	39	44	88.6
EXT (escape)	43	46	93.5
EXT (sensory)	10	16	62.5
total	92	106	86.8
Differential reinforcement	85	103	82.5
Punishment			
time-out	39	44	88.6
water mist	6	7	85.7
total	45	51	88.2
Other			
response interruption	13	23	56.5
restraint fade	6	6	100
sensory integration	0	1	0
naltrexone	0	1	0

is extremely conservative because 44 of the 51 punishment interventions consisted of time-out, which consisted of very brief (30 s to 2 min) suspension of ongoing activity. As a result, it was impossible to determine with any certainty whether this procedure amounted to time-out rather than EXT (attention), so it was listed as both procedures in the table. When time-out is removed from consideration, applications of punishment (water mist) are reduced to seven cases.

DISCUSSION

Results of the present study, in which single-subject designs were used to examine the functional properties of SIB in 152 individuals, indicated that social reinforcement was a determinant of SIB in over two thirds of the sample,[4] whereas nonsocial (automatic) consequences seemed to account for about one fourth of the cases. Undetermined sources of influence were evident in less than 5% of the cases. These findings indicate that methodologies derived from the experimental analysis of behavior may be helpful not only in identifying the maintaining contingencies for disorders such as SIB on an individual basis, but also in generating epidemiological data on behavioral function across large groups of subjects. Although the process is both labor intensive and time consuming, results permit confident conclusions about the effects of varying contingencies on behavior through highly controlled and systematic manipulation. For example, the present data base offers 152 replications, each comprising a complete and valid experimental design. To the best of our knowledge, this represents the largest single-subject analysis ever reported in the literature. Before commenting on specific aspects of the data and their implications, some limiting features of the study should be noted.

First, because the data presented here were collected over an exceedingly long period of time (11

[4] This overall category includes SIB maintained by social–positive reinforcement, social–negative reinforcement, and cases of multiple control in which social reinforcement (positive or negative) was one of the maintaining variables.

years), they do not accurately reflect either incidence (number of new cases) or point prevalence (number of existing cases) for differing functions of SIB (Kiley & Lubin, 1983). Practical considerations prevented us from completing the study over a shorter time. Most subjects entered directly into treatment programs immediately following the conclusion of their assessment, thus allowing concurrent assessment of only 2 or 3 individuals at any one time. Additional interruptions in continuous data collection were caused by time and activity necessary to process referrals or to conduct training and follow-up, and by periodic suspension of all sessions for various reasons. Finally, routine procedures necessary for conducting the study (e.g., subject transportation, session preparation and take down, intersession breaks for subjects, reliability assessment, and data reduction and review) consumed an inordinate amount of time, such that a conservative estimate of the total amount of time devoted only to the assessment component of the study probably exceeds 5,000 person hours.

The second limitation is that the subject sample was taken from a referred population. Thus, results may not be representative of the distribution of SIB by function among all individuals who have the disorder. It is possible, for example, that very mild cases of SIB not referred for treatment might reflect the influence of maintaining contingencies in proportions different than those found in our study. Although the use of a referred sample limits the extent to which our data may be generalizable throughout the population, this limitation extends to all existing studies on the incidence or prevalence of SIB. In each of the epidemiological surveys reviewed by Johnson and Day (1992), the subject sample was limited by one or more setting-related factors (e.g., community-based residential facility, institution, pediatric clinic, private service provider, etc.). Thus, it seems reasonable to conclude that data presented here on the functional characteristics of SIB are comparable with those reported elsewhere on its descriptive characteristics.

The third possible limitation of this study is that, although our assignment of cases to a particular maintaining contingency reflects the predominant influence of a given source of reinforcement, it may not reflect all potential influences. Using the data in Figure 2 as an illustration, only 2 of the 9 subjects (A40 and A111) exhibited SIB only during the test condition for social–positive reinforcement. Thus, it is remotely possible that the influence of some other (albeit weak) contingency accounted for the SIB observed in other conditions by the other 7 subjects. However, examination of not only the present data but also those published in numerous other studies indicates that the complete absence of responding during control conditions is a rare finding.

Although these problems require somewhat cautious interpretation of the data, we feel that several conclusions are supported by our findings. The first is that SIB appears to be a disorder maintained largely by social reinforcement, suggesting that many individuals have not acquired socially appropriate means for gaining access to reinforcement through others or, alternatively, that the social environments of many individuals are not responsive to less aberrant forms of attention-seeking or escape behavior. This finding underscores the importance of interventions that replace the target response (SIB in the present case) with another topography serving the same function. These interventions collectively have been described as "functional communication training," and their effectiveness has been well established in a series of recent studies (see Carr & Durand, 1985, as an example and Reichle & Wacker, 1993, for a comprehensive review). As a preventive strategy for all individuals at risk for SIB, early language instruction aimed at developing and maintaining simple yet reliable mands (i.e., responses that serve the functions of "I want" and "I don't want") makes eminent sense.

Social–negative reinforcement accounted for the largest proportion of SIB among our subjects. This result was somewhat surprising because the inadvertent delivery of social–positive reinforcement (contingent attention) has long been considered to be the primary operant mechanism responsible for the development of SIB. That view was based on research (e.g., Lovaas, Freitag, Gold, & Kassorla, 1965; Lovaas & Simmons, 1969; Peterson & Peterson, 1968; Schaeffer, 1970) conducted at a time when most individuals with developmental dis-

abilities received little by way of formal education and often lived in environments that were both physically and socially impoverished. Thus, it is quite possible that our results would have reflected a higher proportion of SIB attributed to social–positive reinforcement (occasioned by socially depriving conditions) had the study been done a decade or so earlier.

The current philosophy toward treatment for individuals with mental retardation and other handicapping conditions places emphasis on "active treatment," which has been defined by federal standard as "aggressive consistent implementation of a program of specialized and generic training" (U. S. Department of Health and Human Services, 1988, p. 20459). We believe that the high proportion of escape-maintained SIB seen in our subjects may reflect difficulties in implementing this philosophy. In an attempt to make up for lost time, it is possible that the therapeutic environments that have been designed are deficient in at least two respects. First, an overemphasis on "aggressive" intervention may leave little time for some individuals to acquire valuable leisure skills under conditions that are typical for most of the population, or even to spend a sufficient amount of time "off task." Second, failure to provide frequent reinforcement for appropriate performance during training may create a situation in which instruction per se amounts to aversive stimulation.

Regardless of the specific cause, it appears that current instructional programs do not generate high levels of motivation on the part of some individuals and instead may produce escape behavior, which is gradually shaped to the point at which SIB and aggression become the most effective means of terminating ongoing activity (Iwata, 1987). In light of our results indicating that escape is an important (and perhaps the most common) reinforcer for SIB, current instructional technologies might benefit from incorporating strategies that are specifically designed to reduce the frequency of aberrant escape behavior. Examples include increasing the density of positive reinforcement for compliance (Horner, Day, Sprague, O'Brien, & Heathfield, 1991; Mace & Belfiore, 1990), gradually increasing response requirements during training (Pace, Iwata, Cowdery, Andree, & McIntyre, 1993), teaching individuals to request help when faced with difficult tasks (Carr & Durand, 1985), and strengthening alternative escape behaviors that produce temporary breaks from work (Steege et al., 1990).

Another interesting finding was that some subjects' SIB was maintained by access to (or termination of) highly specific or unusual sources of stimulation (as in the case of Subject D117's escape from ambient noise). Data for these subjects suggest that our system of classification is quite broad and that each maintaining contingency (e.g., social–negative reinforcement) could include a long list of specific and idiosyncratic events, some of which may serve different functions for different individuals. For example, social interaction maintained SIB in many of our subjects, but it evoked escape behavior in 2 of them (see Figure 2, Subject D145, as one example). Because the same stimulus could and did have opposite reinforcing effects for different individuals, descriptions of behavioral function based on contingency seem to have more generality than those based on unique events.[5] However, the finding that some subjects' SIB was maintained by unusual reinforcers underscores the importance of individualization during the assessment process. Data from the present study indicate that functional analysis methodologies are quite flexible and can accommodate a wide range of stimuli.

A decision to examine the possible reinforcing effects of a given stimulus could be based on information from a variety of sources, including interviews, informal observations, or systematic manipulation. We found all three helpful in conducting the present study. For example, indigenous staff informed us that food was a powerful reinforcer for Subject A111, observations conducted during nonsession times suggested that Subject D45's SIB was maintained by escape from medical examinations, and only through systematic examination of multiple stimuli were we able to determine the

[5] See Iwata, Pace, Kalsher, Cowdery, and Cataldo (1990, p. 17) for further discussion of the advantages of contingency-based descriptions of behavioral function.

access to materials and escape from noise maintained the SIB of Subjects A46 and D117, respectively. Whether or not experimental manipulations were necessary or, as an alternative, whether other methods of assessment would have been sufficient to conduct the present study remains an empirical question. Other data, however, indicate that existing questionnaire methods are highly unreliable (Sturmey, in press; Zarcone, Rodgers, Iwata, Rourke, & Dorsey, 1991) and that the relative influence of attention and escape contingencies may be difficult to separate through descriptive analyses (Lerman & Iwata, 1993; Mace & Lalli, 1991).

The category of automatic reinforcement remains somewhat elusive. Although casual observation suggests that the reinforcing event for self-stimulatory behavior might be identified merely by looking at the response, research data indicate otherwise. For example, while studying 1 child's stereotypic behavior, which consisted of spinning a plate on a table top and watching it, Rincover (1978) found that auditory rather than visual stimulation served as reinforcement. Some topographies of SIB also produce multiple sources of stimulation. Hand mouthing and biting, for example, stimulate both the hand and the mouth, and it is not clear which of these account(s) for behavioral maintenance. Additional research is needed to identify (or isolate) the specific reinforcing events produced by stereotypic behavior. Well-controlled studies using sensory extinction under conditions that do not suppress responding through other mechanisms (e.g., Rincover et al., 1979) could examine the effects of differentially blocking one or more sources of stimulation to determine which exerts greater influence on responding. Other research based on substitutability theory (see Green & Freed, 1993, for a recent review) might permit a determination of reinforcing effects through the discovery of either substitutable (competing) or complementary sources of stimulation.

With respect to treatment outcome, the present data are unique in illustrating the relationship between behavioral function and treatment selection across a large group of individuals. Results from several studies conducted with small subject samples (e.g., Carr & Durand, 1985; Iwata, Pace, Cowdery, & Miltenberger, 1994; Repp, Felce, & Barton, 1988) have shown that interventions relevant to behavioral function are more likely to be effective than those that are arbitrarily chosen. The present data reveal these differential outcomes to a much greater degree. For example, extinction effects were highly selective across behavioral function and were predictable based on results of the functional analysis assessments. Several authors have proposed methods for treatment classification and selection that take into account both the behavior-reducing mechanisms of intervention and the maintaining contingencies for behavior (e.g., Iwata, Vollmer, Zarcone, & Rodgers, 1993; Repp & Karsh, 1990); the present data indicate that failure to consider either of these factors may produce highly undesirable results.

Because attempts to match treatment with behavioral function are evident in a relatively small proportion of studies, much of the literature reflects varying approaches to treatment implementation. Given the heavy emphasis placed on procedural aspects of intervention and on progression from lesser to more "restrictive" forms of treatment, it is certain that a number of "failures" reported in the literature amount to one or more of the following: (a) differential reinforcement applied to escape-maintained behavior, in which the extinction component consisted of "planned ignoring"; (b) differential reinforcement applied to attention-maintained behavior, in which arbitrary reinforcers such as play materials were delivered for the absence of the target behavior but attention (e.g., a reprimand) still followed occurrences of the target behavior; (c) "response blocking," "redirection," or other social forms of interruption applied to attention-maintained behavior; and (d) time-out applied to behavior that was maintained by either escape or automatic consequences. These problems are not exhaustive but exemplify difficulties encountered when behavioral function is unknown.

Although the degree to which treatment failures reflect irrelevant applications of reinforcement and extinction cannot be determined, it might easily account for the results reported in two recent meta-

analyses of research on severe behavior disorders, in which independent reviews indicated that punishment-based interventions were much more effective in reducing behavior than were reinforcement-based interventions (Carr, Taylor, Carlson, & Robinson, 1991; Cataldo, 1991). By contrast, the present data on treatment outcome indicated that, when the noneffects of irrelevant interventions were eliminated from consideration, reinforcement approaches to behavior reduction were just as effective as punishment approaches. In fact, antecedent interventions (mostly noncontingent reinforcement), differential reinforcement, and extinction were so effective that punishment (contingent aversive stimulation via water mist) was used in only 7 of 121 cases. This finding lends considerable support for one of the potential benefits ascribed to functional analysis methodology, namely, a reduction in the use of punishment (Axelrod, 1987).

In summary, results of this long-term study on SIB support three major conclusions: (a) Experimental approaches to behavioral assessment are highly effective and relatively efficient methods for identifying contingencies that currently maintain behavior on an individual basis; (b) from an epidemiological perspective, SIB appears to be primarily a learned disorder; and (c) knowledge about behavioral function can and should determine the course of treatment.

REFERENCES

Axelrod, S. (1987). Functional and structural analyses of behavior: Approaches leading to reduced use of punishment procedures? *Research in Developmental Disabilities, 8,* 165–178.

Carr, E. G. (1977). The origins of self-injurious behavior: A review of some hypotheses. *Psychological Bulletin, 84,* 800–816.

Carr, E. G., & Durand, V. M. (1985). Reducing behavior problems through functional communication training. *Journal of Applied Behavior Analysis, 18,* 111–126.

Carr, E. G., Newsom, C. D., & Binkoff, J. A. (1976). Stimulus control of self-destructive behavior in a psychotic child. *Journal of Abnormal Child Psychology, 4,* 139–153.

Carr, E. G., Taylor, J. C., Carlson, J. I., & Robinson, S. (1991). Reinforcement and stimulus-based treatments for severe behavior disorders in developmental disabilities. In U.S. Department and Health and Human Services, *Treatment of destructive behaviors in persons with developmental disabilities* (pp. 173–229) (NIH Publication No. 91-2410). Bethesda, MD: National Institutes of Health.

Cataldo, M. F. (1991). The effects of punishment and other behavior reducing procedures on the destructive behaviors of persons with developmental disabilities. In U.S. Department of Health and Human Services, *Treatment of destructive behaviors in persons with developmental disabilities* (pp. 231–341) (NIH Publication No. 91-2410). Bethesda, MD: National Institutes of Health.

Day, R. M., Rea, J. A., Schussler, N. G., Larsen, S. E., & Johnson, W. L. (1988). A functionally based approach to the treatment of self-injurious behavior. *Behavior Modification, 12,* 565–589.

Derby, K. M., Wacker, D. P., Sasso, G., Steege, M., Northup, J., Cigrand, K., & Asmus, J. (1992). Brief functional assessment techniques to evaluate aberrant behavior in an outpatient setting: A summary of 79 cases. *Journal of Applied Behavior Analysis, 25,* 713–721.

Dorsey, M. F., Iwata, B. A., Reid, D. H., & Davis, P. A. (1982). Protective equipment: Continuous and contingent application in the treatment of self-injurious behavior. *Journal of Applied Behavior Analysis, 15,* 217–230.

Edelson, S. M., Taubman, M. T., & Lovaas, O. I. (1983). Some social contexts for self-destructive behavior. *Journal of Abnormal Child Psychology, 11,* 299–312.

Green, L., & Freed, S. (1993). The substitutability of reinforcers. *Journal of the Experimental Analysis of Behavior, 60,* 141–158.

Griffin, J. C., Williams, D. E., Stark, M. T., Altmeyer, B. K., & Mason, M. (1984). Self-injurious behavior: A statewide prevalence survey, assessment of severe cases, and follow-up of aversive programs. In J. C. Griffin, M. T. Stark, D. E. Williams, B. K. Altmeyer, & H. K. Griffin (Eds.), *Advances in the treatment of self-injurious behavior* (pp. 1–25). Austin, TX: Department of Health and Human Services.

Heidorn, S. D., & Jensen, C. C. (1984). Generalization and maintenance of the reduction of self-injurious behavior maintained by two types of reinforcement. *Behaviour Research and Therapy, 22,* 581–586.

Horner, R. H., Day, H. M., Sprague, J. R., O'Brien, M., & Heathfield, L. T. (1991). Interspersed requests: A nonaversive procedure for reducing aggression and self-injury during instruction. *Journal of Applied Behavior Analysis, 24,* 265–278.

Iwata, B. A. (1987). Negative reinforcement in applied behavior analysis: An emerging technology. *Journal of Applied Behavior Analysis, 20,* 361–387.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1982). Toward a functional analysis of self-injury. *Analysis and Intervention in Developmental Disabilities, 2,* 3–20.

Iwata, B. A., Duncan, B. A., Zarcone, J. R., Lerman, D. C., & Shore, B. A. (in press). A sequential, test-control methodology for conducting functional analyses of self-injurious behavior. *Behavior Modification.*

Iwata, B. A., Pace, G. M., Cowdery, G. E., & Miltenberger, R. G. (1994). What makes extinction work: An analysis of procedural form and function. *Journal of Applied Behavior Analysis, 27,* 131–144.

Iwata, B. A., Pace, G. M., Kalsher, M. K., Cowdery, G. E., & Cataldo, M. F. (1990). Experimental analysis and extinction of self-injurious escape behavior. *Journal of Applied Behavior Analysis, 23,* 11–27.

Iwata, B. A., Vollmer, T. R., & Zarcone, J. R. (1990). The experimental (functional) analysis of behavior disorders: Methodology, applications, and limitations. In A. C. Repp & N. N. Singh (Eds.), *Perspectives on the use of nonaversive and aversive interventions for persons with developmental disabilities* (pp. 301–330). Sycamore, IL: Sycamore.

Iwata, B. A., Vollmer, T. R., Zarcone, J. R., & Rodgers, T. A. (1993). Treatment classification and selection based on behavioral function. In R. Van Houten & S. Axelrod (Eds.), *Behavior analysis and treatment* (pp. 102–125). New York: Plenum.

Johnson, W. L., & Day, R. M. (1992). The incidence and prevalence of self-injurious behavior. In J. K. Luiselli, J. L. Matson, & N. N. Singh (Eds.), *Self-injurious behavior: Analysis, assessment, and treatment* (pp. 21–56). New York: Springer.

Kiley, M., & Lubin, R. (1983). Epidemiological methods. In J. L. Matson & J. A. Mulick (Eds.), *Handbook of mental retardation* (pp. 541–556). New York: Pergamon.

Lerman, D. C., & Iwata, B. A. (1993). Descriptive and experimental analyses of variables maintaining self-injurious behavior. *Journal of Applied Behavior Analysis, 26,* 293–319.

Lovaas, O. I., Freitag, G., Gold, V. J., & Kassorla, I. C. (1965). Experimental studies in childhood schizophrenia: Analysis of self-destructive behavior. *Journal of Experimental Child Psychology, 2,* 67–84.

Lovaas, O. I., & Simmons, J. Q. (1969). Manipulation of self-destruction in three retarded children. *Journal of Applied Behavior Analysis, 2,* 143–157.

Mace, F. C., & Belfiore, P. (1990). Behavioral momentum in the treatment of escape-motivated stereotypy. *Journal of Applied Behavior Analysis, 23,* 507–514.

Mace, F. C., & Lalli, J. S. (1991). Linking descriptive and experimental analyses in the treatment of bizarre speech. *Journal of Applied Behavior Analysis, 24,* 553–562.

Mace, F. C., Lalli, J. S., & Lalli, E. P. (1991). Functional analysis and treatment of aberrant behavior. *Research in Developmental Disabilities, 12,* 155–180.

Mason, S. A., & Iwata, B. A. (1990). Artifactual effects of sensory-integrative therapy on self-injurious behavior. *Journal of Applied Behavior Analysis, 23,* 361–370.

Maurice, P., & Trudel, G. (1982). Self-injurious behavior: Prevalence and relationships to environmental events. In J. H. Hollis & C. E. Meyers (Eds.), *Life threatening behavior: Analysis and intervention* (pp. 81–103). Washington, DC: American Association on Mental Deficiency.

Mazaleski, J. L., Iwata, B. A., Rodgers, T. A., Vollmer, T. R., & Zarcone, J. R. (1994). Protective equipment as treatment for stereotypic hand mouthing: Sensory extinction or punishment effects? *Journal of Applied Behavior Analysis, 27,* 345–355.

Michael, J. (1982). Distinguishing between discriminative and motivational functions of stimuli. *Journal of the Experimental Analysis of Behavior, 37,* 149–155.

Michael, J. (1993). Establishing operations. *The Behavior Analyst, 16,* 191–206.

Pace, G. M., Iwata, B. A., Cowdery, G. E., Andree, P. J., & McIntyre, T. (1993). Stimulus (instructional) fading during extinction of self-injurious escape behavior. *Journal of Applied Behavior Analysis, 26,* 205–212.

Peterson, R. F., & Peterson, L. R. (1968). The use of positive reinforcement in the control of self-destructive behavior in a retarded boy. *Journal of Experimental Child Psychology, 6,* 351–360.

Reichle, J., & Wacker, D. P. (Eds.). (1993). *Communicative alternatives to challenging behavior: Integrating functional assessment and intervention strategies.* Baltimore: Paul H. Brookes.

Reid, D. H., Parsons, M. B., Phillips, J. F., & Green, C. W. (1993). Reductions of self-injurious hand mouthing using response blocking. *Journal of Applied Behavior Analysis, 26,* 139–140.

Repp, A. C., Felce, D., & Barton, L. E. (1988). Basing the treatment of stereotypic and self-injurious behaviors on hypotheses of their causes. *Journal of Applied Behavior Analysis, 21,* 281–289.

Repp, A. C., & Karsh, K. G. (1990). A taxonomic approach to the nonaversive treatment of maladaptive behavior of persons with developmental disabilities. In A. C. Repp & N. N. Singh (Eds.), *Perspectives on the use of nonaversive and aversive interventions for persons with developmental disabilities* (pp. 331–347). Sycamore, IL: Sycamore.

Rincover, A. (1978). Sensory extinction: A procedure for eliminating self-stimulatory behavior in developmentally disabled children. *Journal of Abnormal Child Psychology, 6,* 299–310.

Rincover, A., Newsom, C. D., & Carr, E. G. (1979). Using sensory extinction procedures in the treatment of compulsive-like behavior of developmentally disabled children. *Journal of Consulting and Clinical Psychology, 4,* 695–701.

Sackett, D. L., Haynes, R. B., Guyatt, G. H., & Tugwell, P. (1991). *Clinical epidemiology: A basic science for clinical medicine.* Boston: Little, Brown.

Schaeffer, H. H. (1970). Self-injurious behavior: Shaping "head-banging" in monkeys. *Journal of Applied Behavior Analysis, 2,* 111–116.

Schroeder, S. R., Kanoy, R. C., Mulick, J. A., Rojahn, J., Thios, S. J., Stevens, M., & Hawk, B. (1982). Environmental antecedents which affect management and maintenance of programs for self-injurious behavior. In J. H. Hollis & C. E. Meyers (Eds.), *Life threatening behavior: Analysis and intervention* (pp. 105–159). Washington, DC: American Association on Mental Deficiency.

Smith, R. G., Iwata, B. A., Vollmer, T. R., & Zarcone, J. R. (1993). Experimental analysis and treatment of mul-

tiply controlled self-injury. *Journal of Applied Behavior Analysis, 26,* 183–196.

Steege, M. W., Wacker, D. P., Cigrand, K. C., Berg, W. K., Novak, C. G., Reimers, T. M., Sasso, G. M., & DeRaad, A. (1990). Use of negative reinforcement in the treatment of self-injurious behavior. *Journal of Applied Behavior Analysis, 23,* 459–467.

Sturmey, P. (in press). Assessing the functions of aberrant behaviors: A review of psychometric instruments. *Journal of Autism and Developmental Disorders.*

Taylor, J. C., & Carr, E. G. (1992). Severe problem behaviors related to social interaction: I. Attention and social avoidance. *Behavior Modification, 16,* 305–335.

U.S. Department of Health and Human Services. (1991). *Treatment of destructive behaviors in persons with developmental disabilities* (NIH Publication No. 91-2410). Bethesda, MD: National Institutes of Health.

U.S. Department of Health and Human Services, Health Care Financing Administration. (1988, June 3). Medicaid program: Conditions for intermediate care facilities for the mentally retarded; Final rule. *Federal Register, 53*(107), 20447–20505.

Van Houten, R. (1993). The use of wrist weights to reduce self-injury maintained by sensory reinforcement. *Journal of Applied Behavior Analysis, 26,* 197–203.

Vaughan, M. E., & Michael, J. L. (1982). Automatic reinforcement: An important but ignored concept. *Behaviorism, 10,* 217–227.

Vollmer, T. R., Iwata, B. A., Duncan, B. A., & Lerman, D. C. (1993). Extensions of multielement functional analyses using reversal-type designs. *Journal of Developmental and Physical Disabilities, 5,* 311–325.

Vollmer, T. R., Iwata, B. A., Zarcone, J: R., Smith, R. G., & Mazaleski, J. L. (1993). The role of attention in the treatment of attention-maintained self-injurious behavior: Noncontingent reinforcement and differential reinforcement of other behavior. *Journal of Applied Behavior Analysis, 26,* 9–21.

Wiesler, N. A., Hanson, R. H., Chamberlain, T. P., & Thompson, T. (1985). Functional taxonomy of stereotypic and self-injurious behavior. *Mental Retardation, 23,* 230–234.

Zarcone, J. R., Rodgers, T. A., Iwata, B. A., Rourke, D., & Dorsey, M. F. (1991). Reliability analysis of the Motivation Assessment Scale: A failure to replicate. *Research in Developmental Disabilities, 12,* 349–360.

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