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EFFECTS OF INCREASED RESPONSE EFFORT ON SELF-INJURY AND OBJECT MANIPULATION AS COMPETING RESPONSES

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We evaluated the effects of a response-effort intervention on the occurrence of self-injurious hand mouthing and a competing response (object manipulation) with 4 individuals who had profound developmental disabilities. During Phase 1, results of functional analyses showed that all participants engaged in high levels of hand mouthing in the absence of social contingencies, suggesting that the behavior was maintained by automatic reinforcement. In Phase 2, preferred leisure items were identified for participants during assessments in which duration of leisure item manipulation was used as the index of preference. In Phase 3, participants were observed to engage in high levels of hand mouthing and in varying levels of object manipulation when they had free access to their most preferred leisure items during baseline. The effects of increased response effort on hand mouthing and object manipulation were then evaluated in mixed multiple baseline and reversal designs. The response-effort condition was identical to baseline, except that participants wore soft, flexible sleeves that increased resistance for elbow flexion but still enabled participants to engage in hand mouthing. Results showed consistent decreases in SIB and increases in object manipulation during the response-effort condition for all participants. These results suggested that a less preferred reinforcer (produced by object manipulation) may substitute for a more highly preferred reinforcer (produced by hand mouthing) when response effort for hand mouthing was increased.

DESCRIPTORS: self-injurious behavior, automatic reinforcement, reinforcer substitutability, response effort

Research on the functional analysis of self-injurious behavior (SIB) has shown that SIB may be maintained by contingencies of nonsocial (automatic) as well as social reinforcement. For example, Iwata et al. (1994) conducted functional analyses of the SIB of 152 individuals with developmental disabilities and found that automatic reinforcement was the maintaining variable for about one fourth of the sample.

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Interventions for behavior maintained by automatic reinforcement are often difficult to develop or implement because the maintaining reinforcer may be impossible to identify or control (Vollmer, 1994). Furthermore, if the behavior's maintaining reinforcer is always available as a direct product of responding, stimuli delivered under differential reinforcement contingencies typically consist of arbitrary reinforcers (those unrelated to maintenance of the problem behavior), which are delivered in the absence of extinction. Thus, interventions that do not restrict access to reinforcement for the target behavior necessarily create a condition in which two reinforcers are concurrently available: One is produced by the target behavior

and the other is available by engaging in some other response (or, alternatively by not engaging in the target response).

Research on the substitutability of reinforcers (see Green & Freed, 1993, for a review) is relevant to the treatment of behavior problems maintained by automatic reinforcement because the alternative reinforcer delivered during treatment should be one that competes with (is substitutable for) the reinforcer produced by problem behavior. That is, increased consumption (selection) of the reinforcer associated with alternative behavior should result in decreased consumption of the reinforcer produced by problem behavior. The relationship between substitutable reinforcers, however, is not a static one and may be affected by a number of variables, including delay, magnitude, or response effort associated with one of the choice options. Thus, the concept of reinforcer substitutability suggests at least three strategies in developing reinforcement-based interventions for SIB maintained by automatic reinforcement.

First, alternative reinforcers may be identified that effectively compete with the reinforcers produced by SIB. For example, Shore, Iwata, DeLeon, Kahng, and Smith (1997) observed that, when a highly preferred leisure item and SIB were concurrently available, 3 participants showed almost exclusive preference for object (leisure item) manipulation over SIB. Thus, object manipulation was substitutable for SIB for these individuals under what amounted to baseline conditions.

When continuous access to alternative sources of stimulation does not compete with SIB, a second strategy would be to increase the reinforcement obtained from engaging in the more appropriate alternative response (i.e., to make the alternative option more probable). For example, Horner and Day (1991) decreased 3 participants' aberrant behaviors by teaching them alternative responses that were more efficient than were the target behaviors in obtaining the same functional reinforcers. That is, the alternative responses produced reinforcement more reliably or more quickly, or required less effort, than did the target behaviors.

The behavior problems examined by Horner and Day (1991) were responses maintained by social reinforcement. When behavior is maintained by automatic reinforcement, however, it may be difficult to program more efficient reinforcement for an alternative response, aside from making that response continuously available. As an alternative approach, a third strategy would be to decrease the reinforcing efficacy of SIB. Several studies have demonstrated that mechanical devices such as wrist weights (Hanley, Piazza, Keeney, Blakeley-Smith, & Worsdell, 1998; Van Houten, 1993) or semirigid arm splints (Irvin, Thompson, Turner, & Williams, 1998), which increase the amount of force required to engage in SIB, may be effective forms of intervention. For example, Irvin et al. increased the response effort for elbow flexion by placing flexible sleeves containing stays to increase rigidity on the arms of 2 participants who engaged in SIB that consisted of hand mouthing. The sleeves did not completely prevent SIB but simply made it more effortful. During baseline, both participants engaged in high levels of hand mouthing and object manipulation (1 participant's object manipulation was somewhat variable but often occurred during 100% of the observation intervals). During the response-effort (sleeves) conditions, hand mouthing decreased to near-zero levels, but only small to moderate reductions in object manipulation were observed. However, it is unclear if similar results would have been obtained with individuals who initially showed little preference for leisure engagement. In other words, is it possible that increasing the response effort for SIB may actually increase

leisure engagement if engagement initially occurs at low baseline rates?

The current study extends previous research on response-effort interventions for SIB by examining the effects of flexible arm sleeves on the occurrence of SIB and object manipulation. Two of the participants in this study engaged in high levels of both SIB and object manipulation during baseline, whereas the other 2 participants showed almost exclusive preference for SIB.

PHASE 1: FUNCTIONAL ANALYSIS

Method

Participants and Setting

Four women who lived in a state residential center for persons with developmental disabilities participated in all phases of the study. All 4 had been diagnosed with profound mental retardation. They were nonambulatory, displayed no expressive language, and had multiple skill deficits. Betty, Carol, and Debby were 33-, 40-, and 51-year-old women, respectively, whose SIB consisted of hand mouthing that resulted in tissue damage to both hands and face. Ann was a 33-year-old woman whose SIB consisted of mouthing of her right thumb, which produced skin lesions and infections.

Sessions during this phase and all subsequent phases were conducted at the center in a training room that measured approximately 7.6 m by 7.6 m. The room contained tables, chairs, and various materials (see below) needed for assessment.

Procedure

A functional analysis was conducted to identify the potential maintaining variables for each individual's SIB, based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Sessions lasted for 10 min and were conducted two to four times daily, 3 to 5 days per week. Each individual was initially exposed to three conditions (alone, attention, and demand) arranged in a multielement design. Due to some unusual patterns in Ann's initial results, her assessment was extended with the inclusion of the play condition.

During the alone condition, the room contained no leisure items, the observer did not interact with the participant at any time during the session, and no consequences were delivered for SIB. During the attention condition, the participant had free access to several leisure items throughout the session. The experimenter did not interact with the participant, except to deliver attention (a reprimand) following each occurrence of SIB. During the demand condition, an experimenter presented learning trials to the participant at 30-s intervals, using a three-step prompting procedure (instruction, demonstration, physical prompt). Compliance was followed by praise, and SIB was followed by termination of the trial. During the play condition, the participant had free access to several leisure items throughout the session, and the experimenter delivered attention to the participant at least once every 30 s independent of the participant's behavior.

Response Measurement and Reliability

An observer recorded occurrences of hand mouthing (defined as insertion of any part of the hand past the plane of the upper and lower lips, or touching the tongue with the hand) during continuous 10-s intervals, using a partial-interval recording procedure. Data were summarized as the percentage of intervals during which hand mouthing occurred. A second observer collected data independently during 28.6% of all sessions. Agreements were scored on an interval-by-interval basis, and reliability was calculated by dividing the number of agreement intervals by the total number of intervals and multiplying by 100%. Mean percentages of

Table 1
Mean Percentage of Intervals Containing SIB During Functional Analyses

	Alone	Attention	Demand	Play
Ann	60.4	67.5	79.6	76.7
Betty	69.8	37.3	21.8	
Carol	99.8	88.3	77.5	
Debby	56.7	40.8	67.5	

agreement were 92.2%, 92.4%, 94.1%, and 97.8% for Ann, Betty, Carol, and Debby, respectively.

Results

The duration of assessment ranged from 14 to 22 sessions ($M = 17$ sessions). Results are summarized in Table 1 as the mean percentage of intervals containing SIB per session. All 4 participants consistently engaged in high levels of SIB during the alone condition, and 3 participants engaged in high levels of hand mouthing in other conditions as well (Betty engaged in lower levels of hand mouthing during the attention and demand conditions). These data indicate that the SIB of all participants persisted in the absence of social stimulation and was not differentially sensitive to social consequences (attention or escape), and are consistent with patterns of responding suggestive of maintenance by automatic reinforcement.

PHASE 2: STIMULUS PREFERENCE ASSESSMENT

Method

Procedure

Caregivers who interacted daily with the 4 participants were interviewed to identify preferred leisure items. Based on these interviews and on subsequent informal observations conducted by experimenters, a pool of 15 items was selected for each participant. Preference for these items was assessed using a variation of procedures described by Piazza, Fisher, Hanley, Hilker, and Derby (1996) and by DeLeon, Iwata, and Roscoe (1999). Each item was presented to the participant individually during three trials, each lasting 2 min, which were sequenced randomly across items. During each trial, an item was placed either on the participant's lap tray or in the participant's hand.

Response Measurement and Reliability

An observer measured the duration of object manipulation (defined as holding or manipulating an object with either hand) during each trial with a stopwatch. The watch was started or stopped each time a participant initiated or terminated object manipulation. These durations were summed across trials for each item, yielding a total reflecting the amount of time a participant manipulated an item out of 360 s. A second observer recorded data independently during 33.3% of all trials. Interobserver agreement was calculated by dividing the smaller duration by the larger duration and multiplying by 100%. Mean interobserver agreement was 98.1%, 98.3%, 98.3%, and 98.1% for Betty, Ann, Carol, and Debby, respectively.

Results

Total durations of contact with leisure items across stimuli are shown in Figure 1. The leisure item manipulated for the longest duration by each individual was selected for use during Phase 3, and were, for Betty, a Velcro sticker (46 s); for Ann, a stuffed ball (17 s); for Carol, a weight stick (178 s); and for Debby, a flapper (345 s).

PHASE 3: RESPONSE-EFFORT ANALYSIS

Method

Apparatus

The device used in this phase was adapted from arm restraints described by Fisher, Piazza, Bowman, Hanley, and Adelinis (1997)

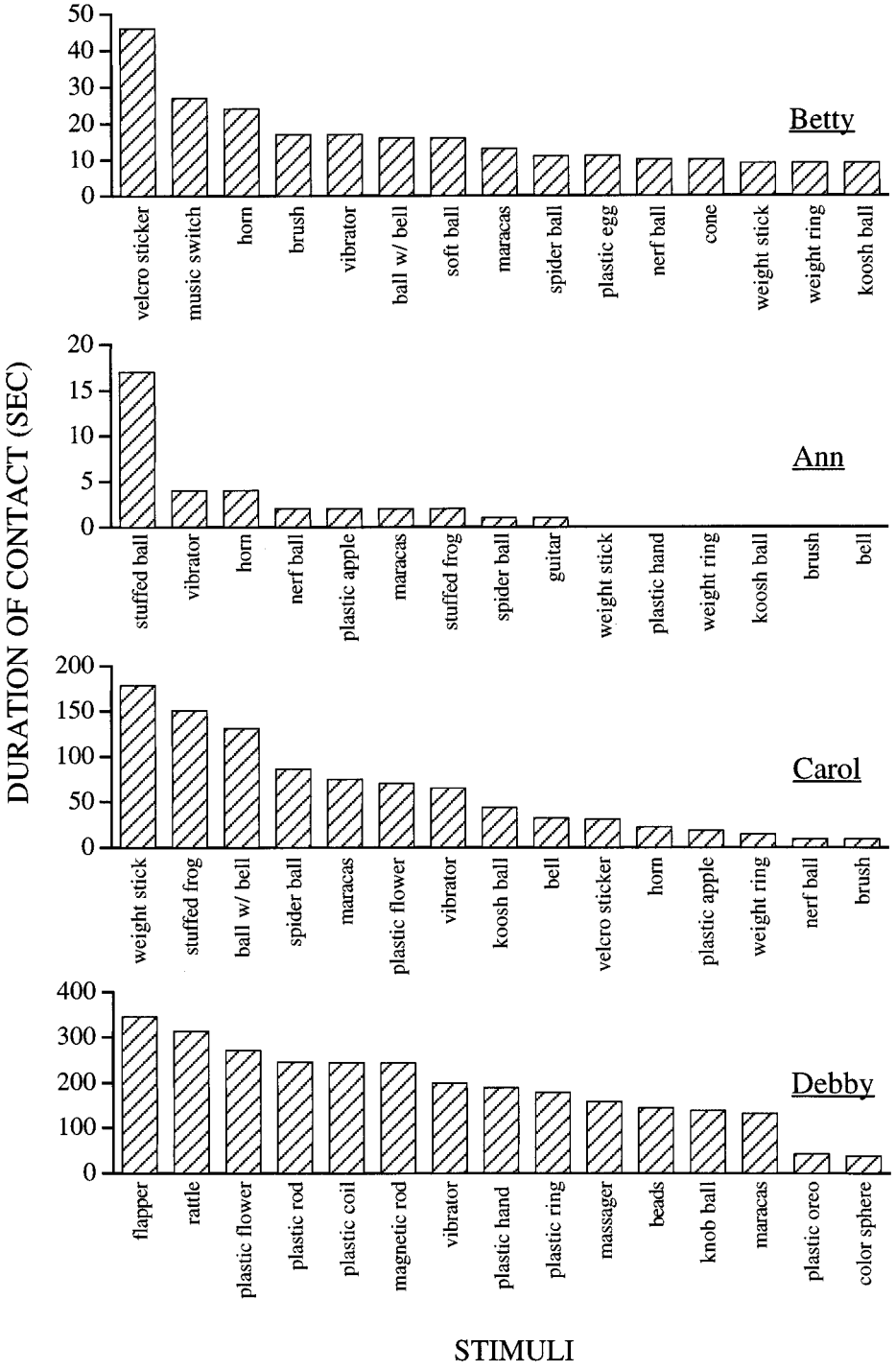

Figure 1. Duration of contact with leisure items during the preference assessments.

and by Irvin et al. (1998). Two modifications were made to the device: (a) The body of the device was constructed of soft material (1-cm thick fleece covered by cordura) instead of canvas, and (b) the device contained no stays (metal or plastic rods) to further restrict range of motion. Thus, the device was an open sleeve with Velcro fasteners. When worn on an arm, it fully covered the arm's circumference and extended from 10 cm above the wrist to 10 cm below the armpit. To estimate the amount of additional response effort that was required to bend an arm while the sleeve was worn, it was necessary to create consistent conditions for measurement, which would not exist when applying the sleeve to an actual person's arm due to uncontrollable differences in muscular tension across measurements. We encased a wooden stick joint in soft foam (to simulate an arm) and placed it in a horizontal position. We then attached a digital scale to one end of the stick and measured the amount of force (weight) required to bend it 90° upward. We repeated the procedure after the sleeve was fitted around the stick, and the difference between the two measurements was taken as the amount of additional resistance attributable to the sleeve. These comparisons were conducted five times, yielding a mean value of 1.44 kg (range, 1.11 to 1.64 kg).

Procedure

Baseline. During this condition, data were collected on hand mouthing and object manipulation (as defined previously) while the participant had free access to the most preferred leisure item identified in Phase 2. Participants did not wear the sleeves during baseline. The experimenter did not interact with the participant throughout the session, and occurrences of SIB produced no programmed consequences. Sessions lasted for 10 min and were conducted two to four times daily, 3 to 5 days per week.

Sleeves (response-effort device). Prior to starting each session, the experimenter placed a sleeve on each arm of the participant (Ann wore one sleeve only because she mouthed only her right hand). A nurse also examined the participant's arms before and after each session to determine if wearing the sleeve may have caused any damage (none was observed). Aside from these changes, sessions were identical to those conducted during baseline.

Response Measurement and Reliability

The dependent variables were hand mouthing (as defined in Phase 1) and object manipulation (as defined in Phase 2). An observer recorded the occurrence of both behaviors during continuous 10-s intervals, using a partial-interval recording procedure. Data were summarized as the percentage of intervals during which responding occurred.

A second observer independently recorded the occurrence of hand mouthing and object manipulation during 71.1% of the sessions. Agreements were scored on an interval-by-interval basis, and reliability was calculated by dividing the number of agreement intervals by the total number of intervals and multiplying by 100%. Mean percentages of agreement for Betty's, Ann's, Carol's, and Debby's SIB were 97.1%, 96.9%, 95.5%, and 97.9%, respectively. Mean agreement percentages for Betty's, Ann's, Carol's, and Debby's object manipulation were 90.3%, 97.0%, 94.9%, and 97.8%, respectively.

Experimental Design

A multiple baseline across subjects design was used to evaluate the effects of the response-effort device. In addition, reversal designs, in which baseline and sleeve conditions were alternated in ABAB fashion, were used with Betty and Ann.

Results

Figure 2 shows the percentage of intervals containing SIB and object manipulation

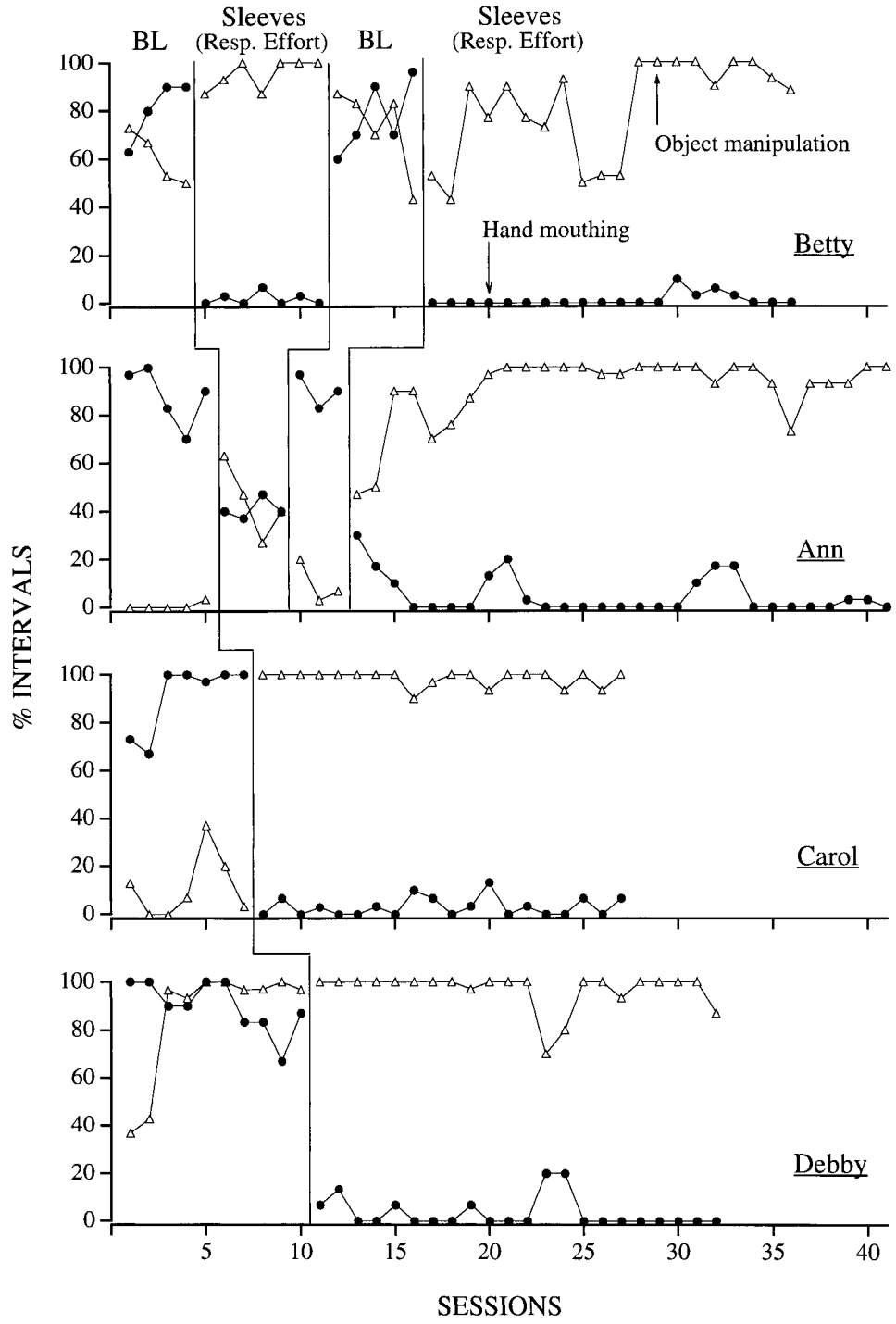

Figure 2. Percentage of intervals containing SIB and object manipulation during baseline and sleeves (response-effort) conditions.

during baseline and sleeve (response-effort) conditions for all participants. During baseline, Betty engaged in high levels of SIB and moderate levels of object manipulation. During the first response-effort condition, her object manipulation increased to levels higher than those observed for SIB during baseline, and SIB decreased to below 5% of the observation intervals. When baseline was reinstated, high levels of SIB and moderate levels of object manipulation were again observed. During the final response-effort condition, Betty's object manipulation increased gradually and was then maintained at above 90%, whereas SIB decreased to zero immediately and rarely occurred throughout the remainder of the study.

Ann engaged in high levels of SIB and almost no object manipulation during baseline. During the first response-effort condition, SIB decreased and object manipulation increased, such that both occurred at similar moderate levels. When baseline was reinstated, high levels of SIB and very low levels of object manipulation were again observed. During the final response-effort condition, Ann's object manipulation increased to levels comparable to or higher than those observed for SIB during baseline, and her SIB decreased to very low levels and rarely exceeded 20% of the intervals throughout the condition.

Carol's pattern of responding during baseline was similar to Ann's: High levels of SIB and low levels of object manipulation occurred. When the response-effort condition was implemented, this pattern was immediately reversed. Object manipulation increased and was maintained at above 90% of the intervals, whereas SIB decreased and remained below 20% of the intervals.

Debbie engaged in high levels of both SIB and object manipulation during baseline, with object manipulation occurring more often than SIB by the end of baseline. During the response-effort condition, her object manipulation was maintained at a high level and her SIB decreased to very low levels until it reached zero, where it remained for the last eight sessions of the condition.

DISCUSSION

Present results showed that, when leisure objects were continuously available during baseline to 4 individuals whose hand mouthing was maintained by automatic reinforcement, different patterns of reinforcer competition were observed. Two individuals (Betty and Debby) engaged in high levels of both hand mouthing and object manipulation, suggesting that the reinforcers associated with these behaviors were not substitutable exclusively. By contrast, Ann and Carol showed a clear preference for hand mouthing and rarely engaged in object manipulation. When the response effort required to engage in hand mouthing was increased through the use of the flexible arm sleeves, all participants' hand mouthing decreased to near-zero levels, and their object manipulation increased to very high levels. These results extend previous research on the treatment of aberrant behaviors maintained by automatic reinforcement in several ways.

First, although results from several studies have shown that continuous access to preferred leisure items will readily substitute for reinforcement obtained from SIB (e.g., Favell, McGimsey, & Schell, 1982; Shore et al., 1997), results from others indicate that object manipulation may not compete with SIB unless SIB is directly reduced through procedures such as response blocking or restraint (Lindberg, Iwata, & Kahng, 1999; Ringdahl, Vollmer, Marcus, & Roane, 1997). Results of the Irvin et al. (1998) study and those reported here suggest an alternative means of reducing SIB through the manipulation of response effort. Although the sleeves worn by our participants and those in the Irvin et al. study may be subject

to varying interpretations regarding degree of intrusiveness, they are much less restrictive than mechanical restraints and may be no more intrusive than response blocking. For example, unlike participants in the Irvin et al. study, the sleeves used in the present study contained no stays to increase their rigidity and thus resembled the endpoint of typical restraint-fading procedures. Moreover, the wearing of sleeves (as used in this study) does not require continuous monitoring by caregivers, as would be the case for interventions such as response blocking. We must note, however, that although no physical side effects (e.g., abrasions, bruises) were observed during the study, when the sleeves were applied for brief periods of time, or after the study, when participants wore the sleeves for extended periods (all day, with 10-min breaks each hour), there are conditions under which wearing the sleeves may have deleterious health consequences (e.g., outside on hot days).

Second, our results extend the findings of Irvin et al. (1998) by demonstrating that a response-effort intervention aimed at reducing SIB may have a facilitative effect on other behavior. Both participants in the Irvin et al. study and 2 in our study (Betty and Debby) initially showed high levels of both SIB and object manipulation. For these participants, the primary benefit of the sleeves was to differentially suppress SIB while leaving object manipulation unaffected. However, 2 of the participants in our study (Ann and Carol) engaged in little or no object manipulation during baseline. When engaging in SIB was made more effortful, they not only engaged in less SIB but also engaged in more object manipulation.

Third, the general approach to behavior reduction exemplified in this study illustrates the alteration of preference for concurrently available reinforcers by decreasing preference for the socially undesirable option when it may not be possible to increase preference for the more socially desirable alternative. In this respect, our results extend the findings of previous research on parameters that affect choice between concurrently available reinforcers (Neef, Shade, & Miller, 1994; Rachlin, Green, Kagel, & Battalio, 1976) and suggest additional clinical applications.

One interesting result in the present study was that levels of object manipulation observed in Phase 2 were somewhat, although not entirely, predictive of baseline performances observed in Phase 3. Betty, Ann, and Debby engaged in object manipulation for moderate, short, and long durations, respectively, during the preference assessment (Phase 2) and engaged in similar levels of object manipulation during baseline in Phase 3. By contrast, Carol engaged in object manipulation for a long duration during the preference assessment but for very short durations during baseline. Also, Carol's and Debbie's high levels of object manipulation during the preference assessment were not predictive of SIB, in that both participants also engaged in very high levels of SIB during baseline. It is possible that additional assessment might have resulted in the identification of stimuli that competed more effectively with SIB (as was observed by Piazza et al., 1996). Thus, the present data suggest that levels of object manipulation observed during brief exposures (three 2-min trials) may sometimes (but not always) be good indicators of reinforcer competition over more extended durations.

The study also contained several limitations that should be noted. First, the intervention essentially involved two components: (a) increased response effort for SIB and (b) continuous access to a leisure object. Although baseline data indicated that the latter component alone had little or no effect on SIB, the singular effect of the former component is unknown because leisure items were always available during the response-effort conditions. We did not include

a sleeves-alone condition in the present study because our objective was to examine the relationship between SIB and object manipulation. It is possible, however, that the sleeves would have suppressed SIB to near-zero levels in the absence of any other treatment, and future research should establish the extent to which this might occur.

Second, the long-term efficacy of the intervention is unknown. For example, it is possible that either increased deprivation from reinforcement produced by SIB or satiation to reinforcement obtained from object manipulation may, over time, occasion reemergence of SIB, regardless of the fact that it is more effortful. If so, additional effort manipulations or reinforcer-variation strategies (e.g., see Egel, 1981) may be helpful. This issue should be addressed through additional research conducted over longer periods of time under everyday conditions. We did not observe increases in SIB when participants wore sleeves during all-day application following the completion of the study, but this observation must be considered tentative because the reliability of the data was not adequately assessed.

Finally, the exact mechanism by which the sleeves suppressed SIB is not entirely clear. Attributing behavior change to the process of response effort seemed reasonable based on casual observation. That is, to experimenters who wore the sleeves and who observed participants wearing the sleeves, arm flexion clearly appeared to be more effortful, although it did not prevent hand mouthing or object manipulation requiring elbow flexion. However, the extent to which increased effort rendered hand mouthing punishing, instead of merely less reinforcing, is unknown. For example, data presented by Mazaleski, Iwata, Rodgers, Vollmer, and Zarcone (1994) indicated that reductions in hand mouthing obtained when individuals wore protective devices may have been a function of punishment rather than extinction. Mazaleski et al. suggested several strategies for determining whether wearing devices functioned as punishment per se (e.g., applying the device contingent on some other arbitrary behavior), which may clarify the basis for the behavior change observed in this study.

Future research could extend the present findings in other ways through the development of response-effort interventions for behavior problems other than hand mouthing (see Friman & Poling, 1995, for a recent discussion) or through the evaluation of response effort with behavior problems maintained by other contingencies of reinforcement. For example, because decreases in SIB were observed in this study even though its reinforcers presumably remained available, it is possible that response-effort interventions might also decrease behavior problems that are maintained by social reinforcement (attention or escape) in the absence of extinction.

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STUDY QUESTIONS

1. What is meant by the term *reinforcer substitutability* and how might it form the basis of treatments for problem behavior maintained by automatic reinforcement?

2. Describe several ways in which an increase in response effort can alter the effects of reinforcement for a given response.

3. Summarize the results of the functional analyses and the authors' conclusions about the variables that maintained participants' SIB.

4. How was preference for leisure items assessed?

5. Describe the apparatus used during the treatment phase of the study and the method used to quantify response effort.

6. What two patterns of results were observed across the 4 participants during the baseline and sleeves conditions?

7. What are the potential advantages of the response-effort device used in this study over interventions involving response blocking or mechanical restraint?

8. The authors did not examine the singular effects of the sleeves condition on SIB. Why would such an analysis be helpful in determining the long-term efficacy of the combined (sleeves and leisure item) intervention?

Questions prepared by Michele Wallace and Juliet Conners, The University of Florida