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A LABORATORY MODEL FOR STUDYING RESPONSE-CLASS HIERARCHIES

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If the members of a functional response class occur in a predictable order, a response-class hierarchy is said to exist. Although this topic has received some attention in the applied literature, it remains relatively understudied. The purpose of the current investigation was to develop an analogue model of a response-class hierarchy. Children with and without developmental disabilities were first taught three responses in an attempt to develop a functional response class ordered along the dimension of response effort (Experiment 1). Following response-class development, an extinction analysis was used to determine whether the responses were hierarchically related (Experiment 2). Results of Experiment 1 indicated that a functional response class was developed, and that there was a relation between response rate and effort for the established response class. Results of Experiment 2 indicated that a response-class hierarchy existed within the previously developed response classes for 3 of 4 participants.

DESCRIPTORS: problem behavior, response covariation, response-class hierarchy

A *response class* can be functionally defined as all responses that produce and are maintained by the same outcome (Catania, 1998). Responses within a class may have special relations to each other such that changes in the frequency of one member of a response class can also affect the frequency of other members of the same class (i.e., response covariation). Some responses occur in a consistent sequence such that one response occurs only when a previous response fails to be effective (Baer, 1982). If the members of a response class occur in such a predictable order, a *response-class hierarchy* is said to exist. A hierarchy is a specific type of response class in which each member of the class is hierarchically related and ordered along various dimensions, including response effort, rate of reinforcement, immediacy of reinforcement, and the probability of punishment (Baer; Borrero & Borrero, 2008; Halle & Drasgow, 2003; Mace, 1994).

The concept of the response-class hierarchy has been helpful in understanding the commonly reported pattern of behavioral escalation, in which an individual progresses through a series of different response topographies, especially when earlier topographies are not reinforced (Albin, O'Brien, & Horner, 1995; Evans, Meyer, Kurkjian, & Kishi, 1988). Lalli, Mace, Wohn, and Livezy (1995) reported an experimental demonstration of problem behavior organized in a response-class hierarchy. A 15-year-old girl with developmental disabilities had been admitted to an inpatient unit of a hospital for the treatment of self-injurious mouthing, aggression, and screaming. After demonstrating that each response topography was maintained by escape from demands, the authors conducted an analysis in which escape was contingent on the occurrence of one topography while the other two topographies were placed on extinction. In the first condi-

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tion, escape was contingent on the occurrence of self-injury. The authors predicted that all three topographies of problem behavior would occur in a predictable sequence (screams, followed by aggression, followed by self-injury) because escape was contingent on the occurrence of the third response in the hierarchy. Results indicated a sequence of responses from screams, to aggression, and then self-injury in 14 of the 16 trials. In the second condition, escape was provided contingent on aggression. Results indicated a sequence of responses from screams to aggression in 27 of the 35 trials. In the final condition, escape was contingent on screams. Results indicated the occurrence of only screams in 19 of the 21 trials. In summary, the authors were able to demonstrate that when screaming was reinforced, the other responses were less likely to occur, and when screaming was extinguished, the other responses were more likely to occur in a predictable, hierarchical order. The authors hypothesized that response effort was the primary dimension along which members of the hierarchy were related (i.e., screaming was less effortful than aggression, which was less effortful than self-injury).

The aforementioned method of (a) first identifying the function of responses in a putative hierarchy, (b) placing one of the responses on extinction, and (c) observing increases (or the probability of occurrence) in the other responses has been replicated in several investigations with responses classes maintained by positive reinforcement (i.e., contingent access to tangible items and attention), escape from demands, or multiple operant functions (e.g., Harding et al., 2001; Kennedy, Meyer, Knowles, & Shukla, 2000; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999; Shukla-Mehta & Albin, 2003).

Smith and Churchill (2002) used the concept of the response-class hierarchy to evaluate problem behavior whose properties are sometimes considered ill suited for a functional analysis (e.g., life-threatening self-injury, intense aggression) by conducting an assessment of behaviors that reliably occurred prior to the more severe response topographies (i.e., precursor behaviors). The authors determined that severe problem behaviors (e.g., head banging, body hitting, knee banging, aggression) and precursor behaviors (e.g., screaming, falling, foot stomping) had a common maintaining contingency. The authors concluded that precursor behaviors were functionally related to more severe topographies of problem behaviors and therefore were members of the same response class. Furthermore, the occurrence of precursor behaviors immediately prior to the occurrence of more severe topographies of problem behavior suggested a response-class hierarchy. Results indicated a reduced rate of severe problem behavior when precursor behaviors were reinforced; however, precursor behaviors continued to occur when only severe topographies of problem behavior were reinforced. The authors hypothesized that response effort was one variable along which the different members of the response class were hierarchically related (similar to Lalli et al., 1995).

The existence of aberrant response-class hierarchies highlights the need for a better understanding of their applied significance. For example, it is not uncommon for individuals with some clinical diagnoses (e.g., autism, mental retardation) to engage in multiple problem behaviors. However, treatments are typically developed and prescribed for single behavior problems (Carr et al., 1999) in the research literature. The limited response-class hierarchy literature indicates that eliminating only one member of a response class might lead to the emergence of others, especially if the reinforcer is unavailable (e.g., with operant extinction; Sprague, 2005).

Unfortunately, research on the identification and modification of response-class hierarchies proves to be difficult for at least two reasons. First, identification of a hierarchy requires the

demonstration of the function of each response in the class (e.g., Kennedy et al., 2000; Shukla-Mehta & Albin, 2003) as well as a subsequent extinction analysis (Lalli et al., 1995); such analyses may be unacceptably time consuming and dangerous for participants who engage in life-threatening problem behavior. Second, it is difficult to identify individuals whose problem behaviors are sequentially ordered because, by definition, not all of the behaviors in the hierarchy will be displayed reliably. The result of these obstacles is that we know relatively little about identifying hierarchies, how they develop (i.e., the variables responsible for their sequential occurrence), and, perhaps most important, how they should be treated.

The purpose of the current study was to develop a laboratory model of the response-class hierarchy to potentially serve as a clinical analogue. First, 4 children were taught three basic manual responses associated with different performance efforts in an attempt to develop a response class (Experiment 1). Following the development of a response class, less effortful responses were placed on extinction to determine whether responses were hierarchically related (Experiment 2). The establishment of the hierarchy occurred if a relation was demonstrated between response rate and effort and within-session analyses identified fixed sequences of behaviors. The study included children with and without developmental disabilities to determine whether the model was effective with a clinically relevant population as well as with a population that might be more easily available for additional translational research on the topic.

GENERAL METHOD

Participants and Setting

Participants were 3 girls (Dora, 4 years old; Gwen, 3 years old; Hillary, 3 years old) with no known developmental or language delays and 1 boy (James, 12 years old) who had been diagnosed with developmental disabilities. James was recruited from a day-treatment program where he was undergoing assessment and treatment of aggression, self-injury, noncompliance, and tantrums. He had diagnoses of autism, severe intellectual disability, and speech impairment. He communicated verbally and initiated some social interactions; however, the majority of his verbal behavior consisted of repetitive phrases and words.

Sessions for Dora, Gwen, and Hillary were conducted in a small partitioned area of their preschool classroom. Sessions for James were conducted in a padded room (3 m by 3 m). During all sessions of Experiment 1, a participant and an experimenter were seated across from or next to each other at a table. Each session lasted 5 min and was conducted once or twice per day, 3 to 5 days per week. During all trials of Experiment 2, a participant and two experimenters were present. Each trial lasted approximately 5 s, with a mean of 80 to 100 trials per session. Sessions lasted between 10 to 15 min each and were conducted over the course of 2 to 3 days.

Materials

The experimental manipulandum consisted of three differently colored 12.5-cm plastic buttons attached to a wooden response panel (75 cm by 30 cm). The buttons were diagonally positioned 10 cm from one another, and the response panel was laterally positioned in front of each participant. Each button on the response panel required a different amount of pressure to activate and was located at different distances from the participant. The pressure required to activate the buttons was adjustable from 200 to 1,500 g, which was analogous to a light touch anywhere on the key to a firm press with both hands. In addition, the button that required the least amount of pressure to activate was positioned approximately 18 cm from the participant. Throughout the remainder of the article, this button will be referred to as the low-effort (LE) button. The button that required slightly more pressure to activate was located

approximately 54 cm from the participant and will be referred to as the medium-effort (ME) button. The button that required the most effort to activate was located approximately 70 cm from the participant and will be referred to as the high-effort (HE) button. The buttons were connected to a laptop computer via a USB interface that allowed button presses to be recorded in real time using the Behavioral Evaluation Strategy and Taxonomy (BEST) software application. Equipment checks were conducted prior to each session to ensure proper functioning and recording of button presses.

Preexperimental Procedure

Stimulus preference assessment. Caregivers of participants were asked to list and rank their child's favorite foods and toys. They were also asked to list any food allergies or foods that they preferred their child not be given during the study. For Dora, Gwen, and Hillary, this information was used to identify a variety of toys that were used as backup reinforcers for pennies earned during sessions. For James this information was used to select stimuli for a subsequent multiple-stimulus (without replacement) preference assessment (DeLeon & Iwata, 1996), which identified Skittles as the most preferred item.

Button training. To prevent adventitious reinforcement of button-pressing chains, participants were taught to perform an orienting response prior to pressing each button on the response panel. The orienting response consisted of pressing a green button that was not attached to the response panel and was located immediately in front of each participant. Training on pressing the orienting button was conducted in a quasirandom order such that each time the participant pressed the orienting button, the therapist prompted the participant to press a different button on the response panel. This introduced a delay between a response on one button and reinforcement for another button and functioned similar to a changeover delay in an operant chamber.

EXPERIMENT 1: RESPONSE-CLASS DEVELOPMENT

METHOD

The purpose of Experiment 1 was to establish button-pressing responses into a response-class hierarchy.

Dependent Variable

The dependent variable in this experiment was the number of button presses per minute.

Experimental Design and Procedure

The experimental design incorporated features of withdrawal (ABCDEFE) and concurrent-schedule designs (Poling, Methot, & LeSage, 1995). The order of the study's key experimental phases was counterbalanced across participants. The stability criterion for phase changes was a minimum of three consecutive data points showing no differential levels of responding.

During all phases, the experimenter read the following instruction to the participant after modeling how to press the buttons: "Now it is your turn to press the buttons by yourself, ready, go." Questions about the procedure were either unanswered or answered by repeating the instruction. If the participant failed to press the orienting button during the session, he or she was reminded to press the orienting button before pressing buttons on the response panel. If the participant moved or walked away from the buttons at any time during the session and returned before 10 s had elapsed, the session continued. If the participant moved or walked away from the buttons before half of the session time (i.e., 2.5 min) had elapsed and remained away from the buttons for at least 10 s, the session was discarded. If the participant moved or walked away from the buttons after half of the session time had elapsed and remained away from the buttons for at least 10 s, the session ended; however, data from the session were still included. Overall, fewer than five total sessions were terminated after a participant moved away from the response panel. All three buttons were present in all phases.

Baseline. During this phase, pressing any of the buttons resulted in no programmed consequences. The purpose of this condition was to identify whether button pressing decreased in the absence of programmed consequences.

Reinforcement phases. James received one piece of candy and Dora, Gwen, and Hillary earned one penny that were exchanged for a variety of backup reinforcers (e.g., crayons, toy jewelry, stickers) at the end of each session for each button press.

Before each of the three phases, the experimenter conducted training trials in which he or she prompted the participant to press each button three times. The experimenter delivered reinforcement only for the button that resulted in programmed consequences in the subsequent phase. In addition, the experimenter prompted three additional training trials on the target button.

During reinforcement for the LE button (fixed-ratio [FR] 1 LE), only presses on the LE button resulted in programmed consequences. During reinforcement for the ME button (FR 1 ME), only presses on the ME button resulted in programmed consequences. During reinforcement for the HE button (FR 1 HE), only button presses on the HE button resulted in programmed consequences.

Class demonstration (FR 1 all). During this phase, presses on any of the three buttons resulted in programmed consequences. The purpose of this phase was to demonstrate that a functional response class of button pressing had been established, and that there was a relation between response rate and effort for the established response class (i.e., a majority of responding on the button that required the least amount of effort, and no responding on the button that required the most effort).

Class modification (FR 1 ME and HE; extinction LE). After the response class was established, the LE response was placed on extinction. Programmed consequences were provided only after the ME or HE button was pressed. If responses on the ME and HE buttons occurred at higher rates, the response class was considered successfully modified.

Results and Discussion

Dora's data are depicted in Figure 1. During baseline, Dora engaged in low rates of button pressing across sessions. Following baseline, she engaged in high rates of LE and low rates of ME and HE button pressing when LE button presses resulted in an FR 1 schedule of reinforcement and ME and HE button presses were on extinction. During the subsequent FR 1 ME condition, she displayed high rates of ME button pressing and low rates on the LE and HE buttons. During the FR 1 HE condition, her rate of button pressing increased on the HE button and remained at near-zero levels on the LE and ME buttons. She allocated responding almost exclusively to the LE button when responses on all buttons were reinforced (FR 1 all). After LE button presses were placed on extinction, and the reinforcement contingency remained in place for the ME and HE buttons (FR 1 ME and HE), responding was almost exclusively allocated to the ME button. Finally, when all button presses again resulted in reinforcement (FR 1 all), responding was almost exclusively allocated to the LE button.

Gwen's data are depicted in Figure 2. During baseline, Gwen engaged in low rates of button pressing across sessions. Following baseline, she engaged in high rates of ME and low rates of LE and HE button pressing when ME button presses resulted in an FR 1 schedule of reinforcement and LE and HE button presses remained on extinction. During the subsequent FR 1 LE condition, she displayed high rates of LE button pressing and low rates on the ME and HE buttons. During the FR 1 HE condition, her rate of button pressing increased on the HE button and decreased to near-zero levels on the LE and ME buttons. During the following condition in which responses on all buttons were reinforced (FR 1 all), rates of

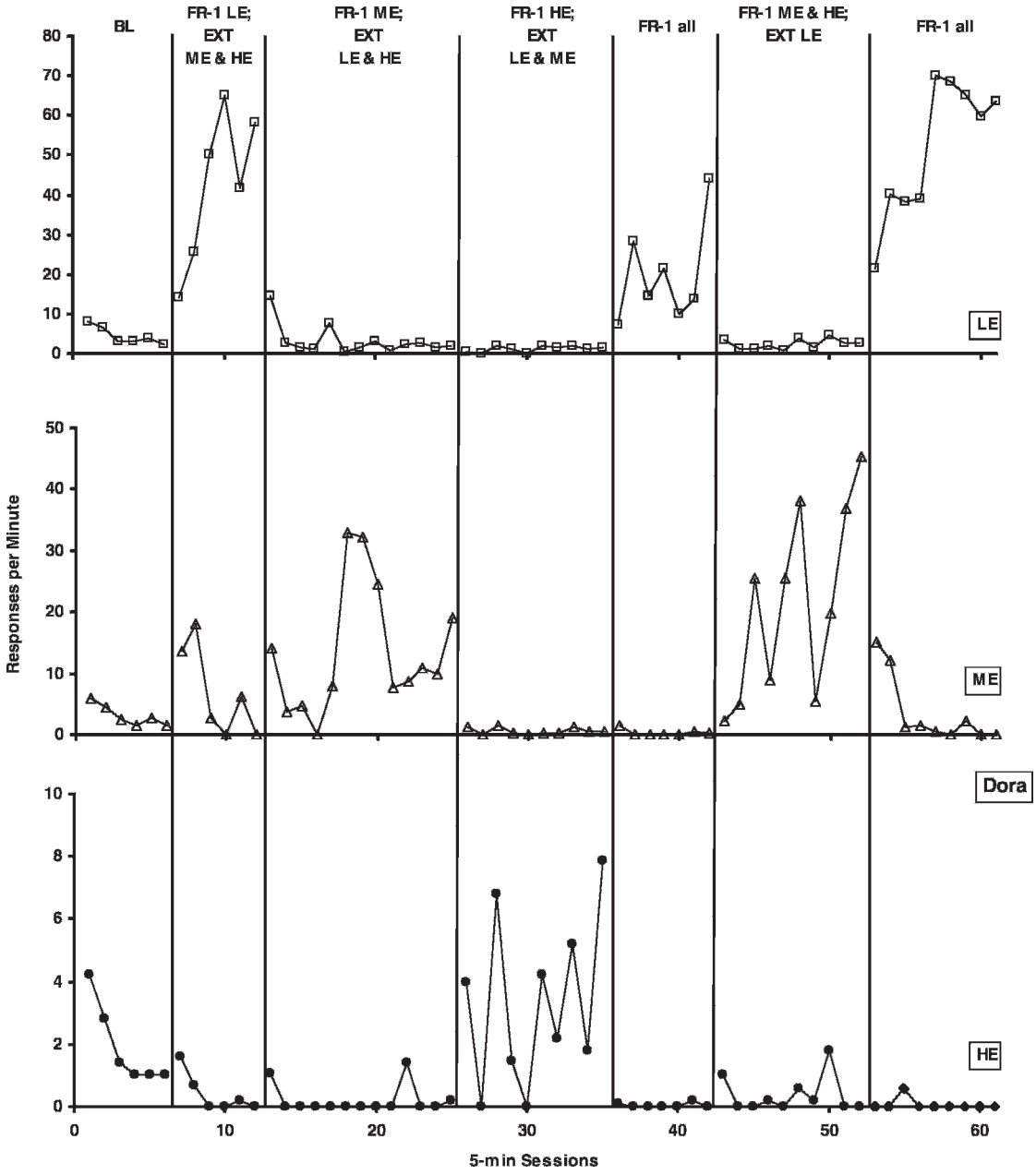

Figure 1. Dora's data from Experiment 1, depicted as responses per minute on the LE (top), ME (middle), and HE (bottom) buttons.

button pressing were highest on the ME button. Following seven sessions (Sessions 57 through 63) in which she continued to press the ME button at high rates, the presession prompted training trials were reimplemented. However, she continued to press the ME button. An adjustment was then made in which the ME button was placed on extinction while the LE and HE buttons remained on an FR 1 schedule. This manipulation resulted in increased responding on the LE button and little responding on the ME and HE buttons. Following this

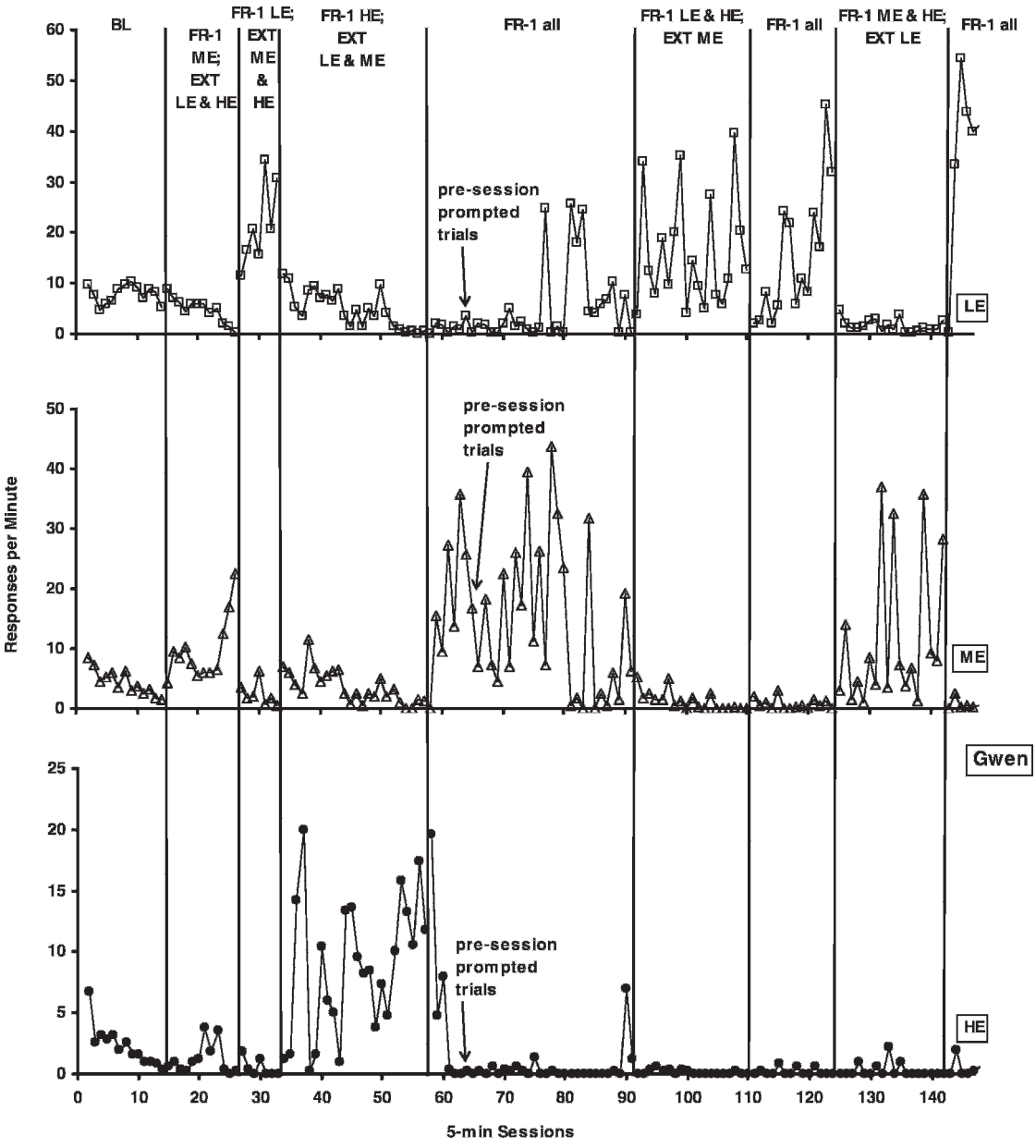

Figure 2. Gwen's data from Experiment 1, depicted as responses per minute on the LE (top), ME (middle), and HE (bottom) buttons.

adjustment, the FR 1 all condition was reintroduced and resulted in high response rates on the LE button and little responding on the ME and HE buttons. In the subsequent condition, LE button presses were placed on extinction and the reinforcement contingency remained in place for the ME and HE buttons (FR 1 ME and HE). She displayed an increase in responding on the ME button and low rates of responding on the LE and HE buttons. Finally, when all button presses again resulted in reinforcement (FR 1 all), responding was almost exclusively allocated to the LE button.

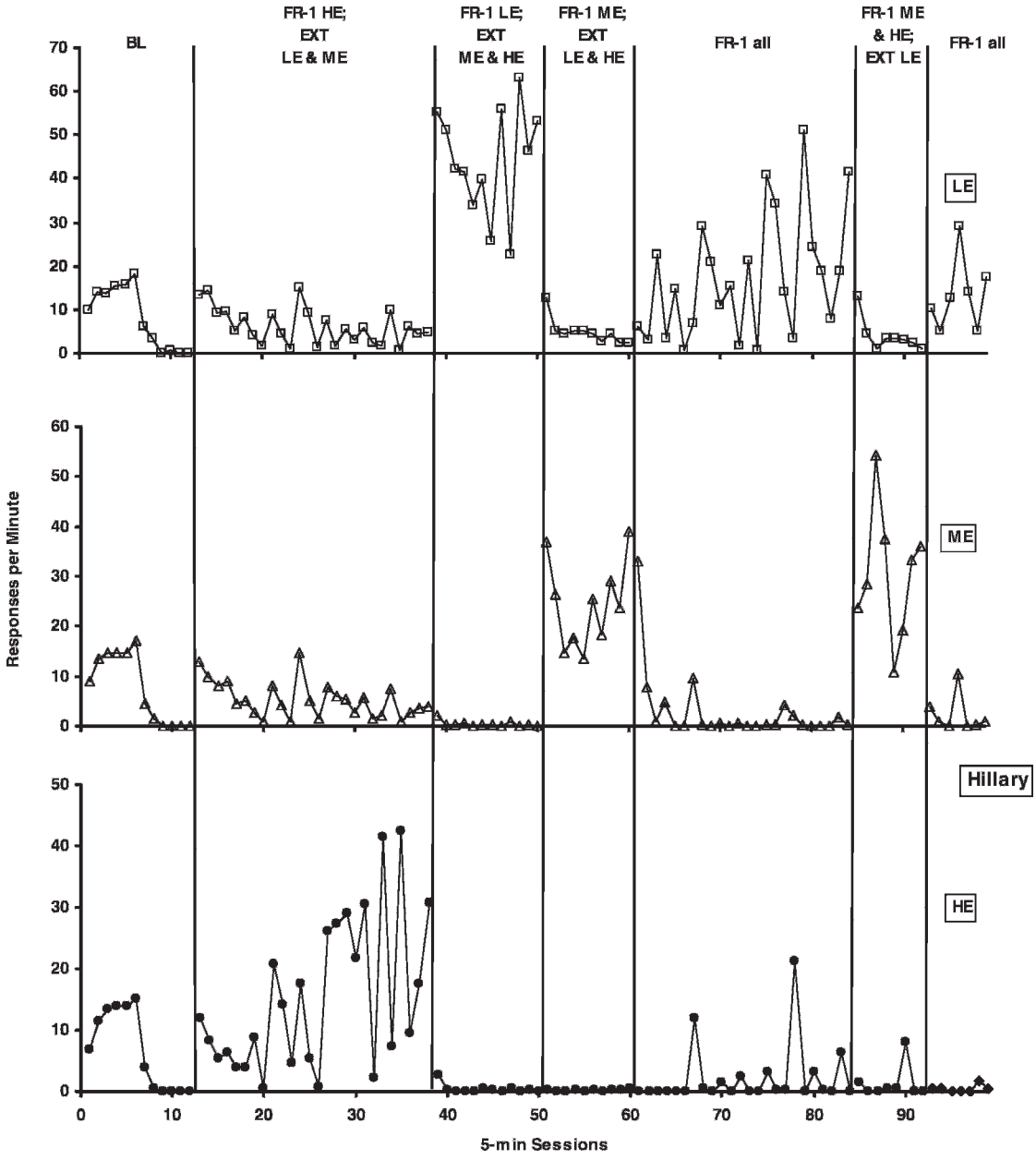

Figure 3. Hillary's data from Experiment 1, depicted as responses per minute on the LE (top), ME (middle), and HE (bottom) buttons.

Hillary's data are presented in Figure 3. During baseline, Hillary initially engaged in high rates of button pressing; however, responding gradually decreased to near-zero levels. Following baseline, she engaged in high rates of HE and low rates of LE and ME button pressing when HE button presses resulted in an FR 1 schedule of reinforcement and LE and ME button presses remained on extinction. During the subsequent FR 1 LE condition, she displayed high rates of LE button pressing and low rates on the ME and HE buttons. During

the FR 1 ME condition, her rate of button pressing increased on the ME button and decreased on the LE and HE buttons. During the following condition in which responses on all buttons were reinforced (FR 1 all), she displayed high rates of button pressing on the LE button and low rates of pressing the ME and HE buttons. After LE button presses were placed on extinction, and the reinforcement contingency remained in place for the ME and HE buttons (FR 1 ME and HE), responding was allocated almost exclusively to the ME button. Finally, when all button presses again resulted in reinforcement (FR 1 all), responding was mostly allocated to the LE button.

James' data are depicted in Figure 4. During baseline, James engaged in low rates of button pressing across sessions with almost no responding on the HE button. Following baseline, he engaged in higher rates of ME and lower rates of LE and HE button pressing when ME button presses resulted in an FR 1 schedule of reinforcement and LE and HE button presses remained on extinction. During the subsequent FR 1 HE condition, he displayed high rates of HE button pressing and low rates on the ME and LE buttons. During the subsequent FR 1 LE condition, button pressing increased on the LE button and decreased to near-zero levels on the ME and HE buttons. During the following condition in which responses on all buttons were reinforced (FR 1 all), responding was almost exclusively allocated to the LE button. After LE button presses were placed on extinction and the reinforcement contingency remained in place for the ME and HE buttons (FR 1 ME and HE), he displayed an increase in ME button pressing and lower rates on the LE and HE buttons. Finally, when all button presses again resulted in reinforcement (FR 1 all), responding was allocated almost exclusively to the LE button.

During Experiment 1, 3 participants (Dora, Hillary, and James) acquired the response class without procedural modification. For the remaining participant (Gwen), prompted training trials and an additional extinction phase were required before the response class was developed. Although adjustments were made to facilitate the development of the response class for Gwen, the response class was successfully demonstrated and modified for all participants. Collectively, the results of Experiment 1 demonstrated that the LE, ME, and HE buttons ultimately were members of a functional response class, and that when multiple responses were available for reinforcement, the response requiring the least response effort was most likely to be emitted.

EXPERIMENT 2: TEST TRIALS FOR HIERARCHICAL STRUCTURE

Method

Following demonstration and modification of the response class in Experiment 1, additional demonstrations of the response class and an original demonstration of the hierarchy were evaluated. An extinction analysis was used to determine the ordinal temporal relations between different members of the response class when some, but not all, of the members of the class were placed on extinction. The purpose of this evaluation was to determine whether participants progressed through fixed sequences of behavior, as predicted by response-class hierarchy theory.

Dependent Variables and Data Collection

Observers scored latency to button presses by activating a timer on the laptop computer to which the buttons were connected. The timer was activated as soon as the cover over the buttons was lifted (described below). The BEST software application recorded the order and timing of button presses. Latency was calculated by subtracting the start time of each trial (activated by the experimenter) from the time each button was pressed. For example, if the start time of Trial 5 was 148 s, and the participant pressed the ME button at 149 s and the HE button at 152 s, the latencies to

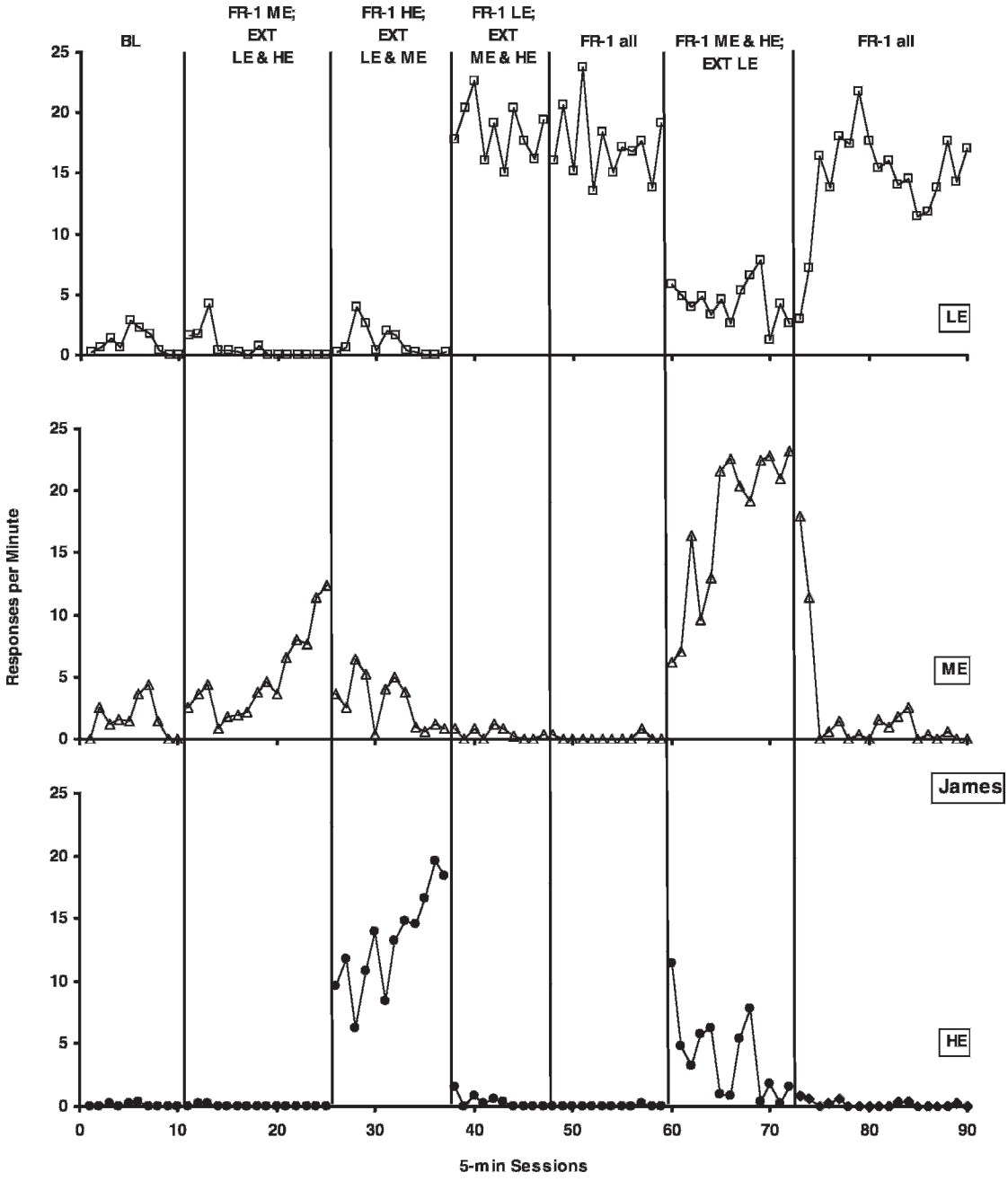

Figure 4. James' data from Experiment 1, depicted as responses per minute on the LE (top), ME (middle), and HE (bottom) buttons.

pressing the ME and HE buttons were 1 s and 4 s, respectively.

Two independent observers verified which button was pressed, because participants occasionally pressed the button closest to them accidentally with their waists or stomachs (this occurred less than five times). Only button presses recorded by both observers and the BEST software were used to calculate latency.

Interobserver Agreement

Interobserver agreement was calculated for 100% of trials across participants. The order of button presses in each trial was recorded by two independent observers. An agreement was defined as both observers recording the same order of button presses. Interobserver agreement was calculated by dividing the number of trial agreements by the number of agreements plus disagreements and converting this ratio to a percentage. Mean agreement was 99.5% for Dora, 99.4% for Gwen, 100% for Hillary, and 96.7% for James.

Experimental Design and Procedure

The experimental design incorporated features from withdrawal (ABABC) and concurrent-schedule designs (Poling et al., 1995). Phase order was counterbalanced. The stability criterion for phase changes was a minimum of six consecutive trials in which button presses on the least effortful button available for reinforcement occurred first. These criteria were slightly adjusted for Hillary in the final phase due to a higher percentage of trials in which no button presses occurred.

During each trial, all three buttons were covered by a lid placed on top of the wooden response panel. The green orienting button was not used in this experiment because the purpose of Experiment 2 was to evaluate response latency. Immediately prior to each trial, the experimenter read the following instruction to participants: "When I lift up this cover, you will see some round buttons in front you. It is your turn to press them, ready, go." The experimenter then lifted the cover and started the timer. The cover was removed for 5 s and then replaced by the experimenter. The experimenter immediately delivered one piece of candy (James) or one penny (Dora, Gwen, and Hillary) for presses on the button associated with programmed consequences during the 5-s interval. Three buttons were present in all conditions.

During reinforcement of the ME and HE buttons and extinction of the LE button (FR 1 ME and HE, extinction LE), only presses on the ME and HE buttons resulted in programmed consequences. During reinforcement of the LE and HE buttons and extinction of ME button (FR 1 LE and HE, extinction ME), only presses on the LE and HE buttons resulted in programmed consequences. During reinforcement of the HE button and extinction of the LE and ME buttons (FR 1 HE, extinction LE and ME), only presses on the HE button resulted in programmed consequences.

Results and Discussion

Results from Dora's response-class hierarchy analysis are presented in Figure 5 (top). During FR 1 ME and HE extinction LE, Dora initially pressed the HE button first and the ME button second, but she then pressed the ME button first for the last six trials. Initially, she pressed the ME button first and the LE button second in the FR 1 LE and HE extinction ME phase. She then pressed the LE button first for the last six trials. During the reintroduction of the FR 1 ME and HE extinction LE phase, she initially pressed the LE button first and ME button second, after which she pressed the ME button first during eight of the last nine trials. By the second trial of the FR 1 LE and HE extinction ME phase, she was pressing the LE button first and continued to do so during eight of the remaining 11 trials. In the FR 1 HE extinction LE and ME phase, she pressed the LE or ME button first during the first four trials, after which she pressed the HE button first during 15 of the remaining 18 trials. In summary, within relatively few trials of each condition, Dora switched to the least effortful button available for reinforcement. Not surprisingly, her transitions from the ME to LE buttons occurred more quickly than her transitions from the LE to ME and HE buttons.

Results from Gwen's response-class hierarchy analysis are presented in Figure 5 (bottom). During the FR 1 LE and HE extinction ME phase, she pressed the LE button exclusively. In

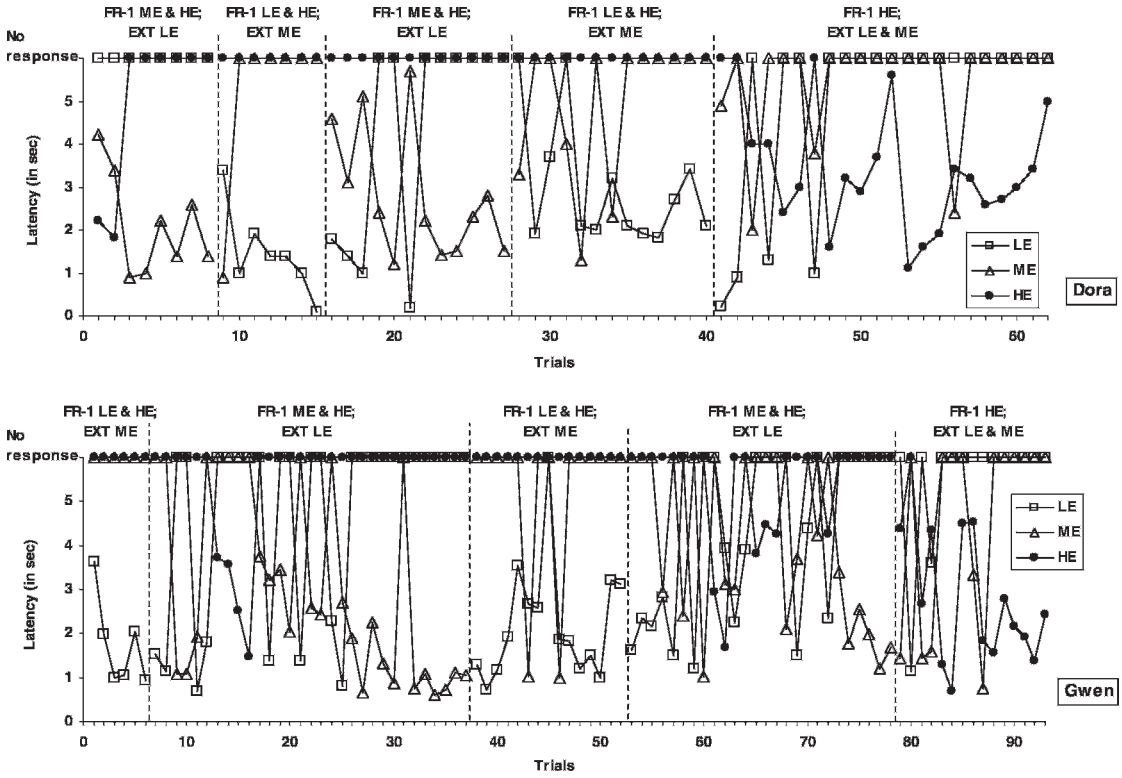

Figure 5. Data from the test trials in Experiment 2, depicted as the latency in seconds to button presses for Dora (top) and Gwen (bottom).

the FR 1 ME and HE extinction LE phase, she alternated between the LE, ME, and HE buttons until Trial 26, in which she pressed the ME button for the last 10 of 11 trials. During the reintroduction of the FR 1 LE and HE extinction ME phase, she pressed the LE button first in 12 of the 15 trials. During the reintroduction of the FR 1 ME and HE extinction LE phase, she initially alternating between buttons but switched to pressing the ME button first for the remaining six trials. In the FR 1 HE extinction ME and LE phase, she began by alternating between the LE, ME, and HE buttons; she began pressing the HE button first in 9 of the last 11 trials. In summary, Gwen switched to pressing the least effortful button available for reinforcement when pressing the LE and HE buttons resulted in reinforcement. However, when pressing the ME button resulted in reinforcement, she pressed the ME button first in 28 of the 57 trials, and she pressed the LE button first in 19 of the 57 trials. Her transitions from the ME to LE and HE buttons occurred more quickly than her transitions from the LE to ME buttons.

Results from Hillary's response-class hierarchy analysis are presented in Figure 6 (top). During the FR 1 ME and HE extinction LE phase, she pressed the ME button exclusively. In the FR 1 LE and HE extinction ME phase, she initially pressed the ME button first. She then switched to pressing the LE button first during the last seven trials. During the reintroduction of the FR 1 ME and HE extinction LE condition, she initially pressed the LE button first. She then switched to pressing the ME button first for the last seven trials. During the reintroduction of the FR 1 LE and HE extinction ME phase, she pressed the ME button first and the LE button second for the first two trials, after which she pressed the LE button first

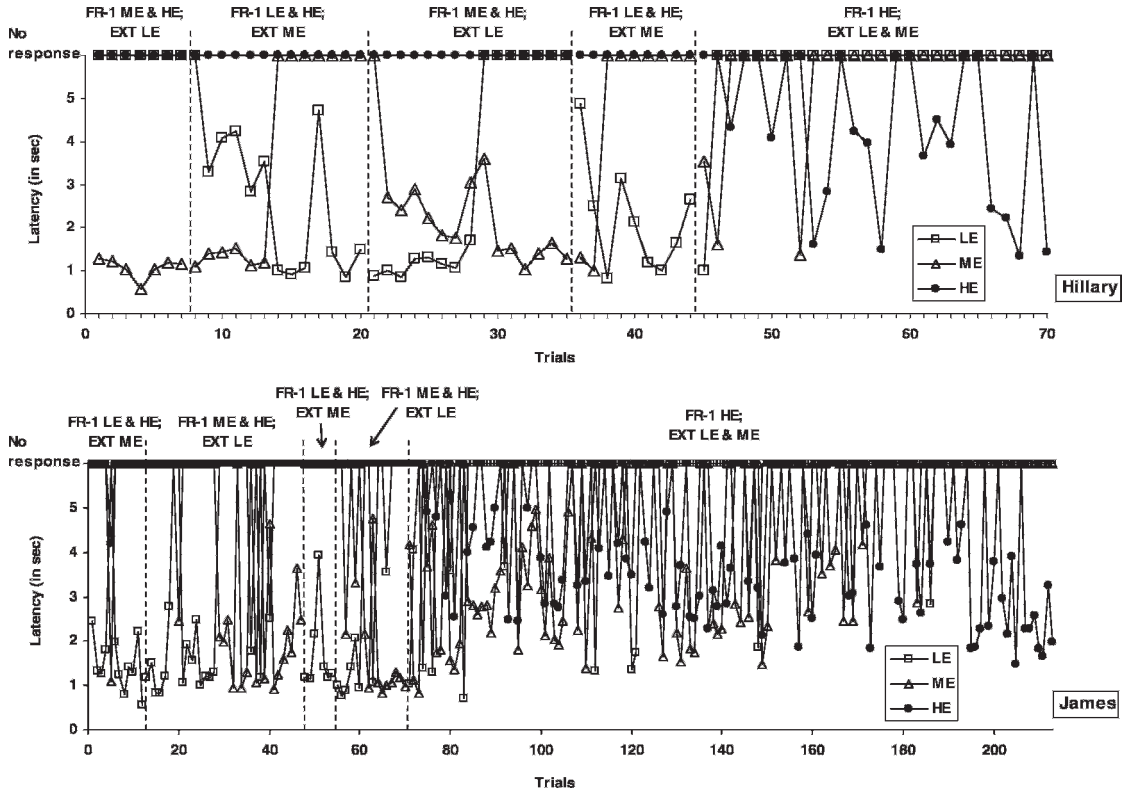

Figure 6. Data from the test trials in Experiment 2, depicted as the latency in seconds to button presses for Hillary (top) and James (bottom).

during the remaining seven trials. In the FR 1 HE extinction LE and ME phase, she began the phase by pressing the LE or ME buttons first during the initial two trials, after which she switched to pressing the HE button first for 14 of the remaining 24 trials. Although she pressed the HE button first in a majority of trials in the final phase, there were several trials in which she did not respond on any button, indicating a suppressive effect of increased response effort. In summary, a majority of Hillary's button pressing was allocated towards the least effortful button available for reinforcement, and her transitions from the ME to LE buttons occurred more quickly as she progressed through phases.

Results from James' response-class hierarchy analysis are presented in Figure 6 (bottom). During the FR 1 LE and HE extinction ME phase, he pressed the LE button first in 11 of 12 trials. In the FR 1 ME and HE extinction LE phase, he continued to press the LE button first during the first six trials, his button pressing became variable, and he switched to pressing the ME button first for 15 of the last 18 trials. During the reintroduction of the FR 1 LE and HE extinction ME phase, he pressed the LE button first in all seven trials. The FR 1 ME and HE extinction LE condition was then reintroduced; he switched to pressing the ME button first on eight of the last nine trials. In the FR 1 HE extinction LE and ME phase, button pressing was variable. For the remaining 137 trials following Trial 75, James pressed the HE button first 44 times and second 33 times. During trials in which he pressed the HE button second he most often pressed the ME button first. Although he pressed the HE button first or second during a high percentage of trials, there were numerous trials in which he did not respond on any button, indicating a suppressive effect of increased response effort (like Hillary). In

summary, James' button pressing was gradually allocated towards the least effortful button available for reinforcement, and his transition from the ME to the LE button occurred quickly. However, his transition from the LE to the ME button required several exposures to the extinction contingency on the LE button. This transition occurred much more quickly during the fourth phase; however, the transition from the ME to the HE button required a lengthy exposure to the extinction contingency in effect for the LE and ME buttons.

The purpose of Experiment 2 was to determine whether responses in the functional class established in Experiment 1 were organized in a hierarchical structure. Although the response patterns evident in the class modification phase in Experiment 1 might seem to suggest the existence of a hierarchy, these patterns constitute insufficient evidence. The response covariation (switching from the LE to the ME button) observed in Experiment 1 could simply be a result of participants pressing all of the buttons before responding on the one that produced reinforcement with the least effort. Thus, a within-session analysis was necessary to confirm the existence of a hierarchy so that the first response made after contacting an extinction contingency could be observed. In Experiment 2, an extinction analysis was used to determine the ordinal temporal relations between different members of the response class when some, but not all, members of the response class were placed on extinction.

Collectively, the results of Experiment 2 demonstrated that the LE, ME, and HE buttons were hierarchically related during a brief temporal window, with button pressing allocated toward the least effortful button available for reinforcement. In general, participants progressed through relatively fixed sequences of button pressing when transitioning between buttons of differential effort, with transitions from the ME to the LE button occurring more quickly than transitions from the LE to the ME and HE buttons.

Although the expected hierarchy did eventually emerge under the relevant conditions for Gwen, the demonstration of the hierarchy was less clear, given the variability in responding during phases when reinforcement was available for the ME and HE buttons only. Her transition to the LE button occurred over the course of fewer trials compared to her transition to the ME button. Given her delayed response to the changes in the contingencies, her pattern of responding may have been influenced by the brief phases of Experiment 2. Alternatively, her results may have been influenced by the effort manipulation used in the current investigation. The difference in effort between the LE and the ME button may have been too small to result in any discernible differences in responding. Results of previous studies (e.g., Lalli et al., 1995; Richman et al., 1999; Smith & Churchill, 2002) that demonstrated the existence of response-class hierarchies included a range of mild (e.g., screams, walking away from task area, crying) to severe (e.g., punching, kicking, head banging) problem behaviors that may have been more distinct in terms of physical effort.

Finally, Gwen, Hillary, and James all continued to press the LE button during a high percentage of trials in which only the ME and HE buttons were available for reinforcement. These results suggest that lower effort responses were slightly more resistant to extinction than the ME or HE responses. However, it is a possible that other variables (i.e., differential reinforcement, reinforcement density, punishment histories, delays to reinforcement, or number of reinforcers delivered during acquisition) may have affected this pattern of results (for a review of these issues, see Lerman & Iwata, 1996).

GENERAL DISCUSSION

The purpose of the current investigation was to evaluate a procedure for the development of a response class that included an original demonstration of a response-class hierarchy. The ultimate goal of this preliminary investigation was to

develop a procedure that could be used in a line of translational research that may lead to a better understanding of how members of a response class relate to one another. In addition, the demonstration of a hierarchy within the established response class may lead to further investigation of how and why individuals progress through different behaviors that comprise a response class. This information may provide a more comprehensive understanding of the hierarchy in terms of its relevance for clinical application.

The results from the current investigation indicate that it is possible to use an analogue model to analyze relations between behaviors within a response class, and that a response-class hierarchy can be produced under laboratory conditions. Furthermore, the procedure used in the current experiment may allow us to conduct future research on the effects of different variables on hierarchically related response topographies that exist within the same functional response class. This, in turn, could lead to a number of implications for the treatment of problem behavior.

Future research in this area may help us to better understand how to treat problem behaviors that are hierarchically related to one another through investigation of the effects of different reductive procedures on hierarchies of problem behavior. For example, it would be interesting to demonstrate the outcome when only one member of the hierarchy is targeted for reduction via a consequence manipulation, as opposed to what might happen with other reductive procedures such as noncontingent reinforcement or antecedent manipulations that may be more likely to affect the entire response class. Furthermore, this type of procedure could be used to evaluate the effects of function-based versus arbitrary or default interventions. Most default interventions target a single topography, whereas most function-based interventions (e.g., differential reinforcement of alternative behavior; noncontingent reinforcement) target the entire class.

This type of research might also have implications for situations in which treatment may actually create a response-class hierarchy. For example, in functional communication training a functionally equivalent communicative response is taught to replace a problem behavior (i.e., differential reinforcement of alternative behavior). The result of these procedures is the addition of a communication response to the response class of which the problem behavior is a member. Frequently, the functional communication response selected is one that is considered to be less physically effortful than the problem behavior. In addition, we typically reinforce the alternative response on a very dense schedule. The result of this training may actually establish the alternative response as a member of the response-class hierarchy. The procedure described in the current study may be used to investigate how to best thin the schedule of reinforcement for the communicative response without causing a resurgence of the problem behavior. In addition, we may be able to evaluate what happens when the alternative response is placed on extinction. Recent research has suggested that placing different members of a response class on extinction will result in the resurgence of other recently reinforced topographies (Lieving, Hagopian, Long, & O'Connor, 2004). However, it is not clear how extinction of a recently taught alternative response may affect resurgence of members of a response-class hierarchy.

There were a few limitations of the current study that should be considered in evaluating the results and their potential contribution to the research literature on response classes and response-class hierarchies. First, although we attempted to prevent adventitious reinforcement of button-pressing chains by including an orienting response (Experiment 1 only), it is possible that button-pressing chains were still reinforced. This may have precluded the development of a response-class hierarchy for Gwen. Future re-

search may attempt to include a more systematic changeover delay that prevents button pressing from being reinforced immediately after a changeover from another button. Second, the differences in physical effort that were manipulated may have not been pronounced enough to facilitate the development of a hierarchy. In other words, effort was defined structurally rather than functionally. Thus, it is possible that increasing the effort of the ME button for Gwen would have precluded the need to resort to extinction in the sixth phase of Experiment 1. Alternatively, we may have not given participants adequate histories with the buttons in Experiment 1. Future studies may attempt to magnify the differences in physical effort by positioning the buttons either farther away from one another or at different heights and incorporate longer training phases during the development of the response class.

In summary, the current investigation provided a preliminary framework for conducting future research in the area of response classes and response-class hierarchies. Further, the procedure appeared to be effective in creating response-class hierarchies with children with and without developmental disabilities. Through additional investigations, this procedure may be further refined and begin to provide more information about how members of a response class and response-class hierarchy are related. As a result, treatments for individuals who commonly engage in multiple forms of problem behaviors may be better informed.

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