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AN EVALUATION OF ANTECEDENT EXERCISE ON BEHAVIOR MAINTAINED BY AUTOMATIC REINFORCEMENT USING A THREE-COMPONENT MULTIPLE SCHEDULE

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We evaluated antecedent exercise for treating the automatically reinforced problem behavior of 4 individuals with autism. We conducted preference assessments to identify leisure and exercise items that were associated with high levels of engagement and low levels of problem behavior. Next, we conducted three 3-component multiple-schedule sequences: an antecedent-exercise test sequence, a noncontingent leisure-item control sequence, and a social-interaction control sequence. Within each sequence, we used a 3-component multiple schedule to evaluate preintervention, intervention, and postintervention effects. Problem behavior decreased during the postintervention component relative to the preintervention component for 3 of the 4 participants during the exercise-item assessment; however, the effects could not be attributed solely to exercise for 1 of these participants.

Key words: antecedent exercise, automatic reinforcement, functional analysis, preference assessment

Antecedent exercise has been found to reduce various forms of problem behavior, including stereotypy (Bachman & Sluyter, 1988; Kern, Koegel, & Dunlap, 1984; Kern, Koegel, Dyer, Blew, & Fenton, 1982; Watters & Watters, 1980), self-injury (Baumeister & MacLean, 1984), disruption (Bachman & Fuqua, 1983), and aggression (McGimsey & Favell, 1988). Antecedent exercise typically involves instructing and providing opportunities for individuals to engage in some form of exercise (e.g., jogging, aerobic activity) and then measuring their problem behavior following the intervention. Because antecedent exercise may be performed with minimal prompting and does not require a dedicated observer or therapist, it may be less staff intensive than consequence-based interventions (Allison, Basile, & MacDonald, 1991; Bachman & Fuqua, 1983; Bachman & Sluyter, 1988; Watters & Watters, 1980). For this reason, it may be particularly useful in clinical settings with low staff-to-student ratios.

A noteworthy example of a study that examined the effects of antecedent exercise was conducted by Bachman and Fuqua (1983), who evaluated the effects of jogging for four individuals with developmental disabilities who exhibited problem behavior, including off-task behavior, inappropriate vocalizations, motor stereotypy, or some combination. During the exercise condition, a therapist jogged a number of laps with the participant, and observers collected data on participants' pulse rates to ensure appropriate engagement with exercise. Data were averaged across three different observation periods (one shortly after exercise, one 1 hr following exercise, and one 2 hr following exercise). Results showed moderate decreases in problem behavior following exercise for three of the four participants. Although this study was exemplary in that it was one of the first to demonstrate experimental control of antecedent exercise, some methodological limitations made it difficult to determine whether

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the effects were solely due to antecedent exercise. First, because the authors summarized data on problem behavior across three different observation periods, it was unclear whether similar effects would have been obtained had problem behavior been measured only immediately following exercise. Second, the effects of antecedent exercise were evaluated in an uncontrolled setting (the classroom). Therefore, contingencies in effect (e.g., reinforcement, extinction, punishment, or some combination) in this setting may have decreased levels of problem behavior. Third, the authors did not conduct a functional analysis, making it unclear what variables maintained participants' problem behavior.

Several experimenters have replicated the findings of Bachman and Fuqua (1983), demonstrating the efficacy of antecedent exercise for reducing problem behavior (Allison et al., 1991; Bachman & Sluyter, 1988; Celiberti, Bobo, Kelly, Harris, & Handleman, 1997; Kern et al., 1982; McGimsey & Favell, 1988; Watters & Watters, 1980). However, all of these studies were associated with methodological limitations similar to those noted above. Larson and Miltenberger (1992) extended previous research by adding an attention control condition to evaluate whether simply providing attention may have similar reductive effects. Neither the antecedent exercise condition nor the attention control condition reduced problem behavior below baseline levels. Therefore, Larson and Miltenberger did not show positive effects of antecedent exercise, and they suggested three potential explanations for why they did not replicate previous research. First, a functional analysis was not conducted to determine the maintaining variables of the participants' problem behavior. Without knowledge of behavioral function, it is difficult to predict the potential effects of antecedent exercise. For example, if problem behavior is maintained by attention, antecedent exercise may decrease subsequent responding due to the frequent delivery of attention associated with exercise delivery. If problem behavior is maintained by escape, however, antecedent exercise may subsequently increase responding due to the demand characteristics of the exercise task. Second, it is possible that uncontrolled contingencies (e.g., the delivery of attention or escape contingent on problem behavior) in the postexercise environment may have contributed to the effects. Third, they noted that a given form of exercise (e.g., jogging or aerobic exercise) may have had idiosyncratic effects. That is, for some participants, the selected form of exercise may have been a preferred activity, whereas for others it may have been an aversive event. In addition, the forms of exercise previously evaluated may not have been appropriate for individuals with less advanced exercise repertoires or for individuals who did not readily comply with instructions to engage in tasks. Therefore, it may be helpful to conduct a preference assessment to identify forms of exercise that participants prefer and will readily engage in for an extended duration.

Although experimenters who have evaluated antecedent exercise did not determine the function of participants' problem behavior, this intervention may have the greatest impact on problem behavior maintained by automatic reinforcement. Antecedent exercise might be similar to providing continuous access to preferred items, a procedure that has effectively reduced automatically reinforced problem behavior (Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Ringdahl, Vollmer, Marcus, & Roane, 1997). In addition, antecedent exercise may function as a type of matched stimulation, a form of stimulation that, when continuously presented, has been found to be more effective than unmatched stimulation for decreasing automatically reinforced problem behavior (Piazza et al.). Therefore, the antecedent delivery of matched forms of stimulation may be more likely to function as an abolishing operation, reducing the reinforcing efficacy of the auto-

matic reinforcer. For this reason, it seems worthwhile to evaluate the effects of antecedent exercise on automatically reinforced problem behavior.

The clinical implication of using exercise as an antecedent-based procedure is that a therapist or care provider may be able to decrease the future occurrence of problem behavior by simply manipulating antecedent events (e.g., by presenting exercise materials and prompting engagement with those materials). To this end, researchers have evaluated the postintervention effects of antecedent exercise by comparing levels of problem behavior following exercise to those obtained prior to exercise (e.g., Bachman & Fuqua, 1983; Larson & Miltenberger, 1992). Because a determination of postintervention effects is critical when evaluating antecedent exercise, the experimental design must permit an evaluation of both the immediate and subsequent effects of the intervention. A multiple-schedule procedure may be particularly useful for this purpose and may ameliorate some of the limitations associated with the antecedent exercise literature.

Multiple schedules have often been used in basic research to study behavior's resistance to change (see Nevin & Grace, 2000). A multiple schedule involves the alternation of two or more component schedules, each correlated with a different stimulus (Catania, 1998). Recent applied studies have also shown the utility of multiple schedules for determining the immediate and subsequent effects of behavioral interventions. For example, Ahearn, Clark, Gardenier, Chung, and Dube (2003) used a multiple schedule to evaluate the immediate and subsequent effects of response-independent reinforcement. To this end, they alternated two four-component sequences, a test sequence and a control sequence. Each 20-min sequence included a no-interaction baseline, variable-time delivery of a high-preference item (test sequence) or no-interaction baseline (control sequence), continuous access to leisure items, and no-interaction baseline. Results showed that participants' stereotypy often decreased during the second component of the test sequence but not in the control sequence. In addition, greater persistence of stereotypy was observed during the fourth component of the test sequence than in this component of the control sequence.

Simmons, Smith, and Kliethermes (2003) used a three-component schedule to evaluate the immediate and subsequent effects of fixed-time (FT) food delivery on a participant's hand mouthing. Each 30-min session consisted of three 10-min components, including alone (baseline), FT food (intervention), and alone (baseline). Results showed significant reductions during the FT food delivery component from the baseline preintervention component. In addition, hand mouthing was consistently lower in the postintervention baseline component relative to the preintervention baseline component, suggesting that noncontingent food delivery may have produced stimulation that was functionally similar to that produced by the participant's mouthing. Subsequent studies have extended this methodology to evaluate the immediate and subsequent effects of noncontingent reinforcement and response blocking on the treatment of automatically reinforced problem behavior (e.g., Rapp, 2006, 2007).

Given the aforementioned methodological concerns associated with the antecedent exercise literature, the purpose of this study was to extend this research by incorporating several methodological advances. First, we conducted functional analyses to ensure that participants' problem behavior was maintained by automatic reinforcement. Second, we included exercise activities identified through systematic preference assessments. Third, we used a three-component multiple schedule for evaluating the immediate and subsequent effects of antecedent exercise. Fourth, we evaluated the independent postintervention effects of exercise

by implementing a multiple-schedule test sequence and two control sequences.

METHOD

Participants and Setting

Four individuals with autism, who attended a school for individuals with autism and other developmental disabilities, participated. Participants were included who exhibited problem behavior that was reported by staff to interfere with their educational programming and social interaction with peers. Steve was a 14-year-old boy who followed multistep directions and communicated using one- to three-word phrases. He exhibited motor stereotypy, including hand wringing and flapping. Drew was a 21-year-old man who followed two-step directions and communicated primarily using pictures in one- to three-word phrases. He exhibited self-injurious behavior (SIB), which included picking and biting his fingers. This behavior had frequently led to tissue damage and resulted in him wearing protective gloves throughout the day. Beth was a 12-year-old girl who responded to simple questions and communicated using single words, phrases, and simple sentences. Her target behavior was motor stereotypy, which included body rocking, hand flapping, and rubbing objects or body parts with her fingers or hand. Naomi was a 10-year-old girl who followed one-step directions and communicated using one- to three-word phrases. She exhibited SIB, including hand-to-head hitting and head-to-object hitting. This behavior had frequently led to tissue damage in the form of bruising and swelling.

All sessions were conducted in a room (1.5 m by 3 m) equipped with a video camera and other materials necessary for conducting experimental sessions.

Response Measurement and Interobserver Agreement

Stereotypy for Steve was defined as any instance of using one hand to bend, twist, or squeeze his other hand for at least 1 s. *Self-injury* for Drew included finger picking or biting, defined as any instance of one finger nail making contact with another finger or one or more fingers making contact with his teeth. *Stereotypy* for Beth was defined as repetitive movement of any or all body parts including rocking or swaying of the torso, head, feet, or body; pressing or rubbing fingers or whole hand against surface or body parts for more than 1 s; or hand flapping, defined as holding hand or fingers up in the air for at least 1 s. *Self-injury* for Naomi was defined as any audible hand-to-head or head-to-object contact.

During the functional analysis, preference assessment, and exercise assessment, observers recorded participants' problem behavior using frequency (Naomi) or momentary time sampling (Beth, Steve, and Drew). Momentary time sampling was used to measure Steve's stereotypy, Drew's skin picking, and Beth's motor stereotypy because these responses varied in duration per occurrence. Using this method, observers scored whether or not a response occurred during the last 2 s of each 10-s interval. Frequency measures were summarized as rate by dividing the total number of responses by the total number of minutes per session, and momentary time-sampling intervals were summarized as percentage occurrence by dividing the total number of intervals in which a response was scored by the total number of intervals in a session.

During the preference assessment, observers also recorded *item engagement*, defined as any instance of hand-to-item contact with leisure items. For exercise items, a specific definition of engagement was developed for each item to ensure that physical exertion occurred through interaction with the item. For example, exercise with the therapy ball was defined as lying on the ball with one's stomach or back or sitting or kneeling on the ball. Exercise with the moon shoes was defined as any instance of having both feet on the moon shoes or one foot on one shoe

while the other foot was off the ground. Exercise with the stationary bike was defined as any instance of the participant sitting upright on the bike seat with both feet on the pedals and moving them in a backward or forward motion. Observers recorded item engagement using 10-s momentary time sampling as described above.

Interobserver agreement data were collected by trained observers, who obtained a minimum of 90% agreement during training sessions. Observers independently recorded data during an average of 45%, 39%, and 34% of all sessions, across participants and conditions, during the functional analysis, preference assessment, and exercise assessment, respectively. During the functional analysis, mean agreement was 95% (range, 90% to 100%) for Steve, 98% (range, 97% to 100%) for Drew, 93% (range, 90% to 100%) for Beth, and 97% (range, 87% to 100%) for Naomi. During the preference assessment, mean agreement for Steve was 96% (range, 83% to 100%), for Drew was 98% (range, 89% to 100%), for Beth was 97% (range, 89% to 100%), and for Naomi was 94% (range, 78% to 100%). During the exercise assessment, mean agreement for problem behavior was 94% (range, 82% to 100%) for Steve, 98% (range, 93% to 100%) for Drew, 99% (range, 93% to 100%) for Beth, and 99% (range, 95% to 100%) for Naomi. Mean agreement for item engagement was 95% (range, 92% to 97%) for Steve, 98% (range, 93% to 100%) for Drew, 99.6% (range, 98% to 100%) for Beth, and 97% (range, 95% to 100%) for Naomi.

Phase 1: Functional Analysis

Procedure

A functional analysis of participants' problem behavior, based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994), was conducted. Sessions lasted 10 min, and three to four sessions were conducted per day. During the attention condition, moderately preferred toys (based on the results of a preference assessment) were continuously available. The therapist told the participant that she had some work to do and withdrew her attention. Contingent on the target response, the therapist provided brief vocal and physical attention. During the demand condition, tasks that were reported to be difficult for the participant were continuously presented using a three-step prompting hierarchy (vocal, gestural, physical). Contingent on the target behavior, task materials were removed for 30 s. During the alone condition, participants were alone in the room and no materials or interaction were provided. During the play condition, the same moderately preferred toys as in the attention condition were continuously available. The therapist delivered brief vocal and physical attention on an FT 30-s schedule.

A modified functional analysis design, similar to that described by Roscoe, Carreau, MacDonald, and Pence (2008), was used for Steve. Alone, attention, and demand sessions were conducted using a 2:1 ratio of alone to attention and demand sessions. This design was used to determine whether stereotypy persisted in the absence of social consequences while still providing exposure to social contingencies. If behavior persisted in social conditions and was low in the alone condition, further analyses would have been conducted to determine whether the behavior was socially maintained. This pattern was not observed with Steve and therefore no further analyses were conducted.

Results and Discussion

Results of the functional analyses are depicted in Figure 1. Steve exhibited high levels of stereotypy across all conditions. Drew exhibited differentially higher levels of SIB during the alone condition. Beth exhibited differentially higher levels of motor stereotypy in the alone condition. Naomi exhibited moderate and variable rates of SIB across conditions, with slightly higher levels in the alone condition. To further evaluate whether Naomi's SIB was

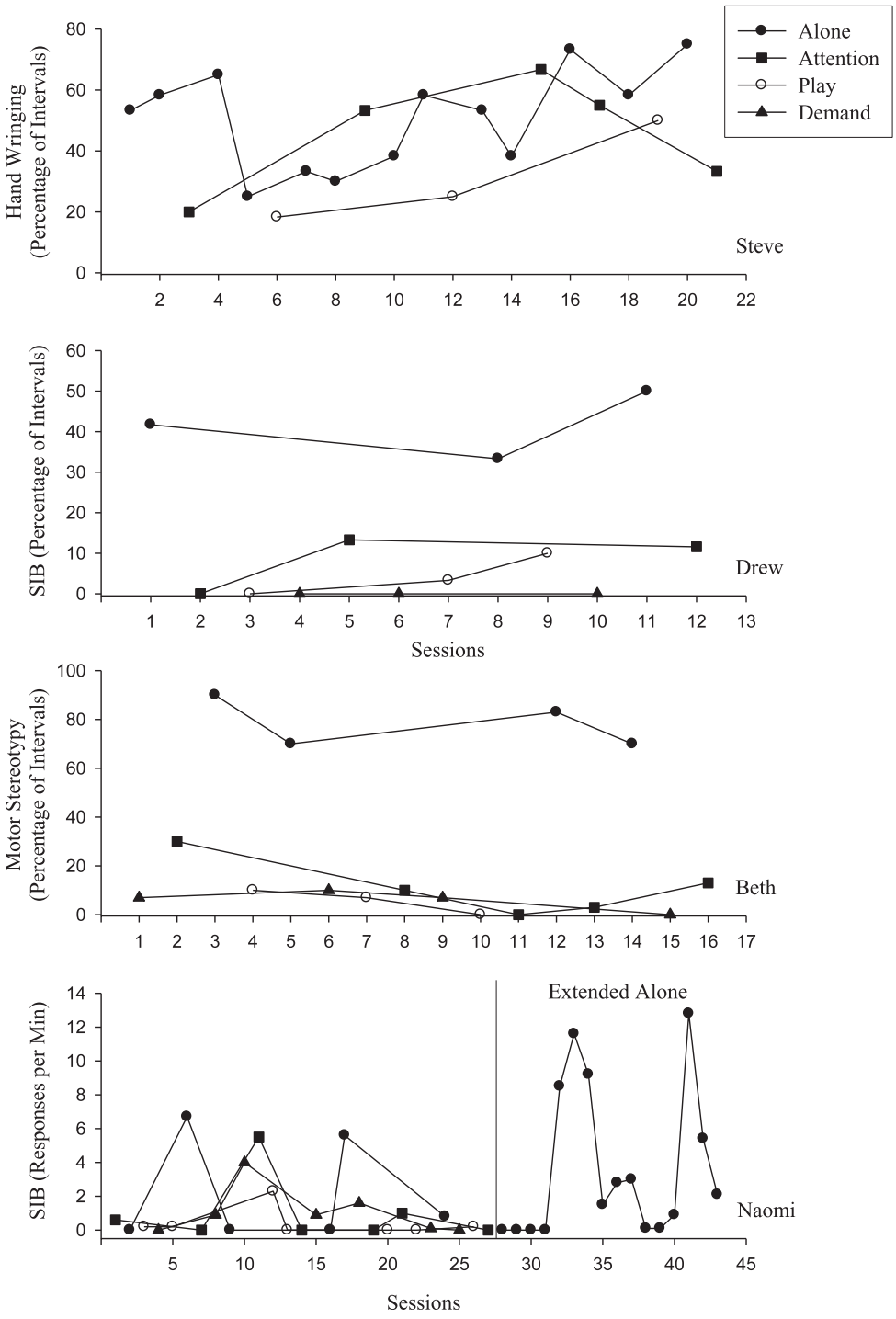

Figure 1. Problem behavior (percentage of intervals or responses per minute) during functional analyses for Steve, Drew, Beth, and Naomi.

maintained by automatic reinforcement, an extended series of alone sessions (as suggested by Vollmer, Marcus, Ringdahl, & Roane, 1995) was conducted. Results of this extended alone phase showed that her SIB was maintained at variable levels, suggesting that her problem behavior, like that displayed by the other participants, was maintained by automatic reinforcement.

Phase 2: Preference Assessment

Procedure

A preference assessment, similar to that described by Piazza, Fisher, Hanley, Hilker, and Derby (1996), was conducted to identify preferred exercise and leisure items (all participants) and edible items (Naomi only) for use during the exercise assessment. Exercise items included activities that provided kinesthetic consequences, such as a therapy ball, scooter board, stationary bike, and moon shoes. Leisure items included activities that could be provided on a tabletop, such as books, musical toys, and Slinky. Edible items (Naomi only) included cheese balls, peanuts, fruit snacks, and chocolate bars.

During this assessment, the therapist singly presented each item for 3 min, four times each. The order of item presentation varied across sessions. At the start of the session, the therapist vocally prompted the participant to engage with the item (e.g., ''play with the toy'') while either handing the participant small and mobile items (e.g. water snake, picture book, bumble ball, etc.) or physically guiding the participant towards larger items (e.g. stationary bike, Stairmaster, etc.). Following this initial prompt, additional prompts or praise were presented every 10 s, starting at Second 5. If the participant was not engaged with the item, a vocal and physical prompt were provided, whereas if the participant was engaged with an item, praise was delivered. Prompts and praise were presented during the middle of 10-s intervals to ensure that item engagement recorded at the end of the interval (using momentary time sampling) was not recorded during seconds in which prompts or praise was delivered. Because Naomi was reported to engage with or consume preferred items for brief durations, we included a varied exercise-item condition (e.g., jumping pad, then moon shoes, were singly presented for 1.5 min each) and a varied leisure and edible condition (e.g., water snake, then peanuts, were singly presented for 1.5 min each) in her preference assessment.

Results and Discussion

Figure 2 depicts the results of the preference assessment for all participants. Items are ordered based on observed percentages of item engagement. Exercise and leisure items associated with high percentages of item engagement (M = 84%; range, 57% to 99%) and low percentages of problem behavior (M = 6%; range, 0% to 33%) were selected for the subsequent antecedent exercise evaluation. The exercise items identified were the stationary bike for Steve and Drew, the moon shoes for Beth, and varied presentation of the jumping pad and moon shoes for Naomi. The leisure or edible items identified were the picture book for Steve, the Mr. Potato Head for Drew, the rabbit for Beth, and varied presentation of water snake and peanuts for Naomi.

Phase 3: Exercise Assessment

Procedure

Design. The immediate and subsequent effects of the exercise intervention were evaluated using a three-component multiple-schedule test sequence. Each 30-min sequence consisted of a 10-min preintervention component, a 10-min intervention component, and a 10-min postintervention component. To allow an evaluation of the postintervention effects of exercise, we compared the antecedent-exercise test sequence with two control sequences, a leisure-item control sequence and a social-interaction control sequence. The control sequences were identical to the test sequence except for the intervention component. The

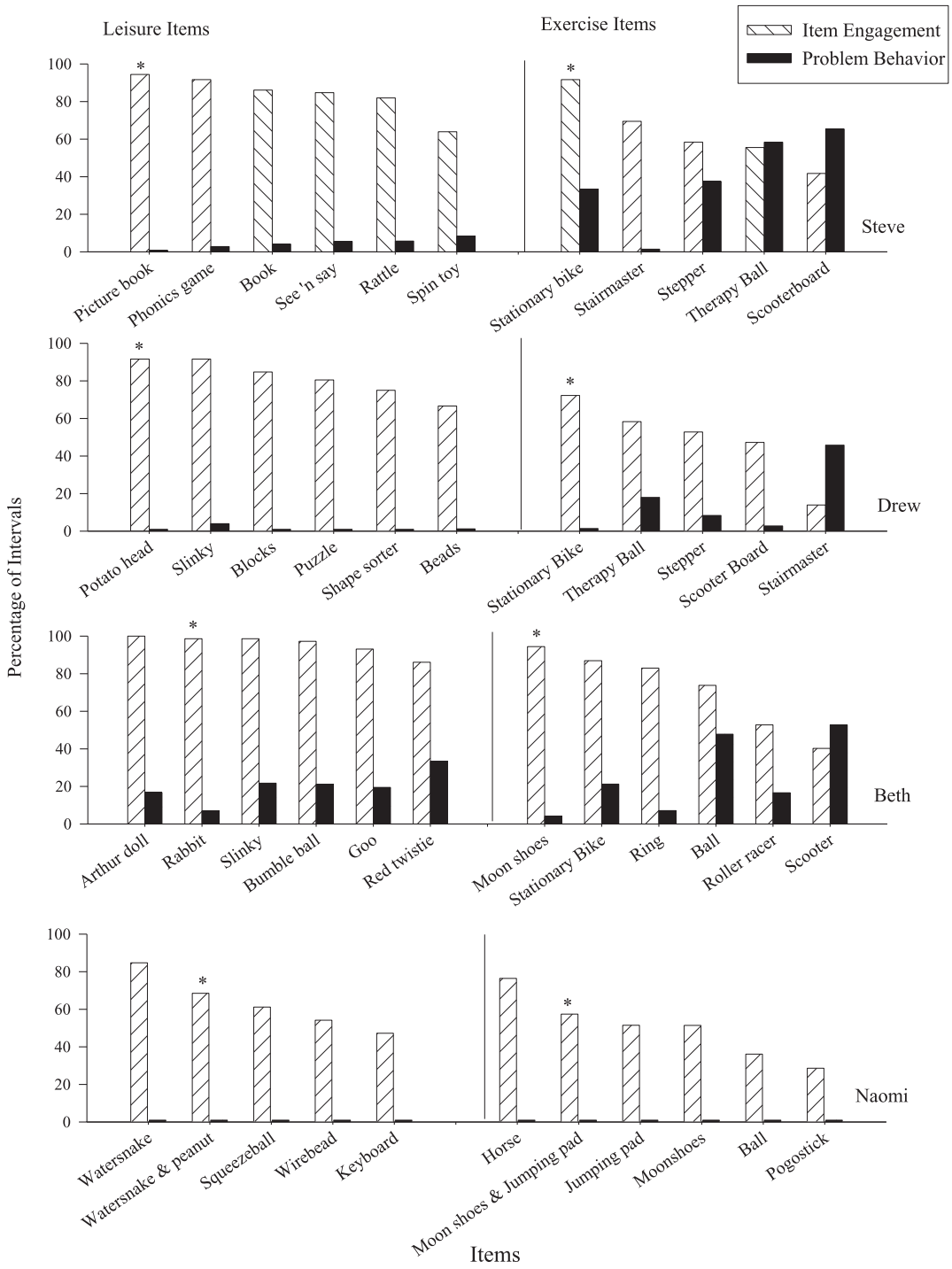

Figure 2. Item engagement and problem behavior (percentage of intervals) for leisure and exercise items during preference assessments for Steve, Drew, Beth, and Naomi.

three different multiple-schedule sequences (exercise test, leisure-item control, and social-interaction control) were alternated in a quasi-random fashion using a multielement design. One of the three sequence types was conducted each day, and each component within a sequence was conducted immediately following the previous component. For example, the intervention component conducted that day (exercise item, leisure item, or social interaction) immediately followed the preintervention component and immediately preceded the postintervention component. To facilitate discrimination between components, preintervention and postintervention components were conducted in one observation room, and intervention components were conducted in a different yet identical-looking observation room that was across a hallway.

Multiple-schedule components. During the preintervention and postintervention components, the participant was alone in the room with no materials. During exercise-item and leisure-item intervention components, the participant had continuous access to the exercise item or the leisure item that had been identified during the preference assessment. The therapist vocally and physically prompted the participant to engage with the item at the start of the session and provided additional prompts (if no engagement was observed) or praise (if engagement was observed) every 10 s (as described for the preference assessment). For Naomi, the therapist singly presented the jumping pad, then moon shoes, for 5 min each during the exercise-item intervention and singly presented water snake, then peanuts, for 5 min each during the leisure-item intervention, as in her preference assessment. During the social-interaction intervention, no materials were presented, and the therapist delivered attention on the same schedule as that used for prompts and praise during the exercise-item and leisure-item components. Attention included praise (e.g., ''Nice job having good hands.'') and neutral statements (e.g., ''It's warm out today.'').

Results and Discussion

Figure 3 depicts the results from the exercise assessment for Steve. During the exercise-item assessment (top panel), he exhibited lower levels of hand wringing during the intervention than during preintervention and postintervention for all sequences, and he showed lower levels of hand wringing postintervention than preintervention for five of the six sequences (Sequences 2 to 6). During the leisure-item assessment (second panel), he showed lower levels of hand wringing during the intervention than during preintervention and postintervention for five of the six sequences (Sequences 1, 2, 4, 5, and 6), and he had lower levels of hand wringing postintervention than preintervention for one of the six sequences (Sequence 1). During the social-interaction assessment (third panel), he exhibited lower levels of hand wringing during the intervention than in preintervention and postintervention components for two of the six sequences (Sequences 2 and 3), and he had lower levels of hand wringing postintervention than preintervention for two of the six sequences (Sequences 3 and 5).

When hand wringing was averaged across the six exercise-item sequences (bottom panel), Steve exhibited lower levels of hand wringing during the intervention (M = 8%) and postintervention (M = 41%) than preintervention (M = 61%). In the leisure-item sequence, he exhibited lower levels of hand wringing during the intervention (M = 5%) but not postintervention (M = 44%) relative to preintervention (M = 40%). For the social-interaction assessment, Steve did not show lower levels of hand wringing during the intervention (M = 60%) or postintervention (M = 68%) relative to preintervention (M = 61%). These results show that consistent yet modest postintervention decreases in hand wringing were observed for only the exercise condition, suggesting that exercise may have functioned as an abolishing operation for Steve's hand wringing.

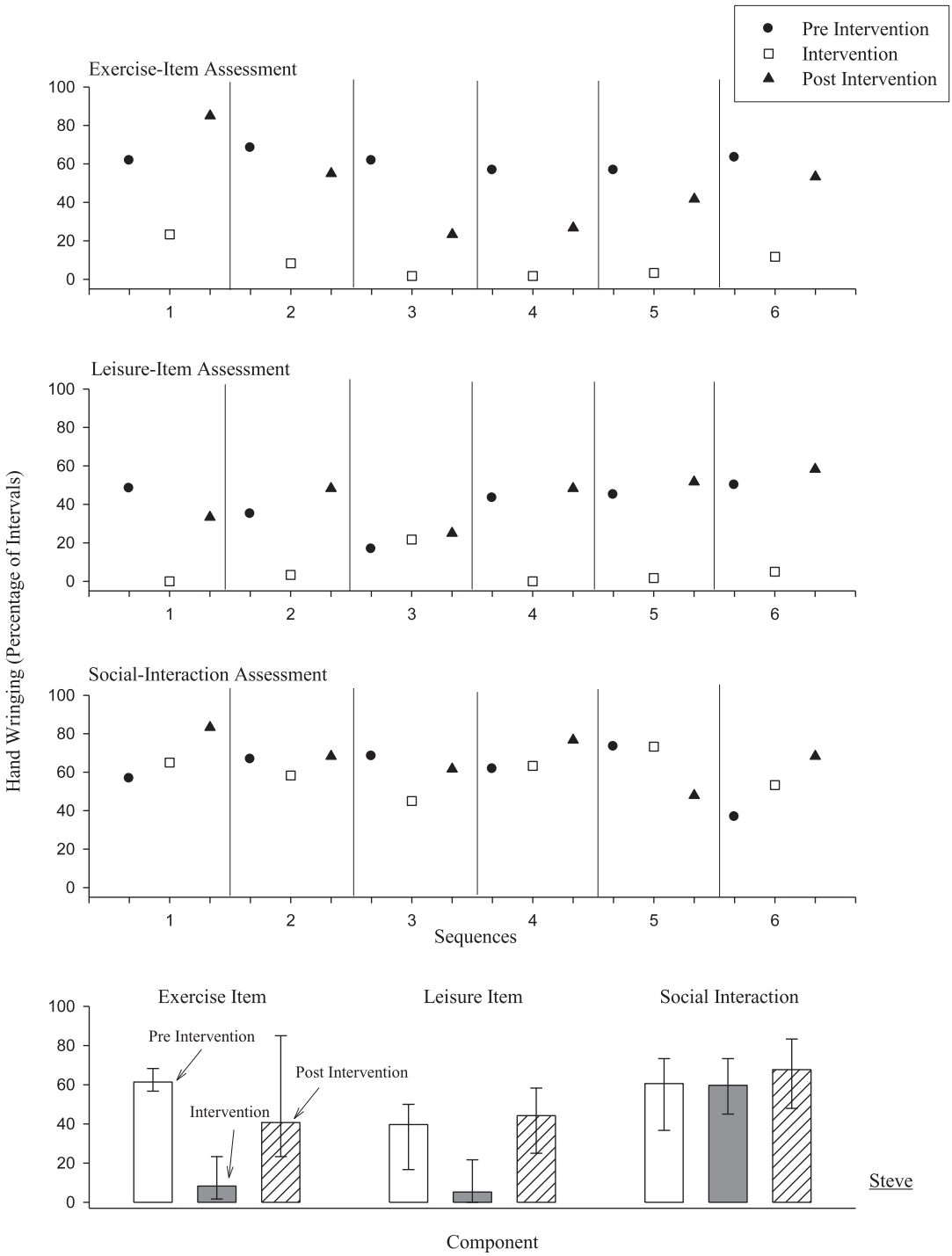

Figure 3. Problem behavior (percentage of intervals) during exercise-item, leisure-item, and social-interaction assessments for Steve. Problem behavior (percentage of intervals), averaged across series, during preintervention, intervention, and postintervention components for exercise-item, leisure-item, and social-interaction assessments for Steve.

Figure 4 depicts the results from the exercise assessment for Drew. During the exercise-item assessment (top panel), he had lower levels of SIB during the intervention and after the intervention than before the intervention for all six sequences. During the leisure-item assessment (second panel), Drew showed lower levels of SIB during the intervention than during preintervention and postintervention for all six sequences, and he had lower levels of SIB postintervention than preintervention for four of the six sequences (Sequences 2, 3, 4, and 6). During the social-interaction assessment (third panel), he exhibited lower levels of SIB during the intervention than in preintervention and postintervention components for three of the six sequences (Sequences 3, 4, and 5), and he had lower levels of SIB after the intervention than before it for one of the six sequences (Sequence 2).

When SIB was averaged across the six exercise-item sequences (bottom panel), Drew showed lower levels of SIB during the intervention ($M = 2\%$) and postintervention ($M = 46\%$) than during preintervention ($M = 60\%$) components. In the leisure-item sequence, he exhibited lower levels of SIB during the intervention ($M = 0.01\%$) than during preintervention ($M = 54\%$) and postintervention ($M = 54\%$), and he showed similar levels of SIB in postintervention and preintervention components. In the social-interaction sequence, he showed lower levels of SIB during the intervention ($M = 55\%$) but not postintervention ($M = 70\%$) relative to preintervention ($M = 62\%$). These results show that consistent yet modest postintervention decreases in SIB were observed for only the exercise-item sequence, suggesting that exercise may have functioned as an abolishing operation for Drew's SIB.

Figure 5 depicts the results from the exercise assessment for Beth. During the exercise-item assessment (top panel) and leisure-item assessment (second panel), she had lower levels of stereotypy during the intervention but not postintervention relative to preintervention for all six sequences. During the social-interaction assessment (third panel), she showed lower levels of stereotypy during the intervention for four of the six sequences (Sequences 1, 3, 5, and 6) and postintervention for one of the six sequences (Sequence 4) than during preintervention.

When stereotypy was averaged across the six exercise-item sequences (bottom panel), Beth showed lower levels of stereotypy during the intervention ($M = 16\%$) than during preintervention ($M = 97\%$) or postintervention ($M = 99\%$), but her stereotypy was not lower postintervention relative to preintervention. In the leisure-item sequence, Beth showed lower levels of stereotypy during the intervention ($M = 20\%$) but not postintervention ($M = 98\%$) relative to preintervention ($M = 97\%$). In the social-interaction sequence, she showed slightly lower levels of stereotypy during the intervention ($M = 89\%$) but not postintervention ($M = 96\%$) relative to preintervention ($M = 94\%$). These results show that consistent reductions in stereotypy were not observed in the postintervention component for any of the assessments, and that exercise did not function as an abolishing operation for stereotypy.

Figure 6 depicts the results from the exercise assessment for Naomi. During the exercise-item assessment (top panel), she exhibited lower levels of SIB during the intervention for all six sequences and during postintervention for five of the six sequences (Sequences 1, 2, 3, 4, and 6) than during preintervention. During the leisure-item assessment (second panel), she exhibited lower levels of SIB during the intervention for five of the six sequences (Sequences 1, 2, 3, 4, and 6) and postintervention for five of the six sequences (Sequences 1, 2, 3, 5, and 6) than during preintervention. During the social-interaction assessment (third panel), Naomi showed lower levels of SIB during the intervention for three of the six sequences (Sequences 2, 4, and 5) and during

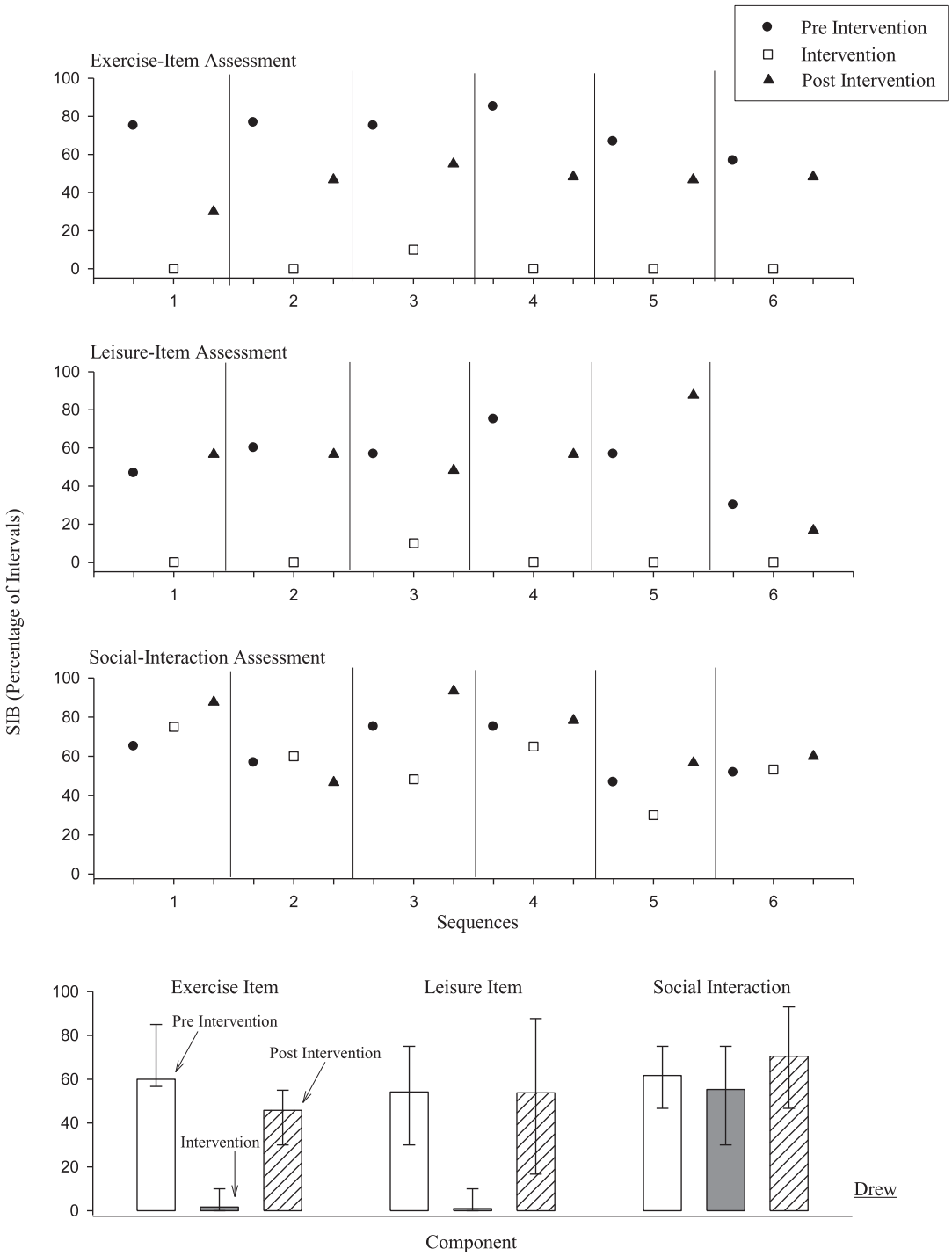

Figure 4. Problem behavior (percentage of intervals) during exercise-item, leisure-item, and social-interaction assessments for Drew. Problem behavior (percentage of intervals), averaged across series, during preintervention, intervention, and postintervention components for exercise-item, leisure-item, and social-interaction assessments for Drew.

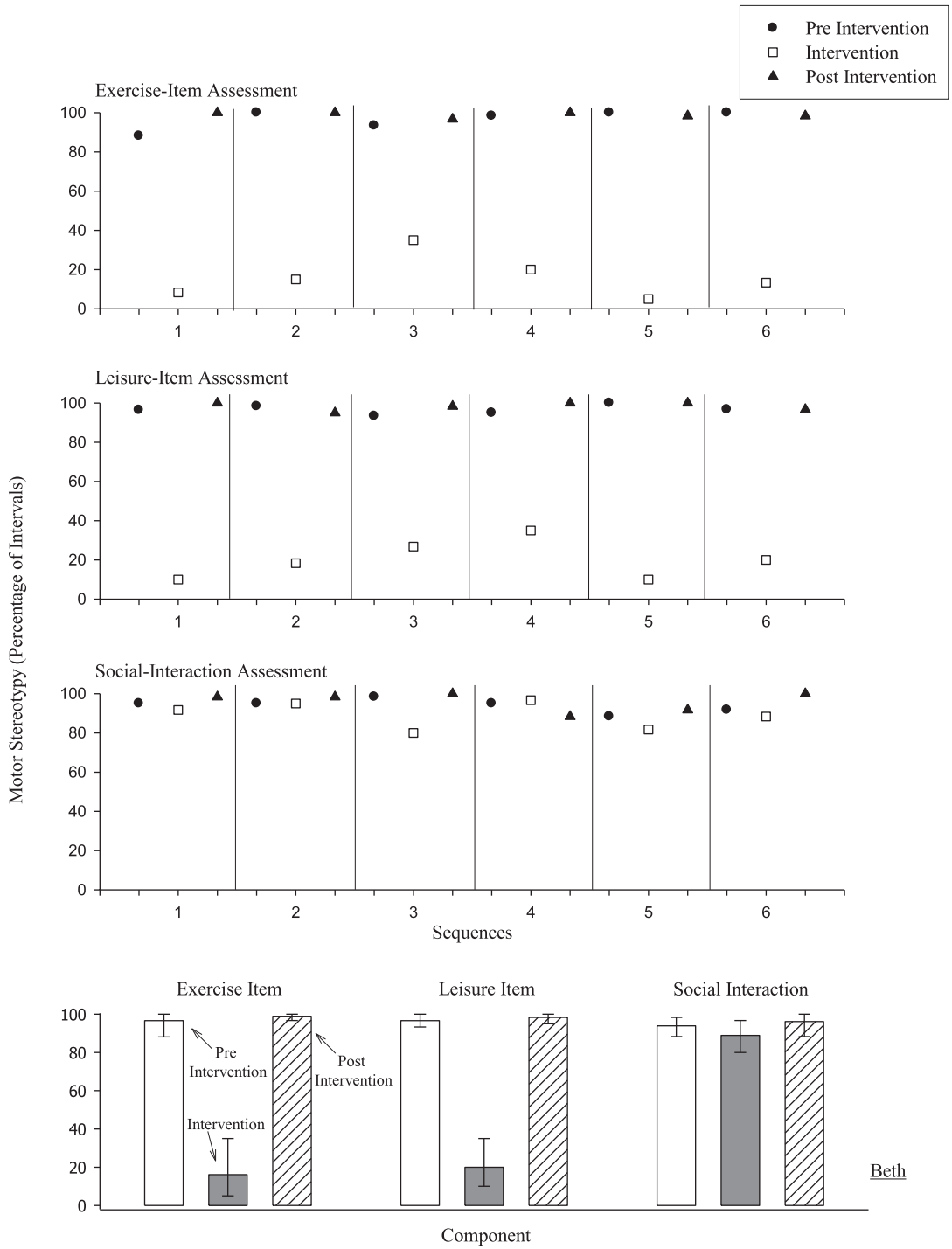

Figure 5. Problem behavior (percentage of intervals) during exercise-item, leisure-item, and social-interaction assessments for Beth. Problem behavior (percentage of intervals), averaged across series, during preintervention, intervention, and postintervention components for exercise-item, leisure-item, and social-interaction assessments for Beth.

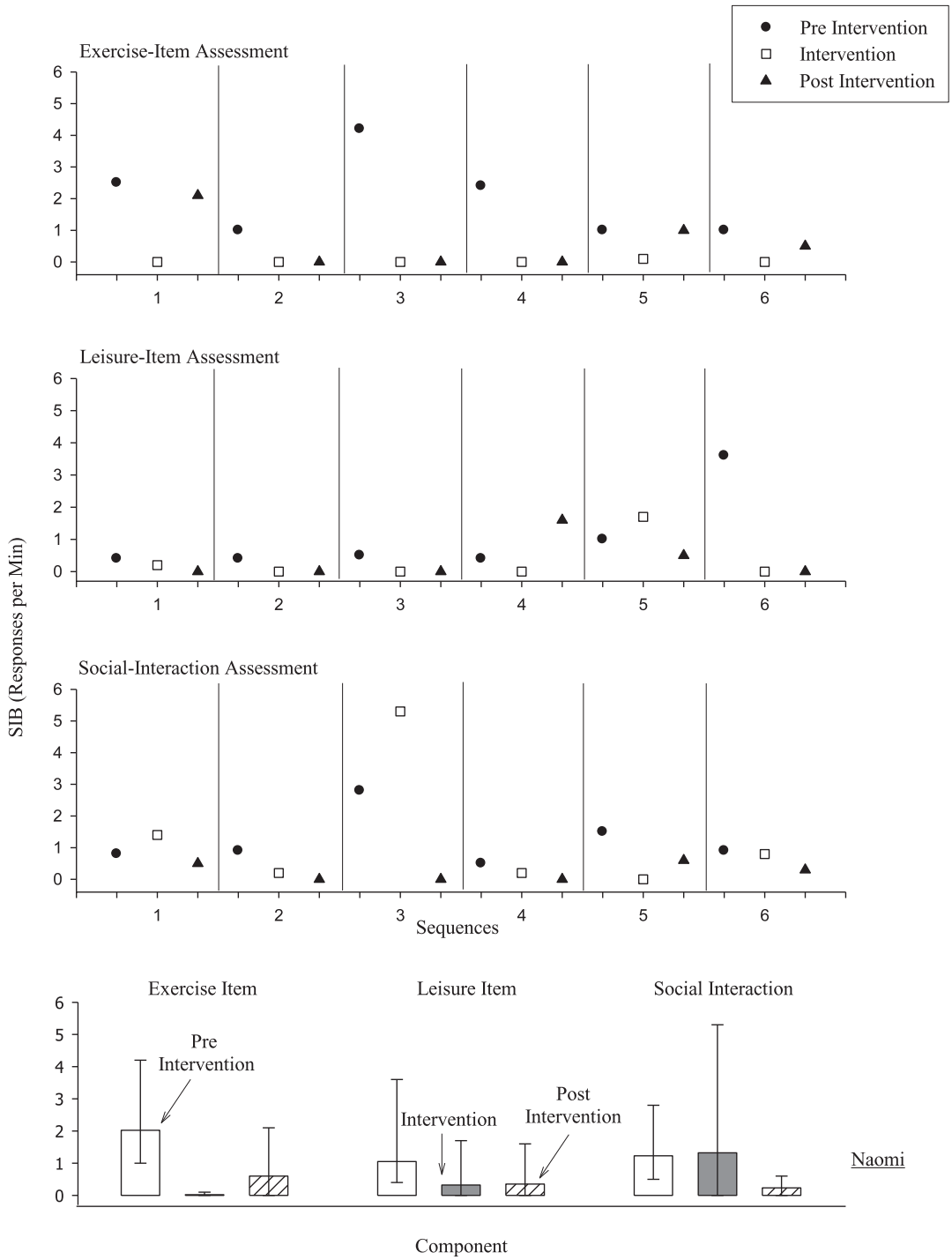

Figure 6. SIB (responses per minute) during exercise-item, leisure-item, and social-interaction assessments for Naomi. Problem behavior (percentage of intervals), averaged across series, during preintervention, intervention, and postintervention components for exercise-item, leisure-item, and social-interaction assessments for Naomi.

postintervention for all six sequences than during preintervention.

When stereotypy was averaged across the six exercise-item sequences (bottom panel), Naomi showed lower levels of SIB during the intervention (M = 0.02 per minute) and postintervention (M = 0.35 per minute) than during preintervention (M = 2.02 per minute). In the leisure-item sequence, Naomi showed lower levels of SIB during the intervention (M = 0.32 per minute) and during postintervention (M = 0.35 per minute) relative to preintervention (M = 1.05 per minute). In the social-interaction sequence, Naomi did not exhibit lower levels of SIB during the intervention (M = 1.32 per minute) but did postintervention (M = 0.23 per minute) relative to preintervention (M = 1.23 per minute). These results show that consistent reductions in SIB were observed in the postintervention component for all of the assessments. Although SIB was lower in the postintervention component than in the preintervention component during the exercise assessment, any potential abolishing operation effect cannot be attributed solely to the exercise intervention because similarly low levels were also observed in the postintervention component for the leisure-item and social-interaction assessments.

Data were also collected on engagement with exercise items and leisure items during the exercise-item and leisure-item conditions, respectively. During exercise-item sessions, exercise averaged 49% of intervals for Steve (range, 28% to 65%), 73% for Drew (range, 62% to 87%), 73% for Beth (range, 62% to 90%), and 74% for Naomi (range, 45% to 85%). During leisure-item sessions, item engagement averaged 88% of intervals for Steve (range, 83% to 93%), 93% for Drew (range, 87% to 95%), 97% for Beth (range, 93% to 100%), and 79% for Naomi (range, 62% to 90%).

In summary, three different patterns were observed. For Steve and Drew, reductions in problem behavior were observed during the postintervention component for exercise, but not for the postintervention component for leisure and social interaction, suggesting that exercise may have been more effective in functioning as an abolishing operation. For Beth, reductions in problem behavior were not observed during any of the postintervention components, suggesting that none of the interventions, including exercise, functioned as an abolishing operation. For Naomi, reductions were observed during the postintervention component during all assessments, suggesting that exercise-item, leisure-item, and social-interaction interventions all functioned as potential abolishing operations. Because the social-interaction intervention component was not effective in consistently reducing problem behavior below that observed in the preintervention component, it is unlikely that this intervention functioned as an abolishing operation. However, because differentially lower levels were not observed during the postintervention component for the exercise-item assessment relative to the postintervention component for leisure-item and social-interaction assessments, any potential abolishing operation effects that may be operating cannot be attributed solely to exercise.

GENERAL DISCUSSION

The current study evaluated the effects of antecedent exercise on automatically reinforced problem behavior using a three-component multiple schedule. In addition, the antecedent-exercise multiple schedule was compared to two additional multiple-schedule control sequences, a leisure-item control sequence and a social-interaction control sequence. During the intervention components, antecedent exercise and access to leisure items reduced problem behavior for all four participants. In addition, antecedent exercise resulted in modest postintervention decreases in problem behavior for three of the four participants, whereas leisure

items and social interaction resulted in postintervention decreases for only one participant.

We extended research on the use of antecedent exercise for treating problem behavior in a number of ways. First, we evaluated the effects of antecedent exercise as an intervention for problem behavior maintained by automatic reinforcement. Because antecedent exercise involves continuous presentation of sensory stimulation, antecedent exercise may be most effective in functioning as an abolishing operation for problem behavior maintained by automatic reinforcement (i.e., problem behavior maintained by its sensory consequences). Although experimenters have evaluated the effects of antecedent exercise for stereotypy, they did not conduct a pretreatment functional analysis, and, therefore, the maintaining variables were unknown. In the current study, we conducted functional analyses to rule out behavioral maintenance by social reinforcement.

Second, we included exercise activities that were appropriate for individuals with limited exercise repertoires. In previous research, jogging was often used as the type of exercise assessed. For many individuals with autism and developmental disabilities, jogging and other forms of aerobic activity cannot be implemented with integrity if these individuals do not have these skills in their repertoires or if they refuse to participate in the designated activity. In addition, we conducted duration-based preference assessments to identify exercise and leisure items associated with high levels of engagement and low levels of problem behavior. Results showed that not all exercise items were equally preferred (i.e., some were associated with higher levels of engagement and lower levels of problem behavior). These findings suggest that some exercise items may be more effective than others when used during an antecedent-exercise intervention.

Third, we used a three-component multiple schedule to evaluate the immediate and subsequent effects of antecedent exercise, allowing us to determine whether the effects of antecedent exercise maintained. By using a three-component multiple schedule, we were able to determine the immediate postintervention effects of antecedent exercise in a controlled setting, eliminating extraneous sources of variability (e.g., competing stimuli that may be present or the delivery of antecedent or consequent variables that may occur in uncontrolled settings). In addition, we could determine baseline levels of problem behavior prior to each exposure to the intervention, allowing a within-sequence comparison of postintervention effects and preintervention effects. This experimental arrangement may be useful for evaluating maintenance effects of other interventions commonly used for treating automatically reinforced problem behavior (e.g., differential reinforcement of alternative behavior and response interruption) as well as for socially reinforced problem behavior (differential reinforcement and extinction).

Fourth, we compared the exercise multiple-schedule test sequence to two control sequences, a leisure-item control sequence and a social-interaction control sequence, to evaluate whether antecedent exercise offered additional benefit to that obtained with more commonly used forms of noncontingent reinforcement (i.e., continuous presentation of preferred leisure items or social interaction). Because previous research has shown that noncontingent access to leisure items may function as an abolishing operation for automatically reinforced behavior, it is possible that antecedent exercise would produce the same effects as those obtained with other forms of preferred stimuli (e.g., leisure items). Results demonstrated that both exercise- and leisure-item interventions effectively suppressed problem behavior for all participants. However, continuous presentation of exercise items resulted in different postintervention outcomes than did continuous access to leisure items. Antecedent exercise resulted in lower levels of problem behavior during postinterven-

tion components relative to preintervention components for three of the four participants, whereas continuous presentation of leisure items did so for only one of the four participants (Naomi). These data replicate previous research demonstrating that noncontingent access to preferred leisure items effectively suppresses participants' problem behavior (Piazza et al., 2000; Ringdahl et al., 1997). These findings also support previous research that has shown the reductive effects of providing antecedent exercise (Bachman & Fuqua, 1983; Bachman & Sluyter, 1988; McGimsey & Favell, 1988).

Simmons et al. (2003) noted that postintervention effects observed in the context of a multiple-schedule design can provide information regarding potential motivating operations associated with the intervention. The postintervention decreases observed during the antecedent-exercise test sequence suggest that this intervention may have functioned as an abolishing operation and that engagement with the exercise item may have produced stimulation that was functionally similar to that produced by problem behavior. By contrast, because postintervention decreases were not consistently observed during the leisure-item or social-interaction control sequences, these interventions may not have provided stimulation that functionally matched participants' problem behavior. Although previous research has shown that leisure items may result in postintervention decreases (Rapp, 2006, 2007), suggesting that they functioned as an abolishing operation, these effects may be idiosyncratic across participants and stimuli. That is, the immediate effects of leisure items associated with high levels of engagement and low levels of problem behavior will not always be maintained when these items are removed. Another possible operating mechanism that may account for the postexercise decreases observed is fatigue. That is, it is possible that exercise may lead to decreases in problem behavior because the participant is too tired to engage in problem behavior. Future research could examine postexercise effects that may be due to fatigue by examining the same form of exercise across different durations and intensity values.

Noncontingent access to social attention did not result in decreases during or after the test condition for three of four participants. The one exception was Naomi, who consistently exhibited lower levels of problem behavior in the postintervention component than in the preintervention component, regardless of the condition. This effect was similar to that reported by Rapp (2007), who observed decreased levels of vocal stereotypy during the third component of successive no-interaction (for one participant) or leisure-item components (for the other participant) relative to the first and second components. Rapp suggested that prior access to the target behavior in the first and second components may have served as an abolishing operation. Naomi's findings illustrate the importance of including an appropriate control sequence, such as the social-interaction sequence used in the current study. If the social-interaction sequence had not been conducted, Naomi's results may have led to an inaccurate conclusion regarding the effects of antecedent exercise (i.e., that it resulted in persistent response suppression when it did not). Although the social-interaction sequence did serve as an adequate control because it involved an independent variable that resulted in marginal behavior change during the intervention component, a sequence of three alone or no-interaction components may have served as a better control for evaluating automatically reinforced problem behavior.

Some limitations and directions for future research deserve comment. First, although antecedent exercise resulted in postintervention reductions for three of the four participants, the levels obtained were not clinically acceptable. Therefore, antecedent exercise should not be recommended as a sole intervention for reduc-

ing automatically reinforced problem behavior. Instead, it might be used as one component of a larger treatment package, and future research could evaluate the enhancing effects of antecedent exercise when combined with other reinforcement-based interventions such as noncontingent reinforcement and differential reinforcement of alternative behavior. Second, the current study evaluated the effects of antecedent exercise only for problem behavior maintained by automatic reinforcement. Thus, the effects of antecedent exercise on problem behavior maintained by social reinforcement warrant further investigation.

Antecedent exercise was found to be effective in suppressing problem behavior during the intervention. In addition, antecedent exercise resulted in modest postintervention decreases for three of the four participants. These findings indicate that exercise may be an appropriate treatment component for participants with problem behavior maintained by automatic reinforcement. An advantage of antecedent exercise is that it is easy to implement and does not require continuous monitoring of the target behavior. Although maintenance of behavior reduction was observed for three of the four participants, persistent response suppression could be attributed solely to exercise for only two participants. Future research could examine the conditions under which antecedent exercise is most likely to be effective. For example, it may be helpful to determine whether preferred forms of exercise are more effective than nonpreferred forms of exercise, whether longer durations of exercise are more effective than shorter durations, and whether exercise may be effective for participants with socially maintained problem behavior.

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