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ANALYSIS OF RESPONSE ALLOCATION IN INDIVIDUALS WITH MULTIPLE FORMS OF STEREOTYPED BEHAVIOR

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Three experiments were conducted to evaluate response allocation of stereotypy during free-operant and restricted-operant conditions. Five children with autism or related developmental disabilities participated in at least one and up to three of the experiments. In Experiment 1, the stereotypic response that emerged as most probable during a free-operant phase was restricted, and response allocation was again evaluated. The results for 3 participants showed that restricting the high-probability response was correlated with covarying reductions in a nontargeted stereotypy. In Experiment 2, the effect of environmental enrichment on response allocation was evaluated. One participant reallocated behavior to appropriate object manipulation, 1 participant showed no change in behavior, and a 3rd participant reallocated behavior to object manipulation only when the putative stimulus products of the object manipulation matched those of stereotypy. In Experiment 3, additional interventions were implemented to promote response reallocation. Results showed that both response restriction and reinforcement for object manipulation decreased stereotypy and increased object manipulation. Collectively, the results of these experiments point to a need for complex evaluations of interventions for stereotypy.

DESCRIPTORS: environmental enrichment, response restriction, stereotypy

Individuals with autism and related developmental disabilities often display stereotypic behavior. *Stereotypy* is typically defined as repetitive or invariant behavior that serves no apparent social function (e.g., Lewis & Baumeister, 1982). Although stereotypy is often referred to as being "automatically reinforced" (e.g., Lovaas, Newsom, & Hickman, 1987), some studies suggest that stereotypy may enter into social contingencies (e.g., Kennedy, Meyer, Knowles, & Shukla, 2000). In many cases, individuals display multiple forms of stereotypy (e.g., Johnson, Baumeister, Penland, & Inwald, 1982; Rollings & Baumeister, 1981; Rollings, Baumeister, & Baumeister, 1977); however, few studies have evaluated the effects of behavioral interventions on multiple forms of stereotypy. For example, it is possible that one form of stereotypy increases as another form of stereotypy decreases. It is also possible that untargeted forms of stereotypy decrease as targeted forms of stereotypy decrease. Finally, it is possible that appropriate behavior begins to emerge as stereotypy decreases. Two relevant lines of research suggest that further evaluation of response allocation in individuals with multiple forms of stereotypy may be warranted. First, there is a large body of basic and applied research aimed at identifying specific patterns of response reallocation under conditions of response restriction. These studies may provide a framework for an analysis of multiple forms of stereotypy. Second, there is a large body of

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basic and applied research on environmental enrichment. These studies also may provide a framework for an analysis of interactions between the emergence of appropriate behavior and reductions in stereotypy.

Using multiple-response environments, the effects of restricted responding have been evaluated in several studies with nonhumans. For example, Dunham and Grantmyre (1982) examined response reallocation in gerbils under conditions in which eating was either restricted or punished. In general, Dunham and Grantmyre found that restricting eating (the third most probable response based on free-operant observations) via punishment or unavailability of food actually produced reductions in nontargeted digging (the second most probable response) and slight increases in running (the most probable response). This outcome could have direct relevance to automatically reinforced aberrant behavior (e.g., stereotypy) insofar as treatment of one behavior may have the positive side effect of reducing another aberrant behavior. As an applied example, Friman and Hove (1987) found that suppression of thumb sucking (a high-probability response) using a punishment procedure also eliminated hair pulling (a low-probability response) that was exhibited by children.

Several studies have used a response-restriction approach to analyze response allocation of individuals with developmental disabilities (G. Green & Striefel, 1988; Hanley, Iwata, Lindberg, & Conners, 2003; Hanley, Iwata, Roscoe, Thompson, & Lindberg, 2003; McEntee & Saunders, 1997). Following response restriction, response reallocation was observed and the most probable response that emerged during response restriction was restricted. This process was then repeated in a diminishing fashion until one or two responses were available. For example, Green and Striefel sequentially restricted access from five activities to one for 4 children with autism. In general, the results showed that restriction of the most probable response increased allocation to other activities. McEntee and Saunders conducted a procedural replication of the Green and Striefel study in an analysis of time allocation to stereotypy and unstructured leisure activity. They found that reallocation during diminishing alternatives produced idiosyncratic response patterns; however, one specific activity typically increased during each successive restriction for each participant. More important, behavior in a category labeled "other," which included stereotypy, increased across each successive restriction. Thus, these studies provide some insight into the conditions under which individuals with developmental disabilities allocate responding to stereotypy, appropriate alternative behavior, or both.

Several commonly prescribed treatments for stereotypy inherently involve restriction of a response (and its product) within a multiple-response repertoire. Stereotypy is typically the restricted response (i.e., treatment is intended to suppress the behavior) while other responses remain or become available. Some early studies involving response blocking of stereotypy found that restricting access to stereotypy actually produced subsequent increases in problematic behavior (Baumeister & Forehand, 1971; Forehand & Baumeister, 1971). In both studies by Baumeister and Forehand, access to body rocking was restricted via physical immobilization or by providing additional reinforcement for engagement in a competing operant. Behavior changes observed in these studies may be explainable in terms of the response-deprivation hypothesis (Timberlake & Allison, 1974). That is, both preparations may have produced deprivation from the reinforcing products of body rocking, thereby increasing the future probability of that response (Klatt & Morris, 2001). Previous studies that involved restriction of a high-probability response have shown that when

a restricted response is subsequently permitted, it occurs at higher levels than it did during the initial free-operant baseline (e.g., Bernstein & Ebbesen, 1978; Holburn & Dougher, 1986; Klatt, Sherman, & Sheldon, 2000; McEntee & Saunders, 1997). This pattern suggests that deprivation (from the stimulation generated by the stereotyped response) was a likely outcome of the restriction.

The vast literature on environmental enrichment as treatment for stereotypy is also relevant (e.g., Davenport & Berkson, 1963; Horner, 1980; Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Vollmer, Marcus, & LeBlanc, 1994). Rarely do behavior analysts restrict access to stereotypic behavior without providing access to alternative stimulation (such as toy play). Mere restriction of stereotypy may have a particular effect on other stereotypic response forms (Hanley, Iwata, Thompson, & Lindberg, 2000; Lindberg, Iwata, & Kahng, 1999), but the inclusion of alternative forms of stimulation may influence response allocation in different ways. For example, environmental enrichment may decrease only high-probability stereotypy or, conversely, multiple forms of stereotypy (high- and low-probability behavior).

In Experiment 1, we evaluated the effects of restricting the most probable form of stereotypy in relation to response allocation to other forms of stereotypy for 4 participants. In Experiment 2, we evaluated the effects of environmental enrichment on response reallocation with 3 participants. In Experiment 3, we evaluated the combined effects of environmental enrichment and additional procedures on response allocation with 2 participants.

GENERAL METHOD

A response was categorized as stereotypy if it occurred in bouts of three or more body-movement repetitions (e.g., hand flapping or body rocking) or was invariant for three or more seconds (e.g., vocalizing or hand mouthing). To be included in the analyses, the response forms in question must have persisted during conditions when no social reinforcement was provided (i.e., during alone or no-interaction conditions).

Participants and Target Behavior

Mike was an 8-year-old boy who had been diagnosed with autism and moderate mental retardation. He exhibited hand mouthing, pacing, ear covering, rapid page turning (of books), and hand biting. Mary was a 5-year-old girl who had been diagnosed with autism and moderate mental retardation. She exhibited pacing, ear covering, pot spinning, hand flapping, mirror viewing (with body movements), and object flicking. Geff was a 14-year-old boy who had been diagnosed with Down syndrome and severe mental retardation. He engaged in body rocking, groin rubbing, hand rubbing, hand flapping, head rubbing, chin hitting, head hitting, snorting, tooth grinding, vocalizing, and object pounding. Alice was a 10-year-old girl who had been diagnosed with childhood disintegrative disorder and severe mental retardation. She displayed pacing, vocalizing, rubbing carpet, and manipulation of clothes (e.g., tugging on shoelaces). Greg was a 10-year-old boy who had been diagnosed with autism and moderate mental retardation. He engaged in thumb sucking, vocalizing, mirror viewing, pacing, and object pounding. For Geff, Alice, and Greg, data were also collected on object manipulation (see Experiments 2 and 3). Response definitions for each participant are provided in Table 1.

Settings

All sessions for Mike, Alice, and Greg were 10 min long and took place in a room (8 m by 12 m) in an inpatient hospital. Ses-

Table 1
Target Responses and Interobserver Agreement Scores

Participant	Response form	Response definition	Mean (%)	Range (%)
Mike	Hand mouthing	Insertion of either hand past plane of mouth	87	80–100
	Hand biting	Closure of teeth on either hand	94	89–100
	Ear covering	Placement of hands over ears	96	93–100
	Pacing	Two or more steps across room	97	89–100
	Page turning	Turning pages every 3 s or less	95	87–100
Mary	Pot spinning	Contact with and visual orientation to the pot lid	97	88–100
	Hand flapping	Two or more up or down or side to side hand movements	89	66–100
	Object flicking	Contact with an object that causes object motion	84	69–100
	Ear covering	Placement of hands over ears	94	84–100
	Pacing	Two or more steps in circles or across a room	90	79–100
	Mirror viewing	Visual orientation toward a mirror	96	86–100
Geff	Shirt mouthing	Insertion of shirt past plane of mouth	88	85–100
	Hand rubbing	Contact of a hand with the other up to the elbow	95	90–100
	Body rocking	Two or more forward and backward torso movements	90	78–100
	Chin hitting	Forceful contact of a hand with the chin	90	79–100
	Head rubbing	Any contact of a hand with head, excluding head hitting	89	85–100
	Snorting	Inhalation of air that produced a “bassy” audible product	95	87–100
	Tooth grinding	Grinding audible product with mouth closed	84	56–100
	Vocalizing	Any audible product with open mouth that was not snorting	84	65–100
	Object pounding	Contact with hand on a table or wall	81	74–100
	Groin rubbing	Contact of hand with groin area	93	92–100
	Hand flapping	Two or more up or down or side to side hand movements	86	83–100
	Object manipulation	Contact of either or both hands with a toy	96	90–100
Alice	Pacing	Two or more steps in circles or across a room	96	95–100
	Manipulating clothes	Two or more finger movements while in contact with clothing	97	94–100
	Vocalizations	Any audible product with open mouth	87	80–100
	Carpet rubbing	Two or more finger movements while in contact with carpet	91	86–100
	Object manipulation	Contact of one or both hands with a toy	95	88–100
Greg	Thumb sucking	Insertion of thumb past plane of mouth	96	95–100
	Pacing	Two or more steps in circles or across a room	97	94–100
	Vocalizing	Any audible product with open mouth	79	65–100
	Mirror viewing	Visual orientation toward a mirror	96	86–100
	Object pounding	Contact with hand on a table or wall	93	85–100
	Sketch toy manipulation	Contact of one or both hands with the sketch toy	98	95–100

sions for Geff were conducted at his school in an area of a room (9 m by 12 m) that was bordered by tables. For Mike, Alice, Greg, and Geff, data were collected 3 to 4 days per week, and one to three sessions were conducted each day. For Mary, data were first collected at her home and subsequently at her school (due to relocation of her family). Data were collected 3 days per week, and one 30-min session was conducted per day. The rooms used for the analysis at Mary's home (i.e., the family room and kitchen) and school were approximately 15 m by 15 m and 20 m by 20 m, respectively. The family room contained a sofa, recliner, two tables, one mirror, and a television, which was unplugged. The kitchen was devoid of manipulable objects, with the exception of pot lids. Mary was free to roam between the two adjacent rooms. The room that was used at Mary's school contained several small tables, a rocking chair, and several computers (none were operational). In addition to differences in relative space, the room at Mary's school contained three mirrors. Due to scheduling conflicts at Mary's school, the last eight sessions were conducted in a room that was approximately 5 m by 8 m. In an attempt to hold time-of-day variables constant, sessions for each participant were conducted at the same time each day, with the exception of Alice, whose sessions were conducted in either the late morning or early afternoon.

Dependent Variables and Interobserver Agreement

Data for each participant were collected through direct observation of the session using laptop computers that were equipped with a program that recorded duration of each response. Each session was videotaped. Interobserver agreement scores were obtained by having a second independent observer either directly collect data simultaneously with the primary observer or later from videotaped sessions. Agreement scores were calculated using average agreement within 10-s intervals. Data collected by the primary and secondary observers were compared in 10-s bins (e.g., there are 60 10-s bins in a 10-min session). For each bin, the smaller number is divided by the larger number and then multiplied by 100% to arrive at the percentage of agreement for that bin. Percentages from each of the bins are totaled and then divided by the total number of bins to arrive at the overall percentage of agreement. Due to the large number of response forms exhibited by Geff, two observers were assigned to collect data on only half of the dependent variables during each session (i.e., one individual served as primary observer for six responses, and the other observer collected data for the remaining five responses). To obtain agreement measurements for Geff's behavior, the observers were randomly assigned to score one or two response forms, for which the other was the primary observer, during each session. Interobserver agreement was obtained for at least 25% of sessions (range, 25% to 42%) for each behavior across all 5 participants. Mean scores for each participant's stereotyped response forms are shown in Table 1.

EXPERIMENT 1: RESPONSE RESTRICTION

The purposes of this experiment were to identify free-operant levels of stereotypy (to identify the most probable or most frequently displayed response form) and to evaluate the effects of restricting access to the most probable response form. It is possible that restricting access to the most probable form would have no effect on other forms of stereotypy, would increase other forms of stereotypy, or would decrease other forms of stereotypy.

Method

Participants

Mike, Mary, Geff, and Alice participated in Experiment 1. Mary's stereotypy was evaluated at her home and at her school.

Procedure and Design

Each participant's stereotypy was first evaluated during sessions in which the individual was either physically alone (Mike only) or an experimenter was present, but no social consequences were provided for stereotypy. Sessions were conducted until either at least two consecutive sessions revealed a consistent order in time allocation for the most probable repetitive response (e.g., pacing occurred for the highest percentage of time for a minimum of two consecutive sessions) or a maximum of 300 min of total session time elapsed. Note that individual sessions were 10 min in duration for every participant except Mary, for whom sessions were 30 min.

During baseline (described below), each participant's most probable stereotyped behavior was determined by visual inspection of trends in data paths across individual sessions within each phase, the overall average time allocation to each response during each phase, or a combination of both. In general, the results of these approaches yielded the same conclusion regarding each participant's time allocation to stereotyped behavior.

The effects of the experimental manipulation (i.e., restriction of the most probable stereotypy) on each participant's behavior were evaluated using a reversal design in which A was the baseline (free-operant) condition and B was the experimental (restricted-operant) condition. Identification of the most probable form of stereotypy was determined based on the criteria described above. The response to which the most time was allocated was designated R1, the response to which the next most time was allocated was designated R2, and so on.

During the free-operant (FO) condition (i.e., baseline), each participant was escorted to the setting described above (alone or no interaction). No social interaction was provided during this condition.

In the restriction of R1 condition, the behavior identified as most probable (according to the criteria established above) during FO was restricted. The most probable stereotypy for Mary was pot spinning, which was subsequently restricted by removing the pot lid from the room. Mike's most probable stereotypy was pacing, and this response was restricted using a mild verbal reprimand (e.g., "no pacing Mike, please sit in the chair") that was delivered contingent on the initiation of pacing. In addition, a salient stimulus card (i.e., a warning stimulus) was placed on the wall in Mike's direct view. After several presentations of the contingent verbal reprimand in the presence of the card alone, the card alone was sufficient for maintaining the absence of the target behavior during most of the sessions (see Piazza, Hanley, & Fisher, 1996). Two reprimands were provided during Session 19 after the card fell from the wall. To restrict Alice's most probable stereotypy (pacing), a therapist sat within 4 m of Alice, physically blocked Alice when she attempted to stand, and provided contingent verbal prompts for her to "stay in your chair" (note that Alice could still reach the carpet). The most probable stereotypy for Geff was hand rubbing, which was restricted by a therapist who stood within 3 m of Geff and gently separated his hands each time contact of one hand was made with the other hand (up to the elbow).

Results and Discussion

Figure 1 (top) shows the allocation of Mike's stereotypy across FO and R1 phases. During the first FO phase, Mike allocated the highest proportion of time to pacing and

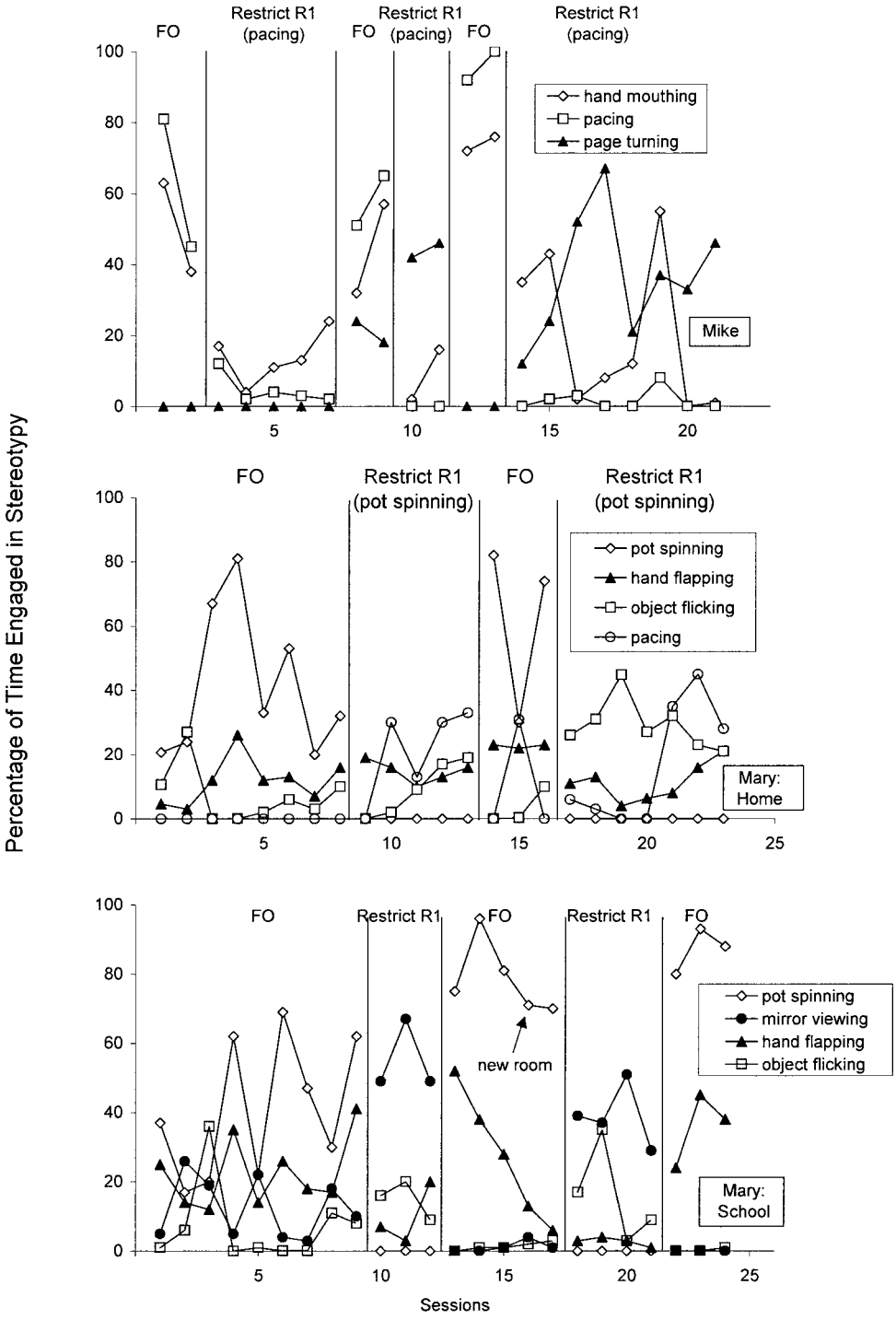

Figure 1. Percentage of time Mike (top) allocated to stereotypy across free-operant (FO) and response-restriction (R1) phases. Percentage of time Mary allocated to stereotypy at home (middle) and school (bottom) across FO and R1 phases.

hand mouthing (M = 63% and 51%, respectively). Time allocation to other responses, such as ear covering and hand flapping, was low across sessions and phases. Therefore, less probable response forms are not depicted on the graph. Based on the results of the first FO phase, pacing was restricted in the following phase. During the first R1 phase (restrict pacing), pacing (M = 5%) and hand mouthing (M = 14%) decreased. In the second FO phase, pacing, hand mouthing, and page turning increased (Ms = 58%, 45%, and 21%, respectively). A return to R1 produced substantial decreases in pacing and hand mouthing (Ms = 0% and 9%, respectively) and an increase in page turning (M = 44%). The third FO phase yielded high levels of pacing and hand mouthing (Ms = 96% and 74%, respectively) and no page turning. A third implementation of R1 decreased pacing (M = 1.6%) and hand mouthing (M = 20%) but produced increased levels of page turning (M = 37%).

Figure 1 (middle) shows the percentage of time Mary allocated to the four most probable forms of stereotypy during FO and R1 conditions. Time allocation to less probable response forms is not depicted in the graph. In the first FO condition, Mary allocated the most time to pot spinning during seven of the eight sessions (M = 41%). She also displayed low levels of hand flapping (M = 12%) and object flicking (M = 7%) and no pacing (M = 0%). In the first R1 phase, pacing increased (M = 27%) and object flicking was on an upward trend (M = 9%). A return to the FO phase increased pot spinning (M = 62%) and decreased both pacing (M = 10%) and object flicking (M = 3%). A return to the R1 phase immediately increased object flicking (M = 30%) and ultimately increased pacing (M = 17%).

Following the analysis that was conducted at Mary's home, the conditions were repeated in a room at her school. Figure 1 (bottom) depicts behavior allocation during the FO and R1 phases. This panel shows the percentage of time Mary allocated to pot spinning, object flicking, mirror viewing, and hand flapping. Time allocation to less probable response forms is not depicted on the graph. Consistent with the home analysis, Mary exhibited relatively high levels of pot spinning (M = 41%) during FO. In the first R1 phase, Mary displayed high levels of mirror viewing (M = 55%), followed by object flicking (M = 15%) and hand flapping (M = 10%). The second FO phase produced high levels of pot spinning (M = 79%), moderate and declining levels of hand flapping (M = 27%), and near-zero levels of mirror viewing and object flicking (Ms = 1% and 1%, respectively). A return to R1 increased mirror viewing (M = 39%) and object flicking (M = 16%) and decreased hand flapping (M = 3%). During the last FO phase, Mary again displayed high levels of pot spinning (M = 87%), moderate levels of hand flapping (M = 36%), and near-zero levels of mirror viewing and object flicking.

Due to the large number of response forms emitted by Geff, only data representing the three most probable response forms (based on observations during FO conditions) are depicted in Figure 2. The top panel shows the percentage of time Geff allocated to snorting and hand rubbing. The middle panel shows the percentage of time Geff allocated to body rocking. Time allocation to other response forms was either low across conditions or unchanged as a function of the restriction. In the first FO phase, Geff allocated variable amounts of time to both snorting (M = 61%) and hand rubbing (M = 61%) and less time to body rocking (M = 31%). In the first R1 phase (restrict hand rubbing), hand rubbing (M = 16%) and snorting (M = 7%) decreased substantially, while body rocking (M = 35%) occurred at similar levels. A return to the FO phase increased hand rubbing (M =

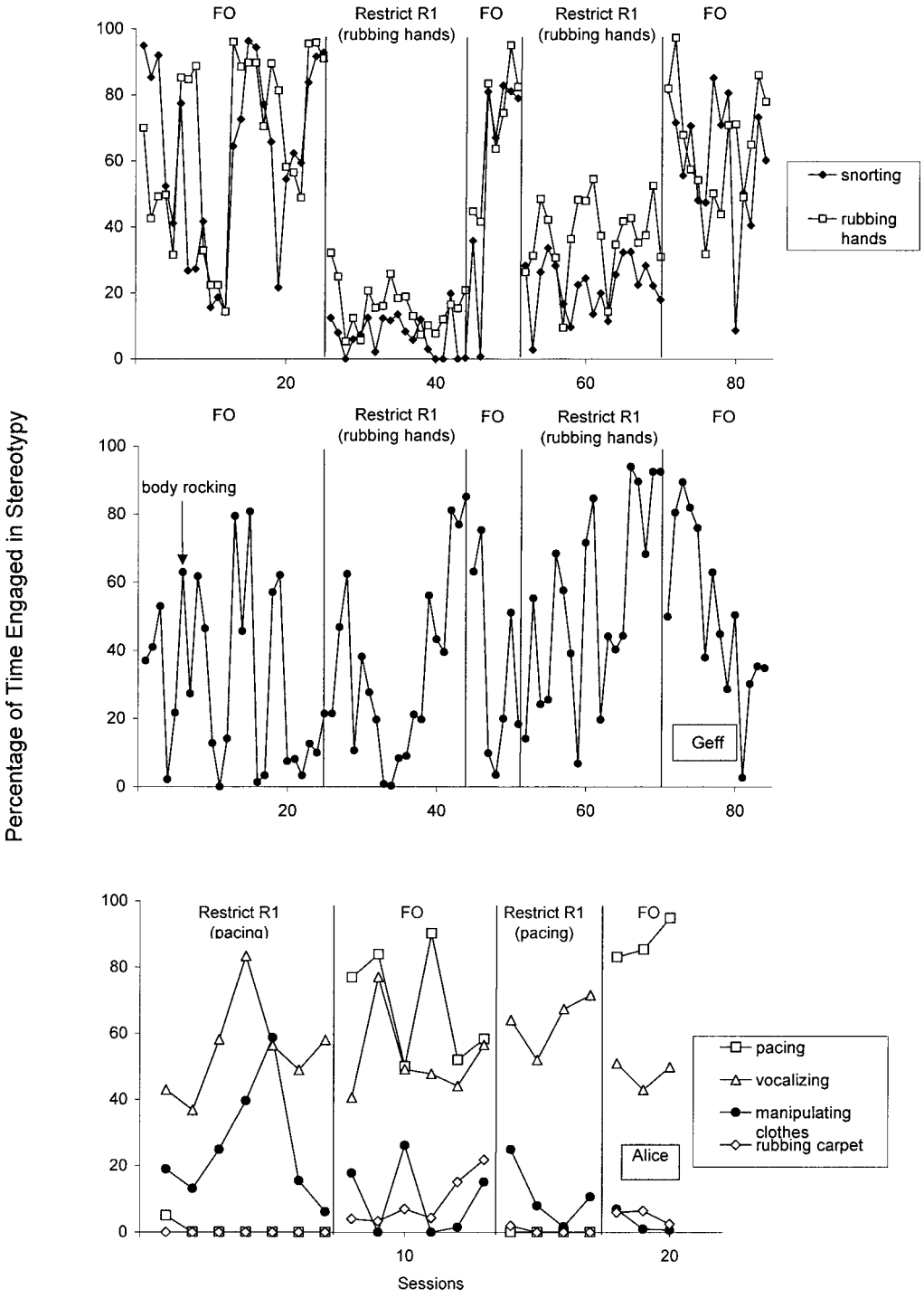

Figure 2. Percentage of time Geff allocated to snorting and hand rubbing (top) and body rocking (middle) across free-operant (FO) and response-restriction (R1) phases. Percentage of time Alice allocated to stereotypy (bottom) across R1 and FO phases.

69%) and snorting (M = 61%) but produced little overall change in body rocking (M = 35%). The second implementation of R1 again decreased hand rubbing and snorting (Ms = 37% and 22%, respectively) and increased body rocking (M = 54%). A third return to FO resulted in high levels of hand rubbing and snorting (Ms = 65% and 60%, respectively) and a comparable level of body rocking (M = 50%); however, a steep downward trend was observed.

Figure 2 (bottom) depicts the percentage of time Alice engaged in pacing, vocalizing, manipulating clothes, and rubbing carpet. Unlike the other participants, the data depicted in this panel begin in R1 (BABA, as opposed to ABAB). With the possible exception of rubbing carpet, R1 had little influence on other response forms.

Overall, results for 3 of the 4 participants show that restriction of the most probable stereotypy decreased an untargeted response form and increased one or more response forms that had been less probable during FO. Only 1 participant (Alice) showed little change in other response forms as a function of restricting the most probable stereotypy.

EXPERIMENT 2: ENVIRONMENTAL ENRICHMENT

Broadly defined, studies involving environmental enrichment as treatment for stereotypy have typically used stimuli that are intended to provide competing sources of reinforcement (e.g., Piazza et al., 2000; Vollmer et al., 1994). Some studies have demonstrated the need for therapist-guided prompts (antecedent stimuli) to facilitate appropriate interaction with items (e.g., Britton, Carr, Landaburu, & Romick, 2002; Singh & Millichamp, 1987). Other studies found that environmental enrichment alone did not increase alternative behavior until stereotypy was restricted (e.g., Lindberg et al., 1999).

Although response restriction produced a desirable reduction in untargeted response forms in some cases in Experiment 1 (see Mike's hand mouthing and Geff's snorting), the procedure also produced higher levels of untargeted response forms in other cases (see Mary's mirror viewing). It is possible that environmental enrichment would influence high-probability response forms and low-probability response forms in different ways. For example, it may be the case that reductions in R1 are not correlated with increases in untargeted response forms. It is also possible that reductions in some response forms may be accompanied by reductions in other response forms. Finally, it is possible that environmental enrichment alters response allocation to some response forms (e.g., high-probability behavior) but not others (e.g., low-probability behavior).

Method

Participants

Geff, Alice, and Greg participated in this study. For Geff and Alice, object manipulation was defined as contact of either or both hands with a toy. For Greg, sketch toy manipulation was defined as contact of either or both hands with the sketch toy (see Table 1).

Procedure and Design

The effects of environmental enrichment on participants' stereotypy were evaluated using either ABAB (Geff and Greg) or BABA (Alice) reversal designs. Data collection and measurement of interobserver agreement were the same as described in Experiment 1. For Geff and Alice, the environmental enrichment condition involved a range of stimuli. For Greg, two experimental conditions were used wherein only one of two items was available per condition. Subsequently, a third condition involved simultaneous access to both stimuli. The purpose of providing only one item per condition

was to determine whether the enriching stimulus produced selective (i.e., decreased only the behavior to which the stimulus was matched; Piazza et al., 2000) or general (i.e., decreased multiple response forms) reductions in stereotyped behavior.

The FO condition (i.e., baseline) was identical to the FO condition in Experiment 1.

During the FO plus environmental enrichment condition for Geff and Alice, several objects that potentially produced a combination of auditory, visual, and tactile stimulation were accessible. The objects used during environmental enrichment for Alice were identified via a stimulus preference assessment (e.g., Roane, Vollmer, Ringdahl, & Marcus, 1998). Items for Geff were selected based on informal observations (e.g., while he was in his classroom) and reports provided by caregivers (Geff never manipulated objects during a formal stimulus preference assessment despite exposure to dozens of stimuli). For Alice, environmental enrichment included a toy phone, a musical keyboard, books, musical books, a comb, and a bead shaker. For Geff, environmental enrichment included large and small attachable blocks, a soccer ball, three large trucks, a musical keyboard, small figurines, and a sketch toy. Three different conditions involving two stimuli were conducted with Greg. The stimuli used in these conditions were identified via stimulus preference assessment (e.g., Roane et al.). In the FO plus sketch toy condition, a sketch toy was continuously available throughout each session. The purpose of this condition was to evaluate the extent to which stereotyped behavior, such as mirror viewing, may be reduced in the presence of a stimulus that provides alternative (putatively matched) visual stimulation. In the FO plus music condition, a small stereo was present from which music (at approximately 80 dB) was played continuously during each session. The purpose of this condition was to determine whether stereotyped behavior that generated audible products (e.g., vocalizing, screaming) would decrease when ambient music was available. Last, in the FO plus sketch toy plus music condition, both the sketch toy and music were present.

Results and Discussion

Figure 3 (top) shows that during the first FO phase, Geff exhibited high levels of snorting (M = 63%) and hand rubbing (M = 46%). Both snorting and hand rubbing were relatively unchanged, and Geff did not engage in object manipulation during environmental enrichment. Time allocation to less probable response forms (not depicted) remained unchanged (and low) across conditions. Thus, environmental enrichment by itself was ineffective for Geff, probably because none of the items were reinforcers (as indicated in the stimulus preference assessment).

Figure 3 (bottom) shows that during the first FO plus environmental enrichment phase, Alice exhibited variable levels of pacing (M = 43%), object manipulation (M = 40%), and vocalizing (M = 36%). In the first FO phase, pacing (M = 69%) increased and vocalizing (M = 38%) was unchanged. In the second FO plus environmental enrichment phase, pacing and vocalizing decreased (M = 41% and 20%, respectively). Alice also exhibited moderate levels of object manipulation (M = 27%). In the final FO phase, pacing (M = 62%) increased and vocalizing was relatively unchanged (M = 24%).

Figure 4 (top) shows that during the first FO phase, Greg exhibited high levels of vocalizing (M = 60%) and mirror viewing (M = 43%). Implementation of the first FO plus sketch toy phase produced high levels of sketch toy manipulation (M = 100%), decreased mirror viewing (M = 1%), and a slight overall decrease in vocalizing (M =

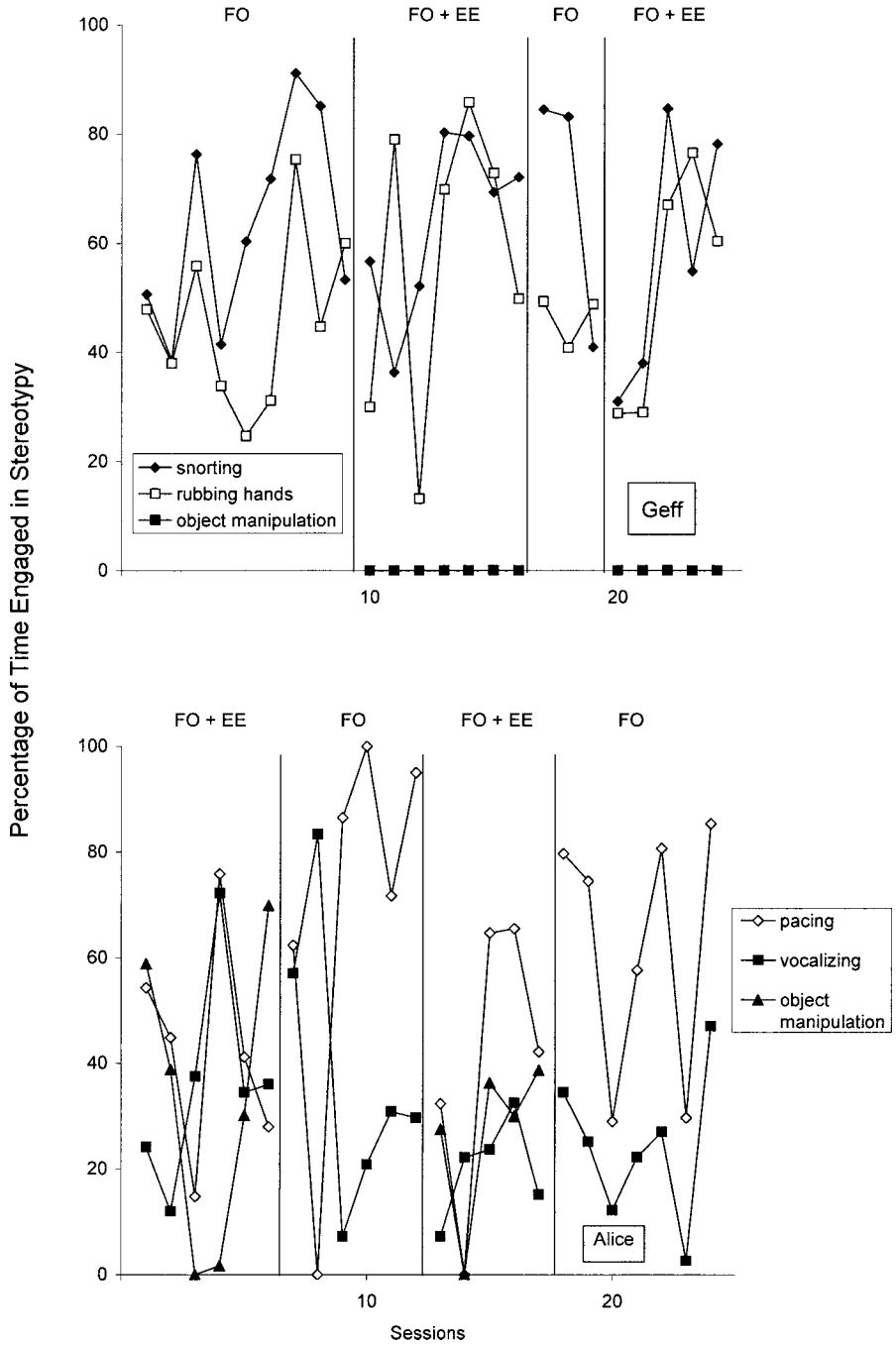

Figure 3. Percentage of time Geff (top) and Alice (bottom) allocated to stereotypy during free-operant (FO) and free-operant plus environmental enrichment (FO+EE) phases.

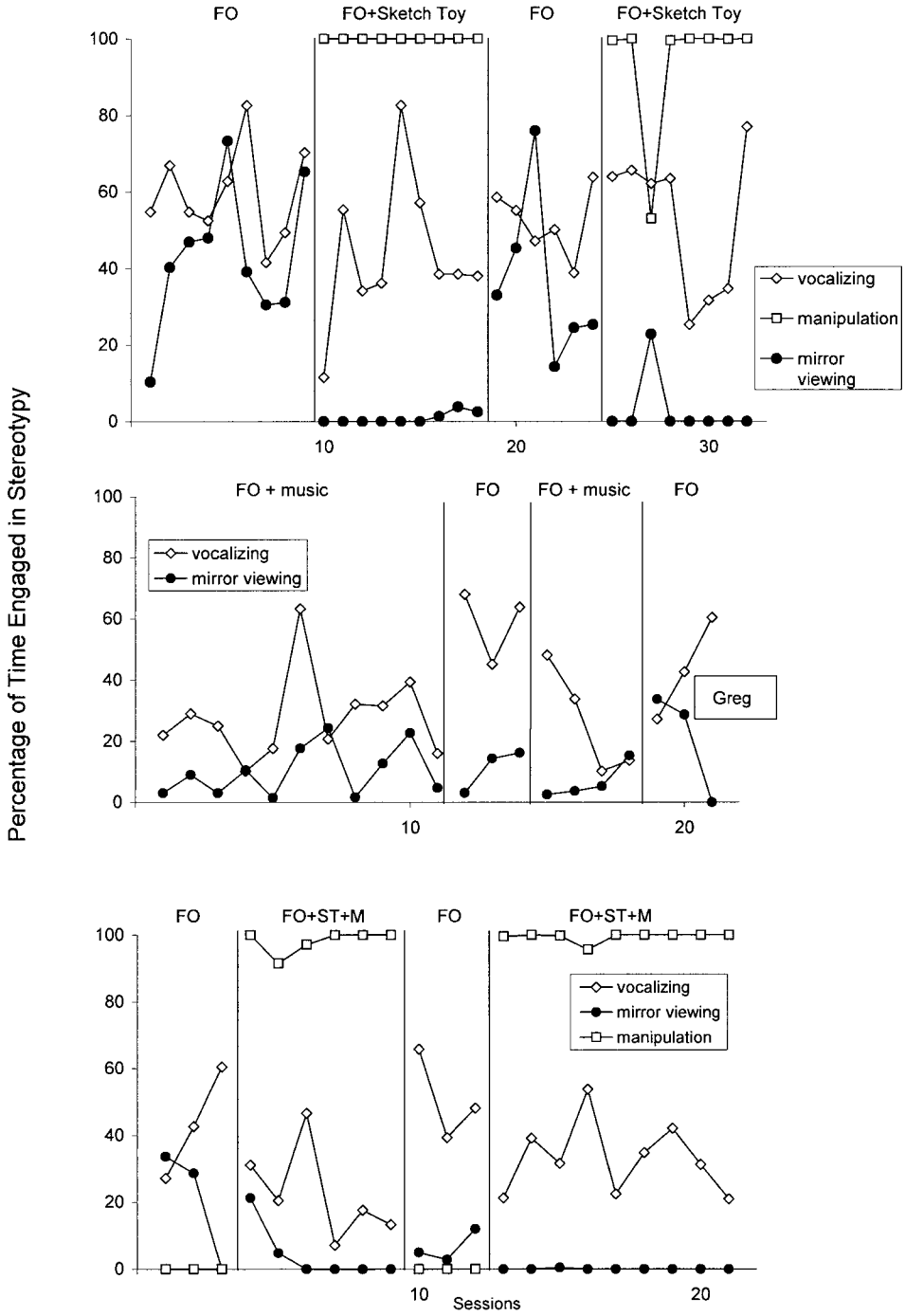

Figure 4. Percentage of time Greg allocated to stereotypy during free-operant (FO) and FO plus sketch toy phases (top), FO plus music and FO phases (middle), and FO and FO plus sketch toy plus music (FO+ST+M) phases (bottom).

44%). A return to the FO phase produced comparable levels of vocalizing (M = 52%) and increased mirror viewing (M = 36%). The second FO plus sketch toy phase again produced high levels of sketch toy manipulation (M = 94%), comparable levels of vocalizing (M = 53%), and decreased mirror viewing (M = 3%).

Figure 4 (middle) shows that during the first FO plus music phase, Greg exhibited moderate to low levels of vocalizing (M = 28%) and mirror viewing (M = 11%). A return to FO increased vocalizing (M = 59%) but produced little change in mirror viewing (M = 11%). The second FO plus music phase produced a gradual reduction in vocalizing (M = 26%) and low levels of mirror viewing (M = 7%). The second FO phase increased vocalizing (M = 43%) and mirror viewing (note the decreasing trend; M = 21%).

Figure 4 (bottom) shows that during the first FO condition, which was also the second FO condition in the center panel (it served as a baseline here), Geff exhibited high levels of vocalizing and moderate levels of mirror viewing. In the first FO plus sketch toy plus music phase, sketch toy manipulation was high (M = 98%), vocalizations decreased (M = 23%), and mirror viewing continued to occur at low or zero levels (M = 4%). The subsequent FO phase yielded increased vocalizing (M = 51%) and mirror viewing (M = 7%). In the final FO plus sketch toy plus music phase, sketch toy manipulation was again high (M = 99%) and both vocalizing and mirror viewing decreased (Ms = 33% and 0.1%, respectively).

In general, environmental enrichment had idiosyncratic effects for each participant. In no case, however, did reductions in R1 influence response allocation to other forms of stereotypy (as seen in several cases in Experiment 1). For Geff, environmental enrichment had no effect on stereotypy. For Alice, environmental enrichment had a modest effect on R1 (pacing). For Greg, environmental enrichment had a selective effect depending on the type of alternative stimulus used. In addition, response allocation for Greg shifted toward object manipulation in the FO plus sketch toy condition.

EXPERIMENT 3: ENVIRONMENTAL ENRICHMENT PLUS ADDITIONAL PROCEDURES

Because Geff and Alice showed either no reduction in stereotypy during environmental enrichment (Geff) or modest reductions in stereotypy during environmental enrichment (Alice), the extent to which additional procedures might facilitate response reallocation was evaluated. In Geff's case, there was no reallocation of responding during environmental enrichment. It is possible that if toy play were reinforced, there would be a concurrent reduction in stereotypy. In Alice's case, environmental enrichment produced low levels of object manipulation. It is possible that if R1 was restricted, she would allocate more time to object manipulation (see Hanley et al., 2000).

Method

Participants and Procedure

Geff and Alice participated in this experiment. For both participants, the effects of environmental enrichment plus an additional intervention were evaluated using a reversal design. The dependent measures were the same as in the previous experiment. In addition, for Geff, toy responses were defined as contact of either hand with a toy that resulted in an audible product (e.g., pressing a key on a keyboard so that it produced a sound). Accordingly, each toy response was also scored as object manipulation. Consequences were provided for toy responses only (i.e., reinforcement was not provided for simply touching toys).

For Alice, the FO plus environmental en-

richment condition was the same as described in Experiment 2. For Geff, this condition was the same as in Experiment 2 with the exception that two more toys were added. These toys were equipped with keys and buttons that produced sounds when pressed. During this condition, neither the potential discriminative stimulus for reinforcer delivery (i.e., a therapist standing near the toys) nor juice was present.

During environmental enrichment plus R1 restriction (Alice only), Alice was provided access to the same stimuli that were available during FO plus environmental enrichment. In addition, access to pacing, which was previously identified as Alice's most probable stereotypy (see results of Experiment 1 and Experiment 2), was restricted. Pacing was restricted in the same manner as described in Experiment 1. Restriction of pacing included prompts for Alice to sit in a chair that was next to a table on which the alternative stimuli were placed.

During environmental enrichment plus fixed-ratio (FR) 1 (Geff only), the environment was identical to that described in the FO plus environmental enrichment condition except that toy responses were reinforced on an FR 1 schedule with juice (i.e., a 2-s drink from a bottle of juice). Because Geff did not initially engage in independent toy responses, a three-step prompting sequence involving verbal, gestural, and physical prompts was used until he acquired the toy-play responses. Prompts were faded after three sessions. Only independent responding is depicted in Figure 5.

Results

Figure 5 (top) shows that the first environmental enrichment plus R1 phase produced high levels of object manipulation (M = 60%), moderate levels of vocalizing (M = 37%), and no pacing (M = 0%). Removal of the pacing restriction (FO plus environmental enrichment) produced increased pacing (M = 54%), decreased object manipulation (M = 16%), and comparable vocalizing (M = 40%). A return to EE+R1 decreased pacing (M = 0%), increased object manipulation (M = 31%), and did not change vocalizing (M = 42%).

Figure 5 (bottom) shows that in the first FO plus environmental enrichment condition (this was also the second FO plus environmental enrichment condition from Experiment 2), Geff exhibited high levels of snorting (M = 55%) and hand rubbing (M = 52%) and little object manipulation (M = 0.9%). In the first environmental enrichment plus FR 1 phase, object manipulation increased (M = 47%), and both snorting (M = 27%) and hand rubbing (M = 38%) decreased to slightly lower, stable levels. During the second FO plus environmental enrichment phase, hand rubbing (M = 60%) and snorting (M = 59%) increased to previous levels, and object manipulation decreased to zero. In the second environmental enrichment plus FR 1 phase, object manipulation (M = 66%) increased, and again, both snorting (M = 37%) and hand rubbing (M = 26%) decreased.

GENERAL DISCUSSION

Results from Experiment 1 showed that for individuals who display multiple forms of stereotypy, a specific response form was consistently more probable under FO conditions. In addition, three general patterns of response reallocation emerged when the most probable response was restricted. In the first pattern, restriction of the most probable response yielded reductions in an untargeted response (e.g., restriction of Mike's pacing also decreased hand mouthing). In the second pattern, restriction of the most probable response produced a consistent increase in a previously less probable response (e.g., restriction of Mary's pot spinning increased mirror viewing). In the third pattern, restric-

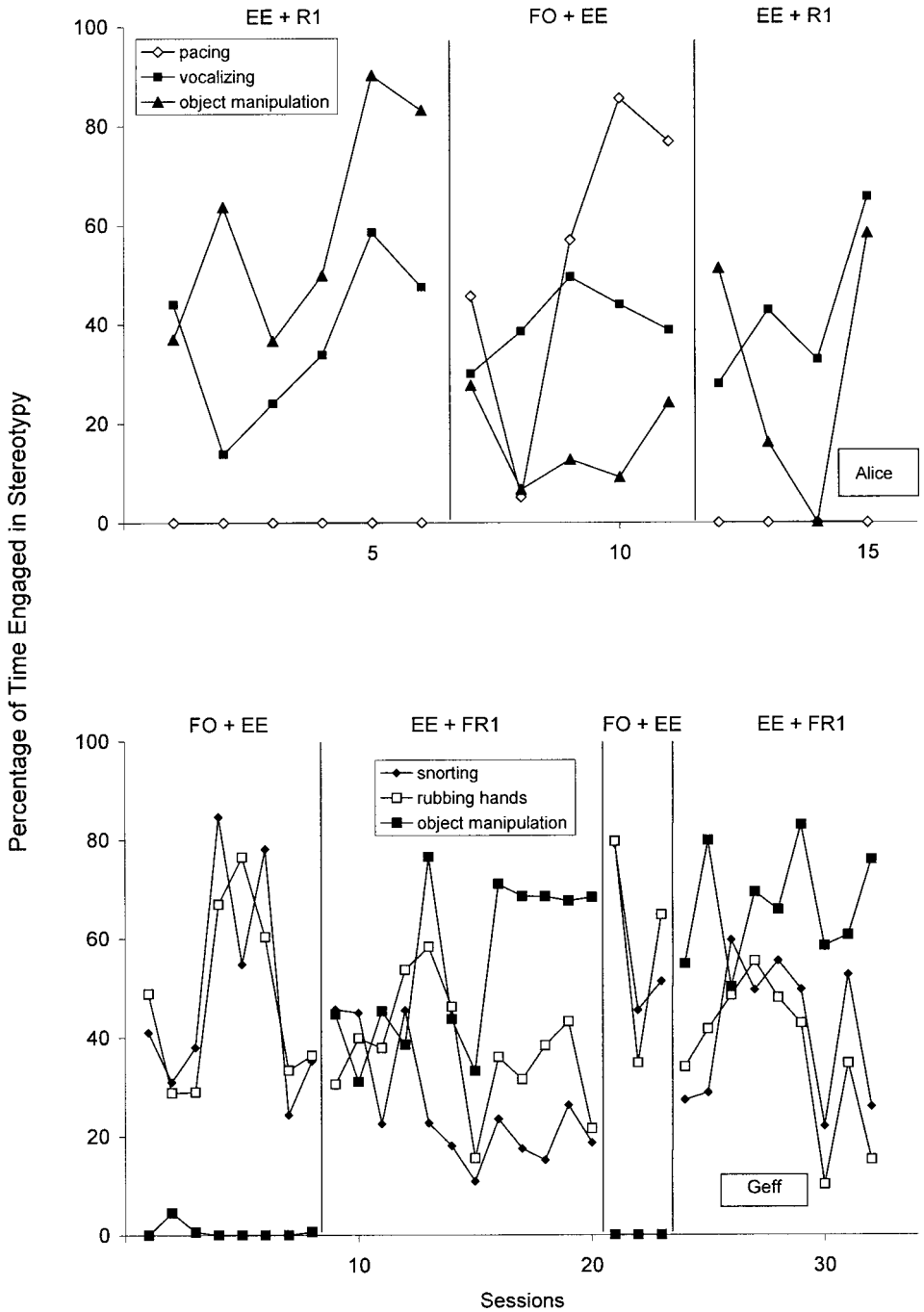

Figure 5. Percentage of time Alice allocated to stereotypy during free-operant plus environmental enrichment (FO+EE) and environmental enrichment plus response restriction (EE+R1) phases (top). Percentage of time Geff allocated to stereotypy and object manipulation during FO+EE and free-operant plus environmental enrichment plus FR 1 toy play (FO+EE+FR 1) phases (bottom).

tion of the most probable response did not alter time allocation to other response forms (e.g., restriction of Alice's pacing did not produce consistent change in any other behavior). These patterns were also displayed in various combinations. For example, when Mike's hand mouthing decreased during restriction of pacing, page turning emerged as the most probable response.

The effect of environmental enrichment on the stereotyped behavior of 3 individuals was also evaluated. The results showed that environmental enrichment produced different outcomes for each participant. For Alice, environmental enrichment increased manipulation of several different objects and primarily decreased the most probable stereotyped response. By contrast, Geff's behavior was unchanged by comparable provisions of alternative stimulation. For Greg, environmental enrichment involving either the sketch toy or music primarily reduced a single stereotyped response that putatively produced stimulation that was similar to the enriching stimulus. Thus, the short-term effectiveness of two variations of environmental enrichment for reducing stereotypy was demonstrated for 2 of the 3 participants.

Two different approaches for facilitating time allocation to object manipulation were evaluated in Experiment 3. For Alice, restriction of her most probable stereotyped response yielded levels of object manipulation that exceeded levels previously observed during FO plus environmental enrichment (i.e., without restriction of pacing). For Geff, reinforcement for toy responses also increased time allocation to an alternative stimulus and simultaneously decreased his two most probable stereotyped responses (snorting and hand rubbing).

Reductions in untargeted responses that were observed in the present study are consistent with previous treatment studies involving noninjurious repetitive behavior (e.g., Friman & Hove, 1987; Johnson et al., 1982). There are at least four interpretations for this effect. Friman and Hove found that repetitive hair pulling of several children was eliminated when thumb sucking was suppressed with contingent punishment; however, they also noted that thumb sucking preceded nearly every instance of hair pulling. In basic research with nonhumans, Dunham and Grantmyre (1982) described this behavior–behavior relation in terms of "sequential dependency." This description does not appear to account for the present results because the covarying response was also shown to occur, though infrequently, independent of R1 (e.g., Mike displayed hand mouthing when pacing was unavailable). It is also possible that engagement in the covaried response was a function of its compatibility with the most probable response (i.e., engagement in R1 narrowed the range of responses that could be simultaneously displayed). For example, Mike might have engaged in hand mouthing because it was the only other response that he could emit while pacing (the most probable response).

It is also possible that covaried reductions in hand mouthing and snorting during R1 for Mike and Geff, respectively, were the result of adventitious punishment that was provided contingent on R1 (R2 and R1 often occurred in close temporal proximity; see Lerman, Kelley, Vorndran, & Van Camp, 2003). Nevertheless, adventitious punishment cannot explain all of the results because simple prevention of R1 (i.e., the item used for stereotypy was unavailable) reduced R2 for Mary (at school). Consistent with this position, Dunham and Grantmyre (1982) found that nonhumans exhibited similar reductions in the same untargeted behavior when R1 was either punished or made unavailable. Last, it is possible that the targeted and untargeted response forms generated complementary reinforcers (e.g., L. Green & Freed, 1993). Thus, restriction of

one reinforcer altered the value of another reinforcer (i.e., product of stereotypy).

For 3 of the 5 participants (Mike, Mary, and Alice), the highest levels of the most probable response (during a single session) were exhibited following the restriction of the respective response. The subsequent increase in time allocation suggests that the experimental conditions may have imposed deprivation (i.e., increased the establishing operation) for the reinforcement produced by the restricted stereotyped response (see Klatt & Morris, 2001). This outcome is similar to that of prior studies that showed increased time allocation to a behavior or an activity following a period of restriction (Bernstein & Ebbesen, 1978; Forehand & Baumeister, 1971, 1973; Holburn & Dougher, 1986; Klatt et al., 2000; McEntee & Saunders, 1997).

The present results seem particularly important for determining whether environmental enrichment provides stimulation that substitutes for or simply competes with the products of automatically reinforced behavior. The most compelling evidence for a substitution explanation is the selective reductions in stereotyped response forms that were produced with the sketch toy and the music for Greg. Specifically, the two most probable responses were separately decreased without producing general changes to Greg's repertoire. The stimulation provided during these environmental enrichment conditions appeared to match the product of the behavior that was reduced: The sketch toy reduced a behavior that was presumably maintained by visual stimulation (mirror viewing), and music reduced a different behavior that previously generated an auditory product (vocalizing). The similarity of the stimulation produced by the matched objects and the selectively reduced response forms is further supported by the absence of stereotypy increases (above previous baseline levels) following the removal of the matched stimuli (i.e., deprivation for the product of stereotypy was not imposed).

The results of the current investigation illustrate at least three important considerations for the treatment of stereotypy. First, interventions that are intended to decrease a specific behavior may alter other behavior in the individual's repertoire. Theses changes may be desirable or undesirable. Second, interventions involving the addition of stimulation that is intended to compete with stimulation generated by stereotypy may be most effective when matched to the overt products of the target behavior (Piazza et al., 2000). Third, stereotypy may increase following the removal of procedures involving response restriction.

Some limitations to the current results should be noted. First, the generality of the current results may be limited insofar as the restriction conditions may not accurately reflect the manner in which treatment is applied for some problem behavior (e.g., the withdrawal of treatment following a brief period of behavior reduction or suppression). Similarly, because participants were selected based on their exhibition of multiple response forms, the present outcomes may not predict response allocation for individuals who exhibit fewer response forms. Nevertheless, similar response patterns were reported in previous studies that did not impose such selection criteria (e.g., Johnson et al., 1982; Rollings & Baumeister, 1981). Second, the relative brevity of the sessions and the inconsistent toy preference exhibited by Alice suggest that lengthier sessions may not have produced comparable reductions in stereotypy in either the environmental enrichment or environmental enrichment plus R1 conditions. Similarly, in the absence of contingent access to juice for Geff, manipulation of toys did not appear to produce stimulation that supported appropriate behavior. Instead of serving as a potential source of competing sensory stimulation, the toy response

more closely resembled a functional mand (for juice).

Results from the present investigation suggest potential directions for further investigation of automatically reinforced behavior using response-restriction procedures. Future research should evaluate changes in response allocation of high-probability behavior as a function of restricting lower probability behavior. Future research should also evaluate the effects of providing extended access to stereotyped behavior during environmental enrichment. It is possible that environmental enrichment produces immediate reductions in stereotypy; however, stereotypy may return to previous levels following some duration of access to stimulation generated by object manipulation. Conversely, objects presented during environmental enrichment may initially exert minimal or no effect on stereotypy, but may occasion appropriate object manipulation following a period of access to stereotypy (i.e., altered establishing operations). The former possibility calls for procedures to prolong the reinforcing efficacy of alternative stimuli, whereas the latter possibility requires a method to rapidly degrade the reinforcing value of stereotypy so that appropriate object manipulation may be evoked.

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STUDY QUESTIONS

1. How were primary data and reliability measurements obtained to accommodate the large number of response forms exhibited by Geff?

2. Describe the different ways in which response-restriction procedures were implemented.

3. In general, how did response restriction affect participants' targeted and untargeted behaviors?

4. How was the environmental enrichment condition implemented, and why was it slightly different for Greg?

5. Summarize the effect of environmental enrichment on stereotypy and object manipulation as shown in Figures 3 and 4.

6. Briefly describe the results obtained in Experiment 3.

7. Why might the authors' suggestion that sequential dependency accounted for observed reductions in untargeted responses be untenable?

8. According to the authors, what considerations for treatment of stereotypy are illustrated by the results of this study?

Questions prepared by Carrie Dempsey and Pamela Neidert, University of Florida