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**DEVELOPMENT OF AN ANALOGUE
OF A RESPONSE-CLASS
HIERARCHY**

by

Daniel B. Shabani

**A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Department of Psychology**

James E. Carr, Adviser

**Western Michigan University
Kalamazoo, Michigan
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DANIEL B. SHABANI

TABLE OF CONTENTS

ACKNOWLEDGMENTS	ii
LIST OF FIGURES	vi
CHAPTER 1 Introduction.....	1
CHAPTER 2 Literature Review.....	3
2.1 The Concurrent Schedule	3
2.2 Matching Law	3
2.3 Response Classes and Response Covariation.....	8
2.4 Response-Class Hierarchies.....	12
2.5 Purpose of the Current Study.....	22
CHAPTER 3 Method.....	24
3.1 Participants and Setting	24
3.2 Materials.....	25
3.3 Pre-experimental Procedures.....	26
3.3.1 Parent Preference Assessment	26
3.3.2 Stimulus Preference Assessment	27
3.3.3 Button Training	28
3.4 Measurement.....	29
3.4.1 Direct Measurement of Behavior	29
3.5 Study 1: Development of a Response Class.....	29
3.5.1 Dependent Variables and Data Collection.....	29

Table of Contents—Continued

3.5.2	Experimental Design and Procedures	30
3.5.2.1	Baseline	31
3.5.2.2	Reinforcement for LE button (FR1 LE)	32
3.5.2.3	Reinforcement for ME button (FR1 ME).....	32
3.5.2.4	Reinforcement for HE button (FR1 HE)	32
3.5.2.5	Class demonstration (FR1 all)	32
3.5.2.6	Class modification (FR1 ME & HE; EXT LE).....	33
3.6	Study 2: Test Trials for Hierarchical Structure	33
3.6.1	Dependent Variables and Data Collection.....	34
3.6.2	Interobserver Agreement	35
3.6.3	Experimental Design and Procedures	35
3.6.3.1	Reinforcement of ME & HE buttons, extinction LE button (FR1 ME & HE, EXT LE)	36
3.6.3.2	Reinforcement of LE & HE buttons, extinction ME button (FR1 LE & HE, EXT ME).....	36
3.6.3.3	Reinforcement of HE button, extinction LE & ME buttons (FR1 HE, EXT LE & ME).....	36
CHAPTER 4 Results.....		37
4.1	Study 1	37
4.1.1	Dora	37
4.1.2	Gwen.....	39
4.1.3	Hillary.....	42
4.1.4	James	44
4.1.5	Rick.....	46

Table of Contents—Continued

4.2	Study 2	49
4.2.1	Dora	49
4.2.2	Gwen.....	52
4.2.3	Hillary.....	55
4.2.4	James	58
4.2.5	Rick.....	61
CHAPTER 5 Discussion		62
5.1	Study 1	62
5.2	Study 2	67
5.3	General Discussion	69
References		75
Appendices		84
A. Human Subjects Internal Review Board Approval Letter		85

LIST OF FIGURES

1.	Dora's response class development graph.....	38
2.	Gwen's response class development graph	40
3.	Hillary's response class development graph	43
4.	James's response class development graph	45
5.	Rick's response class development graph	47
6.	Trial-by-trial data of Dora's latency to button pressing across conditions	50
7.	Trial-by-trial data of Gwen's latency to button pressing across conditions	53
8.	Trial-by-trial data of Hillary's latency to button pressing across conditions	56
9.	Trial-by-trial data of James's latency to button pressing across conditions	59

Chapter 1

Introduction

There are classes of behavior that have special relations to one another such that changes to one member of the response class may result in changes to other members (Skinner, 1953). There are a variety of relations that may exist between behaviors; some behaviors occur in chains, some occur in order to provide the opportunity for others to occur, and some co-occur in particular situations in a consistent hierarchy such that one behavior is most appropriate to a certain situation and another behavior is only appropriate when the first behavior cannot occur (Baer, 1982). Reinforcement will affect these response-response dependencies and predict the distribution of behavior among several alternatives. The term *matching* has been used to describe this relation and refers to how organisms distribute their behavior among two or more alternatives. Herrnstein (1961) demonstrated that the distribution of behavior among two concurrently available options closely approximated the relative rate of reinforcement obtained from each option. This finding provided an experimental preparation and framework for studying choice by presenting a mathematical formula that predicted allocation of responses across concurrent schedules of reinforcement (Baum & Rachlin, 1969; McDowell, 1988; Neef, Mace, Shea, & Shade, 1992; Rachlin, 1989).

In the current investigation, our goal was to develop a model that would begin a line of research designed to examine variables that influence the allocation of responses. Specifically, we sought to develop a model within which response classes and response-class hierarchies could be analyzed and studied. A description of the current investigation will be presented in chapters. Following the introduction in Chapter One, Chapter Two will provide a brief review of the concurrent schedule and matching law. This will include a review of previous research in the areas of response classes, response covariation, and response-class hierarchies. The purpose of the current study will then conclude Chapter Two. In Chapter Three, the method, design, and procedures used in the current investigation will be described. In Chapter Four, an analysis of the results will be presented. Finally, in Chapter Five, a discussion of the results will be presented and suggestions for future research outlined.

Chapter 2

Literature Review

2.1 *The Concurrent Schedule*

Concurrent operant procedures are used to study choice and include two or more options that are simultaneously available and each correlated with an independent schedule of reinforcement (Fisher & Mazur, 1997). The number of responses to each alternative in a concurrent-schedule design can be used as a quantitative measure of choice (de Villiers, 1977). The ubiquity of such schedules in the natural environment (i.e., reinforcers available for more than one response) suggests the concurrent operant approach is an important preparation (Myerson & Hale, 1984). Furthermore, it provides a method for evaluating individuals' preference for one reinforcer over another.

2.2 *Matching Law*

Strict matching law (Baum, 1974; Herrnstein, 1961, 1970) asserts that "an individual will distribute his or her behavior between alternatives in the same ratio that reinforcements have been obtained for these alternatives" (Myerson & Hale, 1984, p. 367). In other words, if two alternatives are concurrently available, and an individual has received five times as many reinforcers for the first alternative than for the second alternative, the individual will perform

alternative one five times as often. This finding has been demonstrated with both humans (e.g., Mace, McCurdy, & Quigley, 1990; Pierce & Epling, 1983) and other animals (e.g., Dunham & Grantmyre, 1982) across a variety of response measures (e.g., lever pressing, key pecking, running speed, and response latency) and reinforcers (e.g., food, water, brain stimulation, money; Davison & McCarthy, 1988; de Villiers, 1977; Plaud, 1992).

Considerable research has confirmed the basic tenet of the matching law since Herrnstein's (1961) seminal study. In his study, Herrnstein demonstrated that when two independent variable-interval (VI) schedules controlled the availability of reinforcers for concurrent responses (i.e., pecking on two different keys) there was a matching relation between relative response rates and reinforcement. Furthermore, when the rate of reinforcement was systematically varied between the two keys, relative rates of responding continued to match relative rates of reinforcement (de Villiers, 1977). Numerous experimental analyses of the matching law have demonstrated these effects.

In an experiment by McSweeney (1975), pigeons' treadle presses were evaluated on concurrent VI schedules. Reinforcement for one alternative remained consistent at 30 food presentations per hr and reinforcement for the second alternative ranged from 15 to 120 per hr. Results indicated rates of responding closely matched the relative rate of reinforcement (i.e., food delivery) provided in each component of the schedule for both alternatives. Baum (1972) reinforced pigeons' key pecking on two keys each associated with the delivery of

food on separate VI schedules. Results indicated the pigeons' proportion of key pecks on each key closely matched the proportion of food received from that key. Nevin (1969) also used a two-key concurrent operant procedure and found that the proportion of responses made by pigeons matched the proportion of reinforcers delivered. Pliskoff and Brown (1970) evaluated relative response rate and relative time across three concurrent VI schedules with pigeons. Results indicated that relative response rate and relative time matched relative reinforcement rate, with time matching somewhat better than response rate. Similarly, Stubbs, and Pliskoff (1969) also found matching for both relative response rate and relative time for three pigeons. Hollard and Davison (1971) exposed three pigeons to a two-key concurrent VI schedule that provided different reinforcers for each alternative. Key 1 was associated with food as the reinforcer and key 2 was associated with ectostriatal brain stimulation as the reinforcer. Results indicated matching between behavior and rate and type of reinforcement. In summary, these selected studies illustrate the reliability of the matching law as a general phenomenon that exists in the lab environment and demonstrate the consistency with which relative rates of responding closely match relative rates of reinforcement.

Several replications with human participants have demonstrated the generality of the strict matching equation (e.g., Bradshaw, Ruddle, & Szabadi, 1981; Bradshaw, Szabadi, & Bevan, 1976; Buskist & Miller, 1981; McDowell, 1988). In one of the earliest investigations, Schroeder and Holland (1969)

evaluated human performance on a vigilance task using a concurrent VI schedule. Participants were told to monitor the display of four dials and report any movement of the pointers within each dial by pressing the appropriate button. Detection of pointer deflections was the reinforcer. The two dials on the participants' left were scheduled by one VI timer, and the two dials to the participants' right were scheduled by a second, independent, concurrently operating VI timer. The participants' eye movements were recorded by a special camera and served as the measure of vigilance. Results indicated humans closely matched relative eye-movement rates to relative rates of reinforcement. Baum (1975) conducted a similar study in which participants played a game of detecting and destroying enemy missiles by holding down different buttons (located to the participants left or right) associated with red or green missiles. Results indicated matching of time spent holding down buttons and reinforcement rate. Conger and Killeen (1974) evaluated human performance during small group discussions in which each group comprised one participant and three confederates. Two confederates reinforced the participants' verbal behavior with brief social praise and the third confederate did not reinforce talking. While there was some variability in the data, overall results indicated matching of talking to relative rates of reinforcement.

Recently, Borrero and Vollmer (2002) applied the matching law to the problem behavior of four children diagnosed with developmental disabilities. Descriptive assessments were conducted with each participant in the natural

environment in order to identify putative reinforcers. The results of the descriptive assessment were then compared to a previously conducted functional analysis using the matching equation. Results indicated that, in all cases, retrospective analysis of the descriptive data indicated a close match between rate of problem behavior and relative rate of reinforcement. The aforementioned studies therefore further demonstrated the phenomenon of matching not only with humans in lab experiments, but also in natural human environments.

In summary, the results of several experimental analyses with both humans and other animals provide support for the basic tenet of the matching theory. However, it is important to point out that there has been some disagreement (e.g., Horne & Lowe, 1993; Myers & Myers, 1977; Wearden & Burgess, 1982) about how well the matching theory describes the relation between reinforcement and allocation of behavior (for a discussion of these issues, see Baum, 1974, 1979). Nonetheless, the concurrent operant model and the matching law have enabled us to better understand and describe operant choice behavior (e.g., Baum & Rachlin, 1969; Davison & McCarthy, 1988; Neef, Mace, Shea, & Shade, 1992; Nevin, 1998; Rachlin, 1989) and make predictions about response allocation across concurrent schedules of reinforcement. The ability to make predictions about the distribution of response alternatives has provided important therapeutic applications for individuals who engage in multiple topographies of problem behavior (e.g., aggression, noncompliance,

self-stimulatory behavior). Concurrent schedules of reinforcement and the matching law suggest that increasing the rate of reinforcement for a concurrently available response alternative should result in a decrease in the frequency of the target behaviors and an increase in the alternative response (McDowell, 1988).

2.3 Response Classes and Response Covariation

The concurrent operant paradigm has provided a framework within which response classes can be analyzed and effectively treated (Lalli, Mace, Wohn, & Livezey, 1995; Shukla-Mehta & Albin, 2002). A functional response class is defined as a collection of responses, all of which produce the same outcome (Catania, 1998). The matching law suggests that the relative rate of each response within a response class may be due to the relative rate of reinforcement produced by each response. Each member of a class produces similar effects on the environment (Catania, 1998; Cooper, Heron, & Heward, 1987), however reinforcement may strengthen responses that are topographically similar to or different from the response reinforced (Skinner, 1969). This interdependency among responses has also been referred to as response covariation (Parrish, Cataldo, Kolko, Neef, & Engel, 1986; Sprague & Horner, 1999) and may be influenced by the same variables that affect relations among topographically different members of a response class. In other words, variables such as physical effort, delay, and schedules of reinforcement may

influence the competition between two or more members of a functional response class.

In an early demonstration of response covariation, Parrish et al. (1986) demonstrated an inverse relation between appropriate (e.g., compliance with requests) and inappropriate (e.g., aggression, disruption, property destruction, pica) behavior with four children diagnosed with mild to moderate mental retardation. For one participant, periods of social negative attention (e.g., social disapproval) were alternated with reinforcement for compliance. Results indicated an increase in appropriate behavior and decrease in inappropriate behavior when compliance was reinforced and noncompliance was placed on extinction. This inverse relation was further demonstrated across additional extinction, social disapproval, and differential reinforcement sessions.

The relation between different members of a response class was also demonstrated in a study by Horner and Day (1991). The authors demonstrated how the efficiency of a response was influenced by three variables: 1) physical effort, 2) the schedule of reinforcement, and 3) the delay to reinforcement. Each variable was evaluated within the context of functional equivalence training. Functional equivalence training is a common intervention used to reduce or eliminate problem behaviors by teaching an appropriate response that serves the same function (i.e., is a member of the same response class) as the problem behavior and placing the problem behavior on extinction. Three individuals who engaged in various types of aggression (e.g., hitting, kicking, scratching others)

and self-injurious behaviors (e.g., face hits and head hitting) participated in the study. In the first study, physical effort was manipulated to evaluate the use of two functionally equivalent behaviors. Following a functional analysis that demonstrated that the participant's aggression was maintained by escape, the participant was taught to sign a functionally equivalent alternative (i.e., "I want to go, please"). Following sentence-sign training, the participant was presented with a difficult task and could escape only by signing the sentence "I want to go, please." or by aggression. Results indicated that the participant continued to engage in aggression. Next, the participant was taught to sign the word "break." Following word-sign training, the participant was again presented with a difficult task and could escape only after aggression, signing "break," or signing "I want to go, please." Results indicated an immediate decrease in aggression and increase in the use of the sign "break." Similar procedures were used to evaluate the effects of different schedules of reinforcement and different delays to reinforcement on functionally equivalent alternative behaviors. In all cases, training in a functionally equivalent alternative behavior resulted in significant decreases in the target behaviors only when the functional alternative was more efficient (i.e., fixed-ratio 1 vs. fixed-ratio 3 reinforcement schedule, 1-s vs. 20-s delay to reinforcement, low vs. high effort).

Shukla and Albin (1996) also demonstrated co-variation among problem behaviors with a nonverbal 19-year-old male with severe to profound mental retardation. The target behaviors included both less severe (e.g., walking away

from the task area, pushing or putting away task materials) and more severe (e.g., throwing and pounding objects, self-injury, or hitting and kicking others) topographies of problem behaviors. Following a functional analysis in which it was demonstrated that the participant's problem behavior was maintained by escape from demands, the effects of extinction applied only to less severe problem behaviors was compared to continuous reinforcement for all forms of problem behavior. Results indicated an increase in more severe forms of problem behaviors when less severe forms were placed on extinction and a decrease in more severe forms of problem behaviors when all forms of problem behavior were reinforced. In a similar study, Sprague and Horner (1992) examined the effects of two treatments designed to reduce several topographies of problem behaviors in three participants. Results indicated that when one member of the response class was blocked, commensurate increases were observed in the other topographies of problem behavior. Following training in a functionally equivalent response for one participant, reductions in all problem behaviors were observed.

The demonstrations of inverse relations between different topographies of appropriate and inappropriate behavior have important implications for treating individuals who engage in multiple forms of problem behavior. Individuals who engage in disruptive behaviors sometimes have more than one problematic behavior and a limited number of appropriate behaviors. In situations where multiple topographies of problem behaviors escalate or become more intense,

practitioners, teachers, and caregivers are taught to prevent problem behaviors or intervene early to avoid highly problematic or severe disruptive behaviors (Albin, O'Brien, & Horner, 1995; Smith & Churchill, 2002). Success in training a functionally equivalent alternative will depend on the relations that exist between members of the response class. Reinforcing milder topographies of problem behavior may result in reducing other, more severe topographies and treating only a single member of a response class may result in escalating problem behaviors. For example, consider a child who engages in mild aggression, screaming, and self-injury when presented with a difficult academic task. If aggression and screaming function to successfully escape the academic demand, the child will continue to aggress and scream. However, if attempts are made to decrease aggression and screaming (e.g., escape extinction) the child's problem behavior may then escalate to a more severe form of disruptive behavior such as self-injury. If self-injury then functioned to escape the demand situation, the child would continue to injure himself as long as aggression and screaming were extinguished.

2.4 Response-Class Hierarchies

The aforementioned studies described several experimental analyses in which a collection of responses all produced the same outcome (i.e., a response class). The relative rate of each response within the response class depended on the contingency in effect. In other words, reinforcing one topography of problem

behavior resulted in a commensurate decrease in a second topography. Sometimes, members of the response class occurred in a predictable order, where more effortful responses (e.g., self-injury, hitting) occurred only after less effortful responses (e.g., walking away from task area) were placed on extinction. When members of a response class occur in 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 response class may be hierarchically related and ordered along various dimensions. Response effort, rate of reinforcement, immediacy of reinforcement, and the probability of punishment are all dimensions along which members of a response class may be related (Baer, 1982; Halle & Drasgow, 2003; Mace, 1994). Changes in the frequency of one member of a response class can also affect the frequency of other members of the same response class (i.e., response covariation).

In 1995, Lalli et al. reported the first experimental demonstration of a response-class hierarchy in a clinical situation. A 15-year-old female with diagnoses of mild mental retardation and autism participated in the study. She was admitted to the inpatient unit of a hospital for the treatment of 1) self-injurious mouthing (i.e., inserting any part of her hand into her mouth), 2) aggression (i.e., slapping, punching, or kicking others), and 3) screams. The primary dependent measure across all phases of the study was response latency. The authors first showed that screaming, aggression, and self-injury were all maintained by escape from demands. Following the functional analysis,

a multielement design was used to evaluate the effects of extinction, contingent escape, and functional equivalence training on the covariation of response-class members.

Across all conditions, escape was made contingent upon the occurrence of one topography of the problem behavior while the other two topographies were placed on extinction. In the first condition, escape was dependent upon the occurrence of self-injury. Based on informal observations, the authors predicted that all three topographies of the problem behavior would occur in a predictable sequence (screams → aggression → 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 out of 16 trials. In the second condition, escape was dependent upon aggression. Results indicated a sequence of responses from screams to aggression in 27 out of 35 trials. In the final condition, escape was dependent upon screams. Results indicated the occurrence of only screams in 19 out of 21 trials. In summary, the authors were able to demonstrate that when screaming was reinforced, the other behaviors were less likely to occur and when screaming was extinguished, the other behaviors were more likely to occur in a predictable, hierarchical order.

Although different reinforcement histories may have influenced the allocation of responses, the authors hypothesized that response effort was the primary dimension along which members of the hierarchy were related. In other

words, screaming was less effortful than aggression, which in turn was less effortful than self-injury. The authors eventually taught the participant a functionally equivalent response (i.e., "No") as treatment for the problematic hierarchy. Results indicated that when escape was dependent upon the occurrence of this functional alternative and all three topographies of problem behavior were placed on extinction, the functional response was used in 28 out of 36 trials. The aforementioned method of (a) first identifying the function of behaviors in a putative hierarchy, (b) placing one of the behaviors on extinction, and (c) observing increases (or the probability of occurrence) in the other behaviors has been replicated in several recent investigations (e.g., Harding, Wacker, Berg, Barretto, Winborn, & Gardner, 2001; Kennedy, Meyer, Knowles, & Shukla, 2000; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999; Shukla-Mehta & Albin, 2003).

Richman et al. (1999) evaluated placing one of the behaviors in a putative hierarchy on extinction in order to clarify the results of an undifferentiated experimental functional analysis in which the primary target behavior did not occur. First, functional analyses were conducted with three children with varying degrees of development disabilities. Target behaviors included multiple topographies of problem behavior such as screams, grabbing, hitting, and kicking. Results of the functional analyses were inconclusive because of the low occurrence of the more severe topography when reinforcers were delivered for all topographies of problem behavior. In other words, reinforcing milder

topographies of problem behavior resulted in lower rates of other, more severe topographies. A second analysis was then conducted in which milder forms of problem behavior were placed on extinction and only more severe forms of problem behaviors were reinforced. Results of the extinction analyses indicated a hierarchical sequence of problem behavior in which milder forms of problem behavior occurred prior to more severe topographies for 2 of 3 participants.

Similar extinction analyses were recently reported by Magee and Ellis (2000) and Shukla-Mehta and Albin (2003) in which less severe problem behaviors were placed on extinction and resulted in slight increases in more severe problem behaviors. In the Richman et al. and Shukla-Mehta and Albin studies, the authors hypothesized that the response effort associated with each member of the response class was the primary dimension along which participants progressed through the response-class hierarchy. In the Richman et al. study, effortful topographies of problem behavior (e.g., aggression) occurred more often when milder and less effortful topographies (e.g., screams, grabbing) were placed on extinction. Similarly, in the Shukla-Mehta and Albin study, more severe topographies of problem behavior (e.g., screaming, pushing, grabbing, and self-injury) occurred more often when less severe topographies (e.g., whining and shaking) were placed on extinction. Although Magee and Ellis did not hypothesize that response effort was a dimension along which the response-class hierarchy was related, results of their study indicated patterns

similar to the results reported in both the Richman et al. and the Shukla-Mehta and Albin studies.

In a study by Smith and Churchill (2002), an experimental functional analysis was used to compare the occurrence of precursor behaviors to more severe topographies of problem behaviors in four participants with developmental disabilities. The purpose of the investigation was to evaluate a method for identifying putative reinforcers for behaviors that may not be allowed to occur (e.g., life-threatening self-injury or aggression) by conducting an assessment of behaviors that occur prior to severe topographies of problem behavior (i.e., precursor behaviors). The authors compared rates of severe problem behaviors (e.g., head banging, body hitting, knee banging, aggression) with rates of precursor behaviors that reliably occurred (e.g., within 10 s) prior to the occurrence of the more severe topographies. Precursor behaviors included screaming, grabbing, falling, vocalizations, crying, reaching, and foot stomping. Results of the functional analyses for severe problem behaviors and precursor behaviors indicated a common maintaining contingency. In other words, when self-injury was demonstrated to be maintained by escape, precursor behaviors for self-injury were also found to be maintained by escape. 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 behaviors 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.

Harding et al. (2001) conducted an experimental investigation in which different topographies of problem behavior were reinforced and placed on extinction as a method for evaluating response-class hierarchies. The combination of a multielement and withdrawal design was used to evaluate reinforcement and extinction conditions. During reinforcement, both mild (e.g., tantrums and task refusal) and severe (e.g., self-injury, aggression, or property destruction) forms of problem behavior were reinforced. During extinction, only severe forms of problem behavior were reinforced. Results indicated increases in more severe forms of problem behaviors for both participants only when milder forms of problem behavior were placed on extinction. In other words, severe forms of problem behaviors occurred predominately during conditions when less severe forms of problem behavior were placed on extinction and returned to near-zero levels when less severe forms of problem behaviors were reinforced. These results suggest that the problem behaviors were hierarchically ordered because contingencies applied to a milder topography of the problem behavior reduced the likelihood of more severe topographies.

Although the authors did not hypothesize about the variables responsible for each participant's progression from mild to more severe forms of problem behavior, it is plausible that response effort was the primary dimension along which members of the response class were related because more effortful responses did not occur until less effortful responses were placed on extinction.

In a study by Albin et al. (1995), a 21-year-old woman diagnosed with severe mental retardation was treated for a variety of problem behaviors that commonly occurred during instruction. Interviews with teachers and classroom staff suggested that the behaviors were members of a functional response class. The results of a functional assessment suggested the problem behaviors were maintained by escape from instructional demands. The intervention consisted of alternating between instructional sessions with and without rule statements (e.g., "Remember, you need to do your work without whining", "No hitting") in an ABAB withdrawal design. Results indicated a reliable increase in problem behaviors during instructional sessions when teachers used rule statements compared to instructional sessions in which no rule statements were given; that is, rule statements appeared to establish escape as a negative reinforcer. Further analysis of the rule-statement sessions indicated a temporal pattern of problem behavior. More specifically, the whine/shake response occurred first in 14 out of 15 trials and the occurrence of the whine/shake response was correlated with an increase in subsequent problem behaviors, specifically pushing/hitting, screaming, and crying. Although an extinction analysis was not completed to

verify the progression through fixed sequences of behavior, the authors' hypothesized that the participant's behavioral sequence consisted of a response-class hierarchy that began with a whine/shake response and escalated to pushing/hitting and screams. The authors' further hypothesized that this progression was related to response effort since subsequent behaviors in the sequence (e.g., pushing/hitting) were more effortful than earlier topographies of problem behavior (e.g., whine/shake).

In a recent study by Sevin, Gulotta, Sierp, Rosica, and Miller (2002), multiple topographies of food refusal were treated by sequentially introducing and removing various treatment components in an ABAB withdrawal design. During baseline, the participant engaged in a high frequency of disruptive behaviors, accepted a very small amount of food, and did not engage in expulsion or packing (i.e., retaining food in the mouth) of food. Following treatment for acceptance and disruption using nonremoval of the spoon (Ahearn, Kerwin, Eicher, Shantz, & Swearingin, 1996) and extinction, disruptive behaviors decreased and acceptance increased. Interestingly, previously low levels of expulsion also increased. When expulsion was then treated by re-presenting the expelled food, expulsion also decreased (disruptive behavior remained low and acceptance continued). However, previously low levels of packing increased. When packing was then treated by redistributing food from the participant's cheek to her tongue, packing also decreased (disruptive behavior and expulsion remained low and acceptance continued). The authors

conceptualized the multiple topographies of food refusal as response covariation. In other words, food acceptance and disruptive behavior were associated with increases in other topographies of problem behavior, specifically expulsion and packing. However, given the progression of the food refusal from disruption, to expulsion, to packing; it is plausible that the multiple topographies of food refusal were actually a response-class hierarchy. Effortful topographies of food refusal (e.g., packing) occurred more often only when less effortful topographies (e.g., disruption and expulsion) were placed on extinction. Furthermore, the members of the response class occurred in a predictable order. In other words, expulsion and packing never occurred when disruptions functioned to escape food. However, when disruption was placed on extinction, expulsion increased and packing rarely occurred. Finally, when disruption and expulsion were placed on extinction, packing increased.

In summary, results of the aforementioned studies suggest that functionally equivalent problem behaviors can be hierarchically organized. The existence of these response-class hierarchies highlights the need for a better understanding of the hierarchy in terms of its relevance for clinical application because of the way treatments are typically implemented. 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., 2002). The limited response-class hierarchy literature indicates that eliminating only one of

the members from a response class might lead to the emergence of others, especially if the reinforcer is otherwise unavailable (e.g., with operant extinction). Given the ubiquity of treating single behaviors and the potential response-response relations identified in the hierarchy literature, additional research is warranted on this topic. Unfortunately, research on the identification and modification of response-class hierarchies proves difficult for at least two reasons. First, identification of a hierarchy requires the experimental demonstration of the function of each behavior in the class (e.g., Kennedy et al. 2000; Shukla-Mehta & Albin, 2003) as well as a subsequent extinction analysis (Lalli et al., 1995); this can be effort prohibitive in some cases and potentially unethical in others because participants who engage in problem behaviors often require immediate treatment. Second, it is difficult to identify individuals whose problem behaviors are sequentially linked because, by definition, not all of the behaviors in the hierarchy will be reliably displayed. 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 importantly, how they should be treated.

2.5 Purpose of the Current Study

Given the potential importance of studying response-class hierarchies and the difficulties associated with such efforts, the purpose of the current study was to develop a basic-research model of a response-class hierarchy. The goal was to

begin a line of research to examine, using the model, different variables (e.g., response effort, immediacy of reinforcement) that determine the order in which behaviors occur and various ways of modifying or treating the hierarchy. The development of the model occurred in this preliminary investigation. First, participants were taught three behaviors in an attempt to develop a response class (Study 1). Each behavior in the response class required a differential amount of effort to perform. Following the development of a response class, less effortful responses were placed on extinction in an attempt to determine whether responses were hierarchically related (Study 2). Response latency was used to determine whether participants progressed through a fixed sequence of behavior, from less to more effortful responses in the response class. 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.

Chapter 3

Method

3.1 Participants and Setting

Participants were 3 females (Dora, Gwen, and Hillary) with no known developmental or language delays and 2 males (James and Rick) diagnosed with developmental disabilities. Dora (4-years old), Gwen (3-years old), and Hillary (3-years old) were recruited from a local childcare center that gave permission for the study to be conducted in their facility. Informed consent was obtained from the children's parents prior to the initiation of the study. One additional child from the childcare center entered the study but did not progress beyond baseline due to continued high rates of responding over the course of several baseline sessions.

James (12-years old) and Rick (14-years old) were recruited from a day-treatment program where they were undergoing assessment and treatment of problem behavior. Informed consent was obtained from each child's parent prior to the initiation of the study. James had been diagnosed with autism, severe intellectual disability, and speech impairment. He was referred to the outpatient program for the assessment and treatment of aggression, property destruction, noncompliance, self-injurious behavior, and spitting. James communicated verbally and initiated some social interaction; however, the majority of his

language consisted of repetitive phrases and words. Rick had been diagnosed with mental retardation and autism and was referred to the outpatient clinic for the assessment and treatment of noncompliance and tantrums. Rick could follow simple instructions (e.g., sit down, touch your nose); however, he had no vocal speech and communicated through a few idiosyncratic manual signs. Rick also engaged in high rates of stereotypy such as hand-flapping, finger twirling, squinting, and rocking.

Experimental sessions for Dora, Gwen, and Hillary were conducted in an open, partitioned area of their classroom. A small number of children were typically present and engaged in regular classroom activities while sessions were conducted. Sessions for James and Rick were conducted in padded treatment rooms (3 m by 3 m). During all sessions of Study 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 1-2 times per day, 3 to 5 days per week. During all sessions of Study 2, a participant and two experimenters were present. Each session lasted between 15 to 30 min and was conducted over the course of 2 to 3 days.

3.2 *Materials*

The experimental manipulandum consisted of three differently colored 12.5 cm plastic buttons attached to a wooden response panel (75 cm x 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 participants. The pressure required to activate the buttons was adjustable from 200-1500 grams, 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 participants. Throughout the rest of the manuscript, 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 participants. This button will henceforth 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 participants. This button will henceforth be referred to as the high effort (HE) button. The buttons were connected to a laptop computer via a USB interface that converted button presses into key presses or mouse clicks and allowed button presses to be recorded for the purposes of data collection. Equipment checks were conducted prior to each session in order to ensure proper functioning and recording of button presses.

3.3 Pre-experimental Procedures

3.3.1 Parent Preference Assessment

Parents (or 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 prefer 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 back-up reinforcers for tokens (i.e., pennies dropped into a bucket) earned during sessions. For James and Rick this information was used to conduct stimulus preference assessments.

3.3.2 Stimulus Preference Assessment

James and Rick were asked to choose from an array of foods or toys using procedures similar to those described by DeLeon and Iwata (1996). Prior to the beginning of the study, the experimenter placed separate arrays of eight foods or eight toys on a table in front of each participant. Next, participants were instructed to select one food or one toy (e.g., "Pick one" or "What do you want?"). After an item was selected, the participant was given enough time to consume the edible item or play with the toy (i.e., approximately 10 s). The chosen item was then removed from subsequent trials and the remaining items were repositioned in a quasi-randomized order. This procedure was continued until all items were selected. If a participant failed to respond, the instruction was repeated. If there was still no response, the items were rearranged and a new trial was presented. Attempts to reach for more than one item were blocked. If the participant picked two items simultaneously, both items were placed back in the array and the instruction was repeated. Three arrays of foods and toys were presented for each participant. Selection percentages were calculated by dividing the number of times an item was chosen by the number of

trials in which it was available across all arrays. These percentages were ranked from highest to lowest and the most highly preferred food or toy were used as reinforcers throughout the study. Skittles® were used for James and an electronic massager was used for Rick.

3.3.3 Button Training

In order to prevent adventitious reinforcement of button pressing chains, participants were trained to perform an orienting response prior to pressing buttons on the response panel. The orienting response consisted of pressing a green button located immediately in front of each participant. This button was not attached to the response panel. Participants were taught to press this button before pressing a button on the response panel. This introduced a delay between a response on one button and reinforcement for another button. This functioned similarly to a changeover delay in an operant chamber. Button pressing was modeled by the experimenter before each button training session and each participant practiced pressing the orienting button (i.e., green or “go” button) between button presses on the response panel until participants met a criterion of 100% correct button presses in 3 consecutive training sessions, each consisting of 3 trials. All participants passed button training.

3.4 *Measurement*

3.4.1 *Direct Measurement of Behavior*

Data were recorded using the Behavioral Evaluation Strategy & Taxonomy (BEST[®]) software application, which allowed for real-time, automated recording of data via several input devices (e.g., keyboard, external switches, buttons). The software application allowed for data collection and within-session analyses of several dimensions of behavior, including frequency and latency of events.

3.5 *Study 1: Development of a Response Class*

The demonstration and modification of the hierarchy began with the development of a response class.

3.5.1 *Dependent Variables and Data Collection*

Responses per min (RPM) of button pressing were measured by connecting the buttons to a laptop computer via a USB interface that converted button presses into key presses or mouse clicks. The BEST[®] software application recorded each button press as a single occurrence. Prior to each session, equipment checks were conducted in order to verify that button presses were accurately recorded by the software application.

Pressing the buttons necessarily resulted in the same reinforcer, although pressing each button required differential effort to perform. Participants were presented with a series of conditions in which all three buttons were present; however, only one of the three buttons was available for reinforcement. For

example, during the first condition only the LE button was available for reinforcement; however, ME and HE buttons were not. Following reinforcement of the LE button, the ME button was available for reinforcement; however, the LE and HE buttons were not. Reinforcement was then provided for pressing the HE button. These initial training conditions were used to evaluate the development of a response class that had topographically similar members (i.e., button presses) and produced a common effect on the environment.

3.5.2 Experimental Design and Procedures

The experimental design incorporated features from the withdrawal (A-B-C-D-E-F-E) and concurrent-schedule designs (Poling, LeSage, & Methot, 1995). The order of the study's 7 sequential experimental phases was counterbalanced across participants. The stability criterion for phase changes was a minimum of three consecutive data points showing visual stability.

During all phases, the experimenter read the following instructions to participants 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 were answered by repeating phrases from the spoken instructions. If participants failed to press the orienting button during the session, they were reminded to press the orienting button before pressing buttons on the response panel. If participants moved or walked away from the buttons at any time during the session and returned before 10 s had elapsed, the session was continued. If participants moved or walked away from the

buttons *before* half of the session time (i.e., 2.5 min) had elapsed and they remained away from the buttons for at least 10 s, the session was terminated. If participants moved or walked away from the buttons *after* half of the session time had elapsed and they remained away from the buttons for at least 10 s, the session ended, however, data from the session were still included. Overall, fewer than 5 total sessions were terminated after participants moved away from the response panel.

3.5.2.1 *Baseline*

During this phase, all three buttons were simultaneously present. Pressing any of the buttons resulted in no programmed consequences. The purpose of this condition was to evaluate the participants' performance in the presence of the buttons to determine if there had been any previous experience or history with buttons and button pressing (e.g., with other toys or games). This phase also served as a screen to identify whether participant rates of button pressing decreased in the absence of programmed consequences. If participants continued to press the buttons in the absence of direct reinforcement, they were excused from the study. This occurred with only one participant who did not progress past baseline.

The following three phases were designed to develop button pressing as a response class. Participants received brief access to previously identified foods (James), toys (Rick), or tokens (Dora, Gwen, Hillary) for pressing specific buttons. James received approximately 5 s to consume edible reinforcers and

Rick was given between 3 to 5 s to play with his massager. Tokens that Dora, Gwen, and Hillary earned were exchanged for a variety of reinforcers (e.g., crayons, toy jewelry, stickers) at the end of each session.

Prior to the initiation of each of the following three phases, a total of three forced-choice training trials were implemented in order for participants to contact the contingency soon to be in effect. Participants were prompted to press each button three times; however, reinforcers were delivered only for the button that resulted in programmed consequences in the subsequent phase. In addition, three additional training trials were prompted on the target button. All forced-choice training trials were conducted in this manner.

3.5.2.2 *Reinforcement for LE button (FR1 LE)*

During this phase, all three buttons were present; however, only presses on the LE button resulted in programmed consequences.

3.5.2.3 *Reinforcement for ME button (FR1 ME)*

During this phase, all three buttons were present; however, only presses on the ME button resulted in programmed consequences.

3.5.2.4 *Reinforcement for HE button (FR1 HE)*

During this phase, all three buttons were present; however, only button presses on the HE button resulted in programmed consequences.

3.5.2.5 *Class demonstration (FR1 all)*

During this phase, all three buttons were present and 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., responding primarily on the button that required the least amount of effort and no responding on the button that required the most effort).

3.5.2.6 *Class modification (FR1 ME & HE; EXT LE)*

After the response class was established, the LE response was placed on extinction and the rates of the other responses were closely observed. Access to preferred items or tokens was only provided every time the ME or HE buttons were pressed. If responses on the ME and HE buttons occurred at higher rates, the response class was successfully modified. Following modification of the response class, the class demonstration phase was replicated.

3.6 *Study 2: Test Trials for Hierarchical Structure*

Following demonstration and modification of the response class in Study 1, additional demonstrations of the response class and an original demonstration of the hierarchy was evaluated. 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. Specifically, participants were presented with a series of trials in which all three buttons were present; however, one of the three buttons was placed on extinction. For example, during the first several trials the ME and HE

buttons were available for reinforcement, however, the LE button was not. During subsequent trials, the LE and HE buttons were available for reinforcement; however, the ME button was not. The purpose of this evaluation was to determine whether participants progressed through fixed sequences of behavior as predicted by hierarchy theory.

3.6.1 Dependent Variables and Data Collection

Target behaviors and equipment for Study 2 were the same as in Study 1. Data were collected across trials in which latency (in seconds) to the first occurrence of each button press was measured. The purpose of this measurement was to determine the ordinal temporal relation between individual topographies within the response class (Lalli et al., 1995). Button presses were previously differentiated into three categories that required varying amounts of pressure to activate (Study 1). A measure of latency to the first occurrence of each button press in Study 2 determined which of the three responses occurred earliest when different contingencies were applied to specific buttons. Response latency was recorded by activating a timer on the laptop computer that was connected to the buttons via a USB interface. The timer was activated as soon as the cover over the buttons was lifted (described below). The BEST[®] software application was used to record the latency to button presses.

3.6.2 Interobserver Agreement

Interobserver agreement was calculated for 100% of trials across participants. The order of button presses was recorded by two observers using a data sheet consisting of 3 columns, which were labeled 1st response, 2nd response, and 3rd response. Interobserver agreement was calculated by dividing the number of trial agreements by the number of agreements plus disagreements and multiplying by 100%. The agreement scores for each participant were 99.5% for Dora, 99.4% for Gwen, 100% for Hillary, 96.7% for James, and 90% for Rick.

3.6.3 Experimental Design and Procedures

The experimental design incorporated features from the withdrawal (A-B-A-B-C) and concurrent-schedule designs (Poling et al., 1995). The order of the second study's sequential experimental phases 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 experimenter read the following instructions 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." Following these instructions, the experimenter lifted the cover and started a timer on the laptop computer that was connected to the buttons. The cover was removed for 5 s and then replaced by

the experimenter. Questions about the procedure were ignored or answered by repeating phrases from the spoken instructions.

3.6.3.1 *Reinforcement of ME & HE buttons, extinction LE button (FR1 ME & HE, EXT LE)*

During this phase, all three buttons were present; however, only button presses on the ME and HE buttons resulted in programmed consequences.

3.6.3.2 *Reinforcement of LE & HE buttons, extinction ME button (FR1 LE & HE, EXT ME)*

During this phase, all three buttons were present; however, only presses on the LE and HE buttons resulted in programmed consequences.

3.6.3.3 *Reinforcement of HE button, extinction LE & ME buttons (FR1 HE, EXT LE & ME)*

During this phase, all three buttons were present; however, only presses on the HE button resulted in programmed consequences.

Chapter 4

Results

4.1 Study 1

4.1.1 Dora

Results from Dora's response class development are presented below in Figure

1. During baseline, Dora engaged in low rates of button pressing (LE, $M = 4.5$ RPM; ME, $M = 3.1$ RPM; HE, $M = 1.9$ RPM). Following baseline, response class development for Dora began with an FR1 schedule of reinforcement for the LE button while the ME and HE buttons remained on extinction. Results indicated high rates of LE button pressing ($M = 42.5$ RPM) and low rates of pressing the ME ($M = 6.7$ RPM) and HE ($M = 0.4$ RPM) buttons. During FR1 ME, Dora displayed high rates of ME button pressing ($M = 13.5$ RPM) and low rates of pressing the LE ($M = 3.2$ RPM) and HE ($M = 0.2$ RPM) buttons. During FR1 HE, Dora's rate of button pressing increased on the HE button ($M = 3.4$ RPM) and decreased on the LE ($M = 1.1$ RPM) and ME ($M = 0.6$ RPM) buttons. The next phase (i.e., class demonstration) consisted of an FR1 schedule for all three buttons. Results indicated high rates of LE button pressing ($M = 19.9$ RPM) and low rates of pressing the ME ($M = 0.3$ RPM) and HE ($M = 0.1$ RPM) buttons. These results demonstrated that a functional response class of button pressing

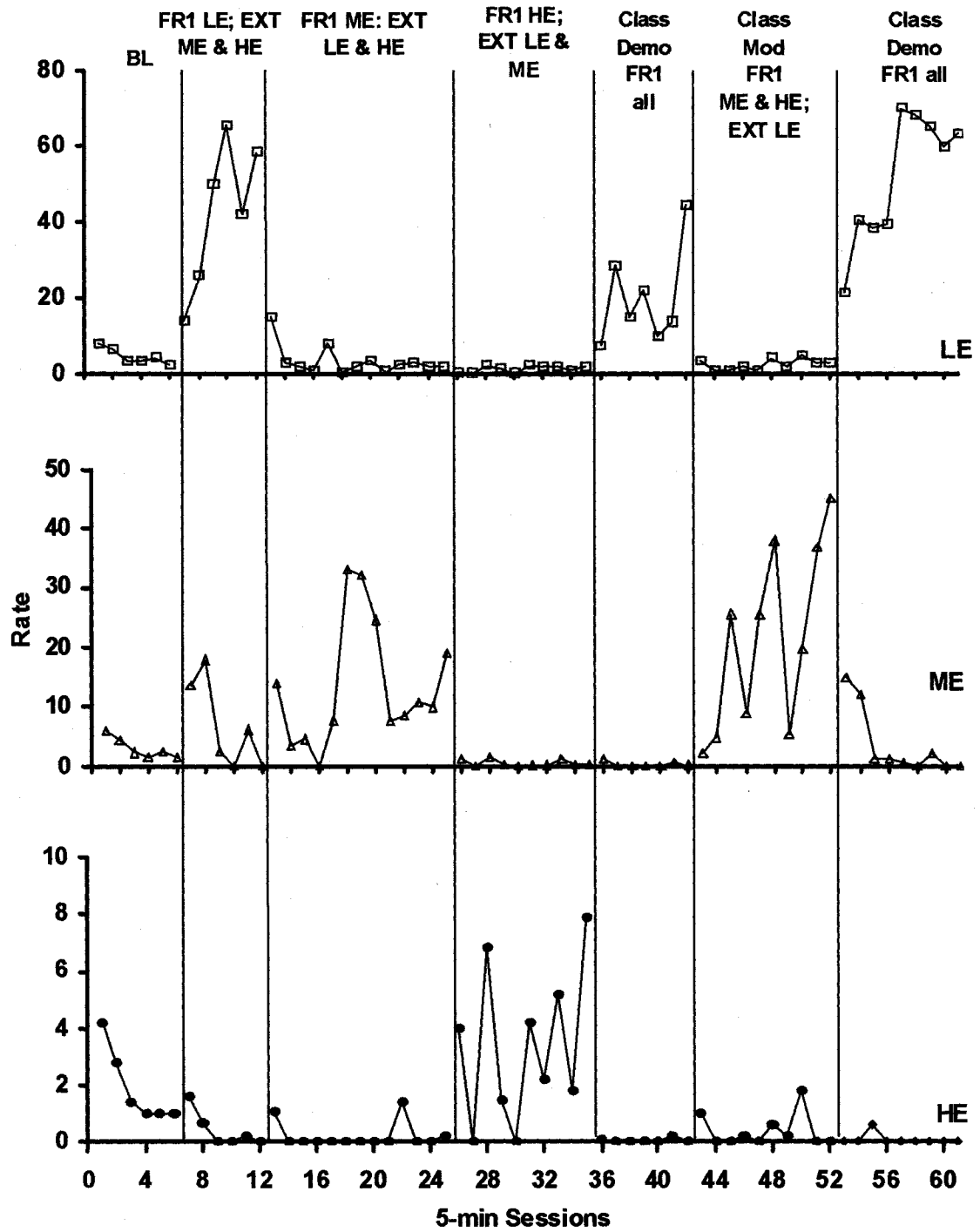


Figure 1. Dora's response class development graph. The LE button is represented in the top panel, the ME button in the middle panel, and the HE button in the bottom panel.

had been established and that there was a relation between response rate and effort for the established response class (i.e., responding primarily on the button that required the least amount of effort and no responding on the button that required the most effort). Responding was then modified such that the ME and HE buttons were available for reinforcement and the LE button was placed on extinction. Results indicated an increase in ME button pressing ($M = 21.3$ RPM), and low rates of pressing the LE ($M = 2.4$ RPM) and HE ($M = 0.4$ RPM) buttons. These results suggested that the response class was successfully modified. Finally, the class demonstration phase was replicated and resulted again in high rates of LE button pressing ($M = 51.8$ RPM) and low rates of pressing the ME ($M = 3.6$ RPM) and HE ($M = 0.1$ RPM) buttons.

4.1.2 Gwen

Results from Gwen's response class development are presented below in Figure 2. During baseline, Gwen engaged in low rates of button pressing (LE, $M = 7.9$ RPM; ME, $M = 4.3$ RPM; HE, $M = 2.3$ RPM). Following baseline, response class development for Gwen began with an FR1 schedule of reinforcement for the ME button while the LE and HE buttons remained on extinction. Results indicated higher rates of ME button pressing ($M = 9.6$ RPM) and lower rates of pressing the LE ($M = 4.8$ RPM) and HE ($M = 1.2$ RPM) buttons. During FR1 LE, Gwen displayed high rates of LE button pressing ($M = 21.4$ RPM) and low rates of pressing the ME ($M = 2.3$ RPM) and HE ($M = 0.5$ RPM) buttons. During FR1

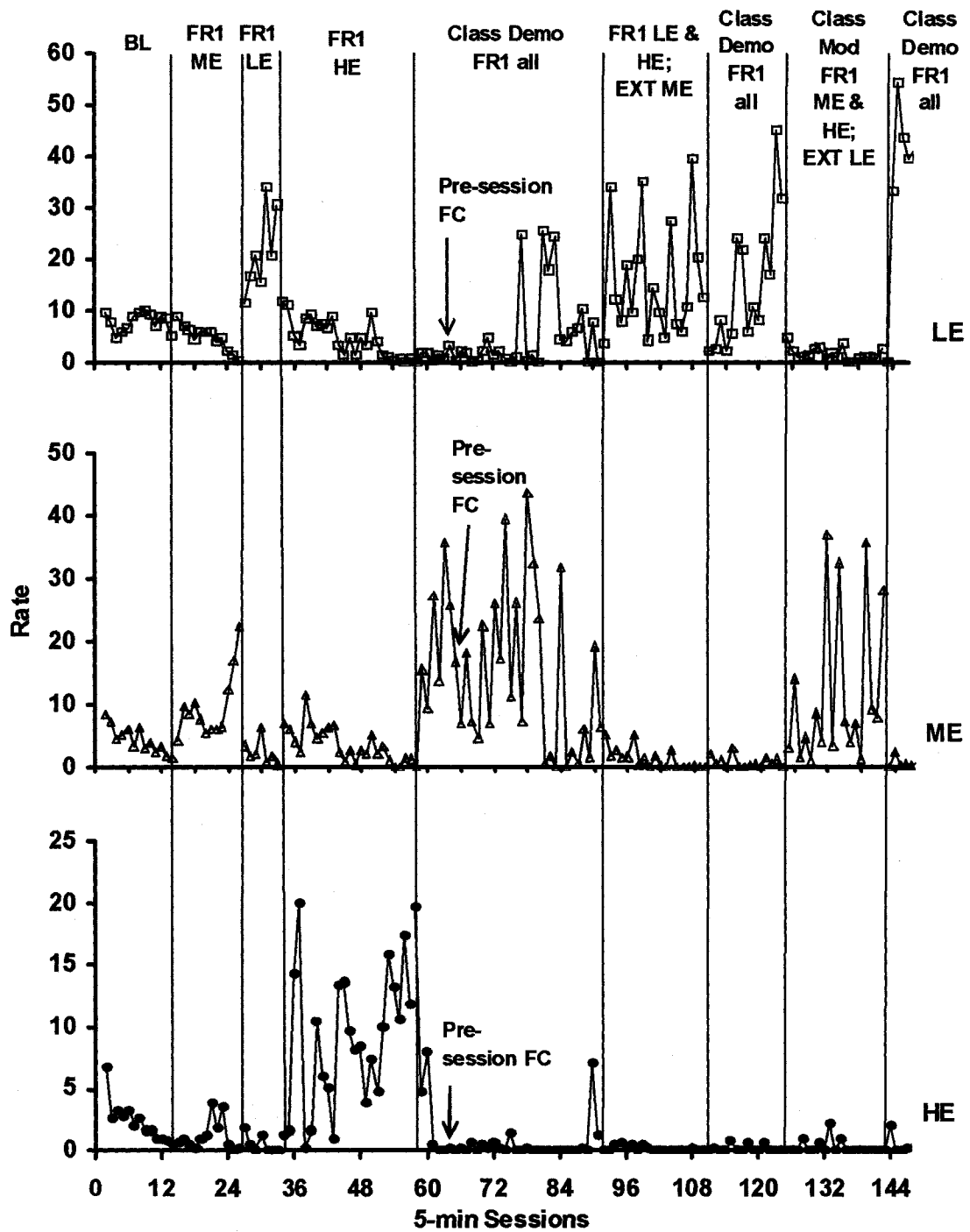


Figure 2. Gwen's response class development graph. The LE button is represented in the top panel, the ME button in the middle panel, and the HE button in the bottom panel. FC = pre-session forced-choice trials.

HE, Gwen's rate of button pressing increased on the HE button ($M = 8.7$ RPM) and decreased on the LE ($M = 4.9$ RPM) and ME ($M = 3.5$ RPM) buttons. During the first class demonstration phase for Gwen, rates of button pressing were highest on the ME button ($M = 14.9$ RPM). Following 7 sessions (i.e., sessions 57-63) in which Gwen continued to press the ME button at high rates, the pre-session forced-choice training trials were re-implemented. However, Gwen continued to press the ME button. As a result, forced-choice training trials were continued for the remainder of the initial class demonstration phase; however, Gwen continued to press the ME button. An adjustment was then made in which the ME button was placed on extinction and the LE and HE buttons remained on an FR1 schedule of reinforcement. Results indicated that Gwen began pressing the LE button ($M = 15.8$ RPM), while ME button pressing decreased ($M = 1.3$ RPM) and HE button pressing remained low ($M = 0.1$ RPM). Following this adjustment, the class demonstration phase was evaluated again and indicated high rates of LE button pressing ($M = 15$ RPM) and low rates of pressing the ME ($M = 0.7$ RPM) and HE ($M = 0.1$ RPM) buttons. These results suggested that a functional response class of button pressing had been established; however it was not clear if physical effort determined which button was pressed. During the class modification phase, the results indicated an increase in pressing the ME button ($M = 11.7$ RPM), and low rates of pressing the LE ($M = 1.7$ RPM) and HE ($M = 0.3$ RPM) buttons. These results suggested that the response class was successfully modified. Finally, the class demonstration phase was replicated a

third time and indicated high rates of LE button pressing ($M = 35.5$ RPM) and low rates of pressing the ME ($M = 0.6$ RPM) and HE ($M = 0.5$ RPM) buttons. The results of this final phase indicated that a functional response class of button pressing had been established and that there perhaps was a relation between response rate and effort for the response class.

4.1.3 *Hillary*

Results from Hillary's response class development are presented below in Figure 3. During baseline, Hillary initially engaged in high rates of button pressing, however, responding gradually decreased to near zero levels. Following baseline, response class development for Hillary began with an FR1 schedule of reinforcement for the HE button while the LE and ME buttons remained on extinction. Results indicated high rates of HE button pressing ($M = 15.3$ RPM) and low rates of button pressing on the LE ($M = 6.2$ RPM) and ME ($M = 5.3$ RPM) buttons. During FR1 LE, Hillary displayed high rates of LE button pressing ($M = 44.2$ RPM) and low rates of button pressing on the ME ($M = 0.4$ RPM) and HE ($M = 0.4$ RPM) buttons. During FR1 ME, Hillary's rate of button pressing increased on the ME button ($M = 24.5$ RPM) and decreased on the LE ($M = 4.9$ RPM) and HE ($M = 0.2$ RPM) buttons. The next phase (i.e., class demonstration) consisted of an FR1 schedule for all three buttons. Results indicated high rates of button pressing on the LE button ($M = 17.2$ RPM) and low rates of pressing the ME ($M = 2.8$ RPM) and HE ($M = 2.1$ RPM) buttons. These results demonstrated that a functional response class of button pressing had

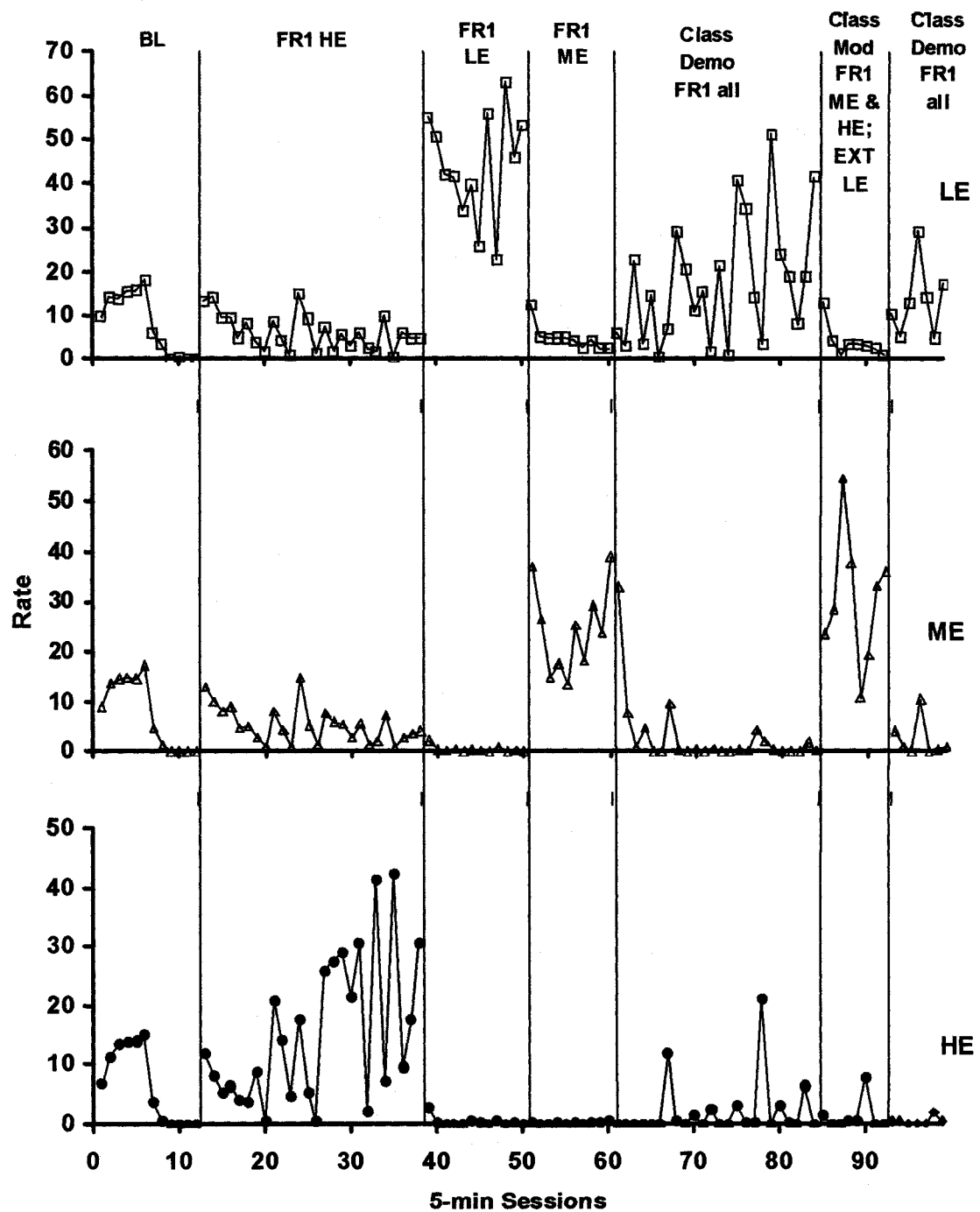


Figure 3. Hillary's response class development graph. The LE button is represented in the top panel, the ME button in the middle panel, and the HE button in the bottom panel.

been established and that there was a relation between response rate and effort for the established response class. Responding was then modified such that the ME and HE buttons were available for reinforcement and the LE button was placed on extinction. Results indicated an increase in ME button pressing ($M = 30.4$ RPM), and low rates of button pressing on the LE ($M = 4.1$ RPM) and HE ($M = 1.3$ RPM) buttons. These results suggested that the response class was successfully modified. Finally, the class demonstration phase was replicated and resulted in high rates of LE button pressing ($M = 13.5$) and low rates of pressing the ME ($M = 2.4$ RPM) and HE ($M = 0.4$ RPM) buttons.

4.1.4 James

Results from James's response class development are presented below in Figure 4. During baseline, James engaged in low rates of button pressing (LE, $M = 1.0$ RPM; ME, $M = 1.6$ RPM; HE, $M = 0.1$ RPM). Following baseline, response class development for James began with an FR1 schedule of reinforcement for the ME button while the LE and HE buttons remained on extinction. Results indicated higher rates of ME button pressing ($M = 5$ RPM) and lower rates of pressing the LE ($M = 0.6$ RPM) and HE ($M = 0.1$ RPM) buttons. During FR1 HE, James displayed high rates of HE button pressing ($M = 13.2$ RPM) and low rates of pressing the ME ($M = 2.9$ RPM) and LE ($M = 1.0$ RPM) buttons. During FR1 LE, James's button pressing increased on the LE button ($M = 18.5$ RPM) and decreased on the ME ($M = 0.4$ RPM) and HE ($M =$

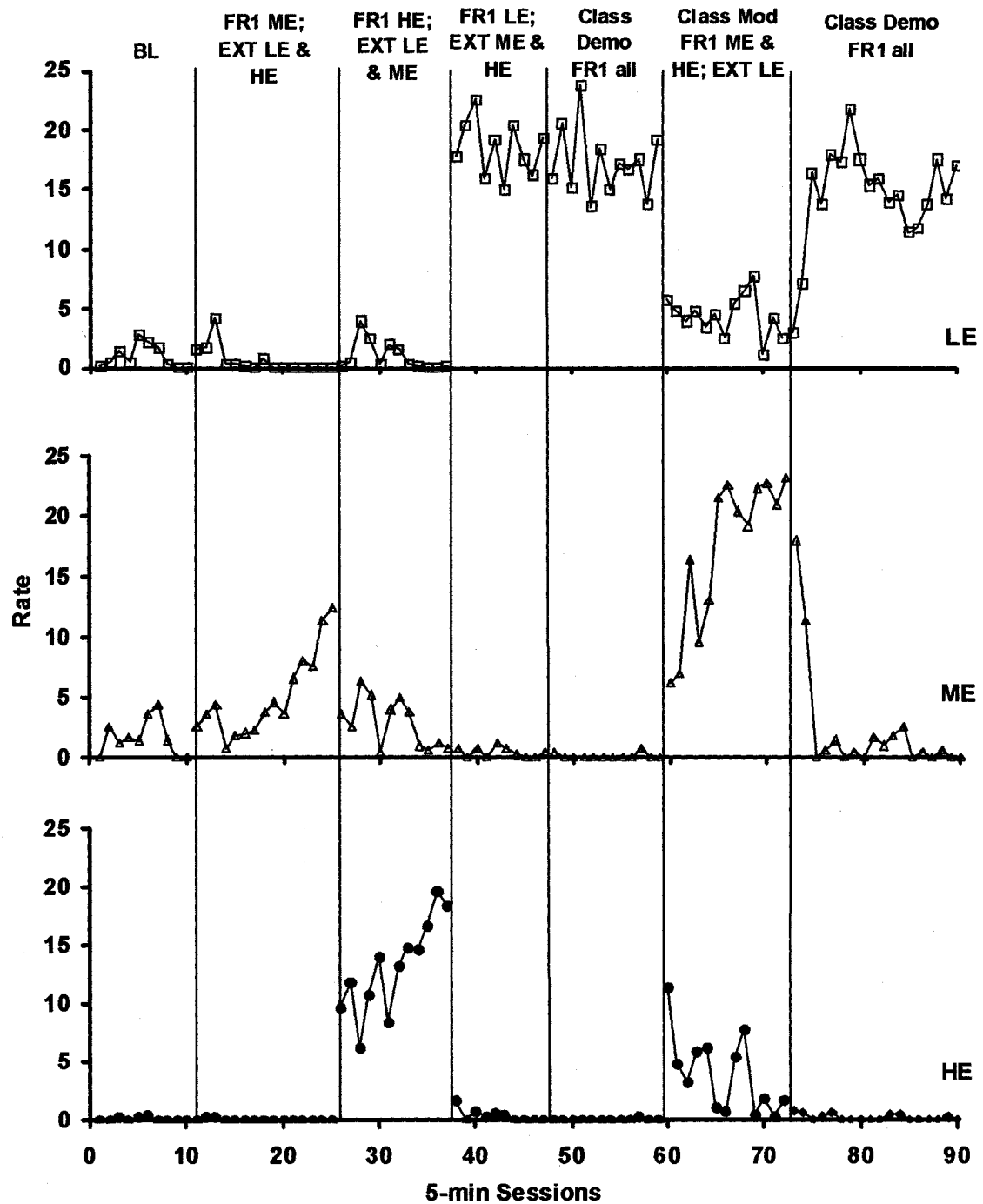


Figure 4. James's response class development graph. The LE button is represented in the top panel, the ME button in the middle panel, and the HE button in the bottom panel.

0.4 RPM) buttons. The next phase (i.e., class demonstration) resulted in high rates of LE button pressing ($M = 17.3$ RPM) and low rates of pressing the ME ($M = 0.1$ RPM) and HE ($M = 0.1$ RPM) buttons. These results demonstrated 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. Responding was then modified such that the ME and HE buttons were available for reinforcement and the LE button was placed on extinction. Results indicated an increase in ME button pressing ($M = 17.3$ RPM), and lower rates of pressing the LE ($M = 4.4$ RPM) and HE ($M = 3.9$ RPM) buttons. These results suggested that the response class was successfully modified. Finally, the class demonstration phase was replicated and resulted in high rates of LE button pressing ($M = 14.5$ RPM) and low rates of pressing the ME ($M = 2.2$ RPM) and HE ($M = 0.2$ RPM) buttons.

4.1.5 Rick

Results from Rick's response class development are presented in Figure 5. During baseline, Rick engaged in low rates of button pressing (LE, $M = 1.8$ RPM; ME, $M = 0.1$ RPM; HE, $M = 0$ RPM). Following baseline, response class development for Rick began with an FR1 schedule of reinforcement for the LE button while the ME and HE buttons remained on extinction. Results indicated high rates of LE button pressing ($M = 9.1$ RPM) and no presses on the ME and HE buttons. During FR1 ME, Rick displayed higher rates of button pressing on

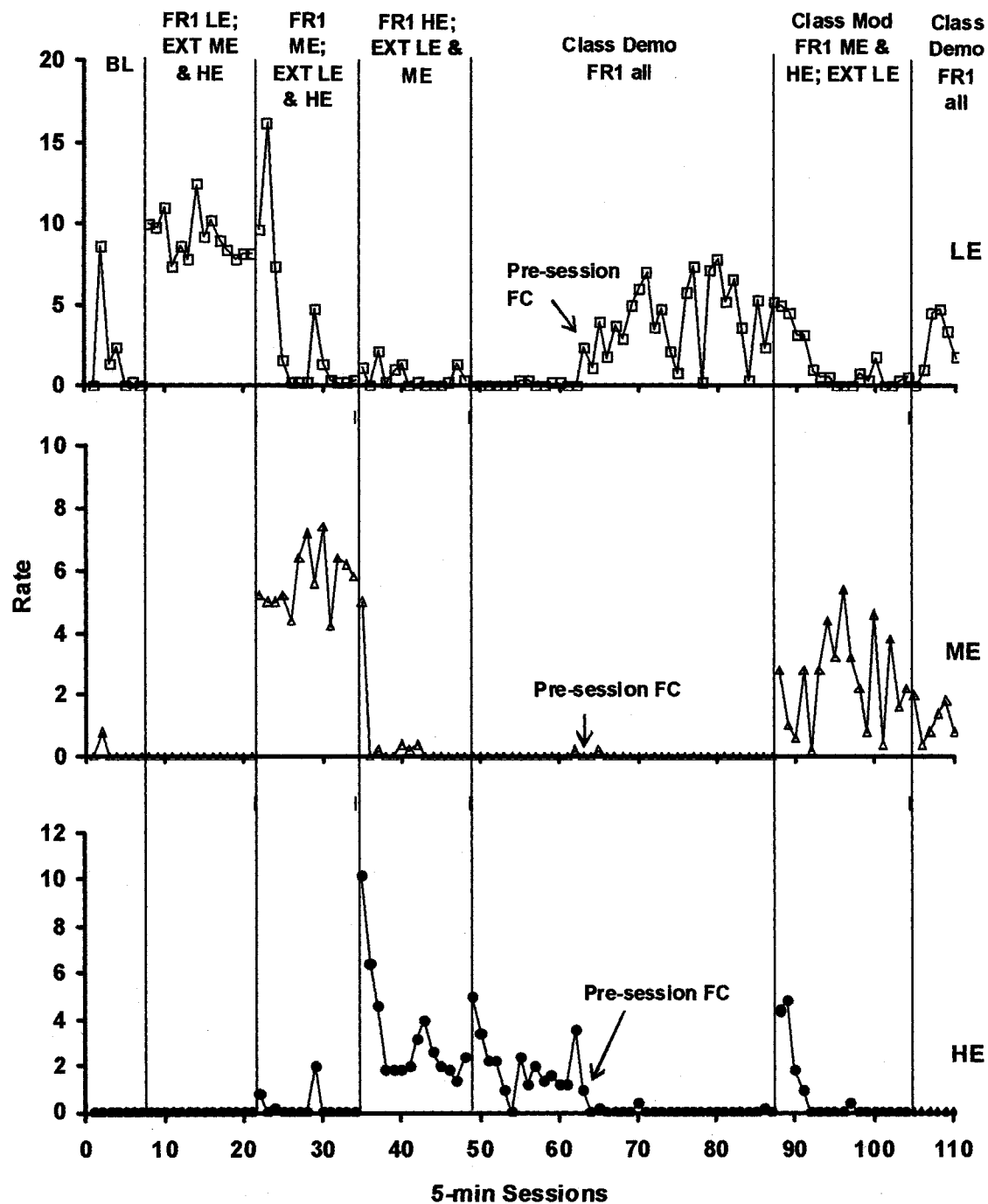


Figure 5. Rick's response class development graph. The LE button is represented in the top panel, the ME button in the middle panel, and the HE button in the bottom panel. FC = pre-session forced-choice trials.

the ME button ($M = 5.7$ RPM) and lower rates of pressing the LE ($M = 3.3$ RPM) and HE ($M = 0.2$ RPM) buttons. During FR1 HE, Rick's rate of button pressing increased on the HE button ($M = 3.3$ RPM) and decreased on the LE ($M = 0.6$ RPM) and ME ($M = 0.4$ RPM) buttons. The next phase (i.e., class demonstration) initially resulted in higher rates of HE button pressing. As a result, the pre-session forced-choice training trials were re-implemented. Following session 63, overall rates of button pressing increased on the LE button ($M = 2.7$ RPM), while pressing the ME ($M = 0.1$ RPM) and HE ($M = 0.8$ RPM) buttons decreased. These results partly demonstrated that a functional response class of button pressing had been established; however it was not clear if physical effort determined which button was pressed given the implementation of the pre-session forced choice procedure. Responding was then modified such that the ME and HE buttons were available for reinforcement and the LE button was placed on extinction. Results indicated an increase in ME button pressing ($M = 2.5$ RPM), and lower rates of pressing the LE ($M = 1.3$ RPM) and HE ($M = 0.7$ RPM) buttons. These results suggested that the response class was successfully modified. Finally, the class demonstration phase was replicated and resulted in higher rates of LE button presses ($M = 2.6$ RPM) and lower rates of pressing the ME ($M = 1.2$ RPM) and HE ($M = 0$ RPM) buttons.

4.2 Study 2

4.2.1 Dora

Results from Dora's response-class hierarchy analysis are presented below in Figure 6. During the first phase, all three buttons were present; however, only button presses on the ME and HE buttons resulted in programmed consequences. Results indicated that Dora initially pressed the HE button first and the ME button second during the first 2 trials. After coming into contact with the reinforcement contingency in effect for the ME button, she continued to press this button first for the remaining 6 trials. In the next phase (i.e., FR1 LE & HE, EXT ME), hierarchically related responses would suggest that Dora quickly switch to pressing the LE button after experiencing extinction on the ME button. During the first trial of this condition, Dora pressed the ME button first and the LE button second. Following this initial trial, she pressed the LE button exclusively for the remaining 6 trials. Next, the initial phase was replicated and hierarchically related responses would suggest that Dora switch back to pressing the ME button first. During the first 3 trials (i.e., trials 16-18) she continued to press the LE button first and the ME button second. During trial 19 she switched to pressing the ME button first. Pressing the ME button first continued for the remainder of this condition, except during trial 21 when she pressed the LE button first and the ME button second. The FR1 LE & HE, EXT ME phase was replicated next and indicated that Dora quickly switched to

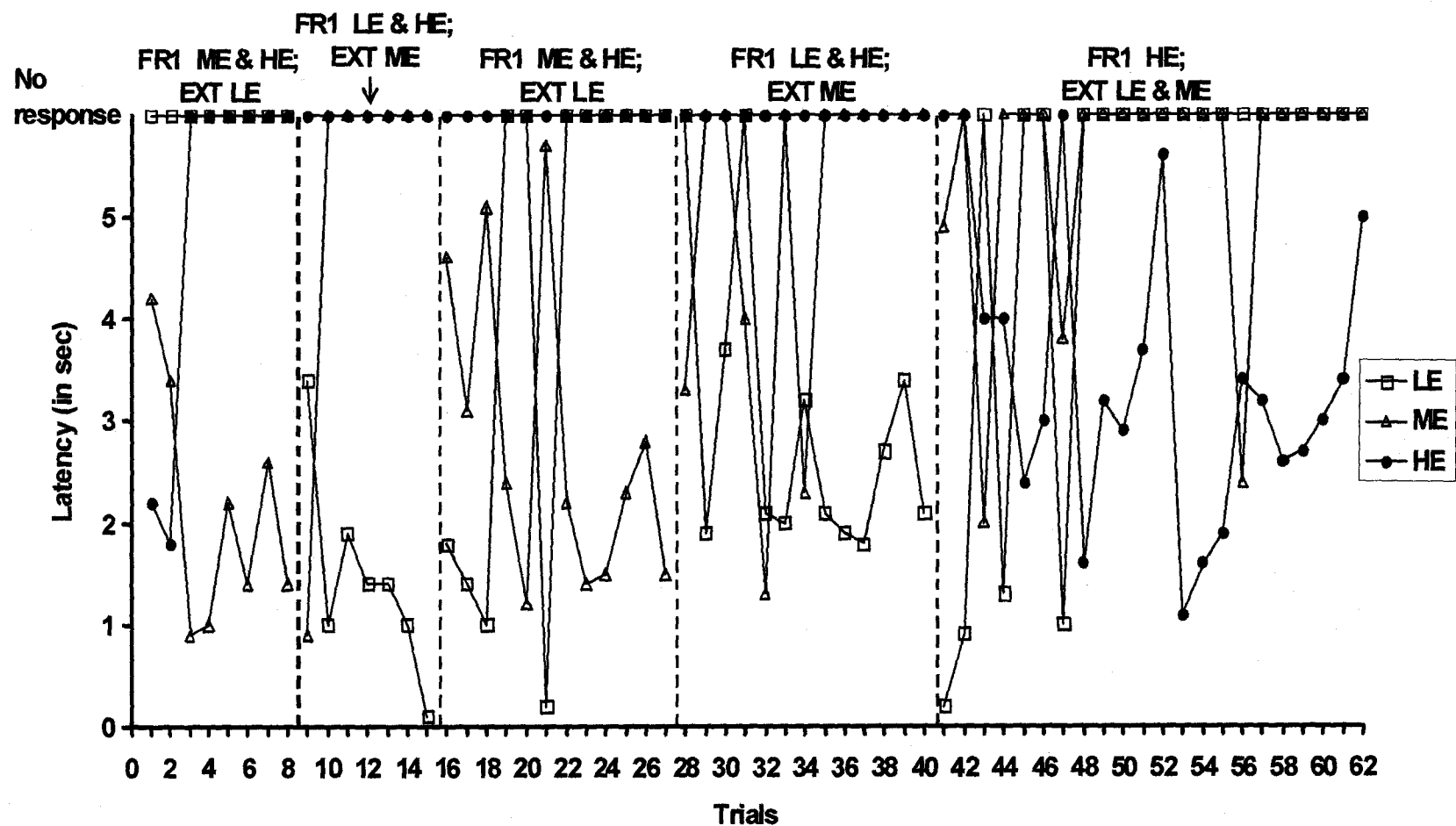


Figure 6. Trial-by-trial data of Dora's latency to button pressing across conditions.

pressing the LE button first. In the final phase, only button presses on the HE button resulted in programmed consequences and hierarchically related responses would suggest that Dora quickly begin pressing the HE button. Results indicated that Dora continued to press the LE and ME buttons first. During trial 43, she pressed the ME button first and the HE button second. She then returned to pressing the LE button first before allocating a majority of her button presses to the HE button (i.e., 16 out of 22 trials).

Dora's transitions between LE, ME, and HE buttons were variable across conditions. In order to meet stability criteria (i.e., minimum of six consecutive data points where button presses on the least effortful button available for reinforcement occurred first), Dora was exposed to a gradually increasing number of trials across phases. During phase 1 (i.e., FR1 ME & HE; EXT LE), Dora required 2 trials before she met stability criteria. During phase 2 (i.e., FR1 LE & HE; EXT ME), Dora again required only 2 trials until she began pressing the LE button and then required several more trials before meeting stability criteria. Her transition to the ME button (i.e., phase 3) after maintaining button pressing on the LE button took three times as many trials. In the transition back to the LE button (i.e., phase 4), button pressing was variable for approximately 8 trials until Dora met stability criteria. In the final transition to the HE button, it took approximately 17 trials before Dora began responding to the HE button first for six consecutive trials.

In summary, a majority of Dora's button pressing was allocated towards the least effortful button available for reinforcement. In other words, when the

LE button was available for reinforcement she pressed this button first in a total of 15 out of 20 trials. When the ME button was available for reinforcement, she pressed this button first in a total of 14 out of 20 trials. Furthermore, she quickly switched to the least effortful button available for reinforcement across conditions; however, her transitions from ME to LE were quicker than her transitions from LE to HE.

4.2.2 *Gwen*

Results from Gwen's response-class hierarchy analysis are presented below in Figure 7. During the initial FR1 LE & HE, EXT ME condition, Gwen pressed the LE button exclusively (i.e., 6 out of 6 trials). During the subsequent phase (FR1 ME & HE, EXT LE), Gwen pressed the LE button during the first 2 trials before switching to the ME button for the next 2 trials (9 and 10). Following trial 10, Gwen began to alternate between pressing the LE, ME, and HE buttons. It was not until trial 26 that Gwen began consistently pressing the ME button first. Overall, she pressed the ME button first in 18 out of 31 trials; however, she also pressed the LE button 8 times and the HE button 4 times. Next, the initial phase was replicated and if responses were hierarchically related Gwen should begin to press the LE button first. Results indicated that she pressed the LE button first in 12 out of 15 trials. The second phase was replicated next and hierarchically related responses would suggest that Gwen begin pressing the ME button first. However, she alternated between buttons and pressed the ME

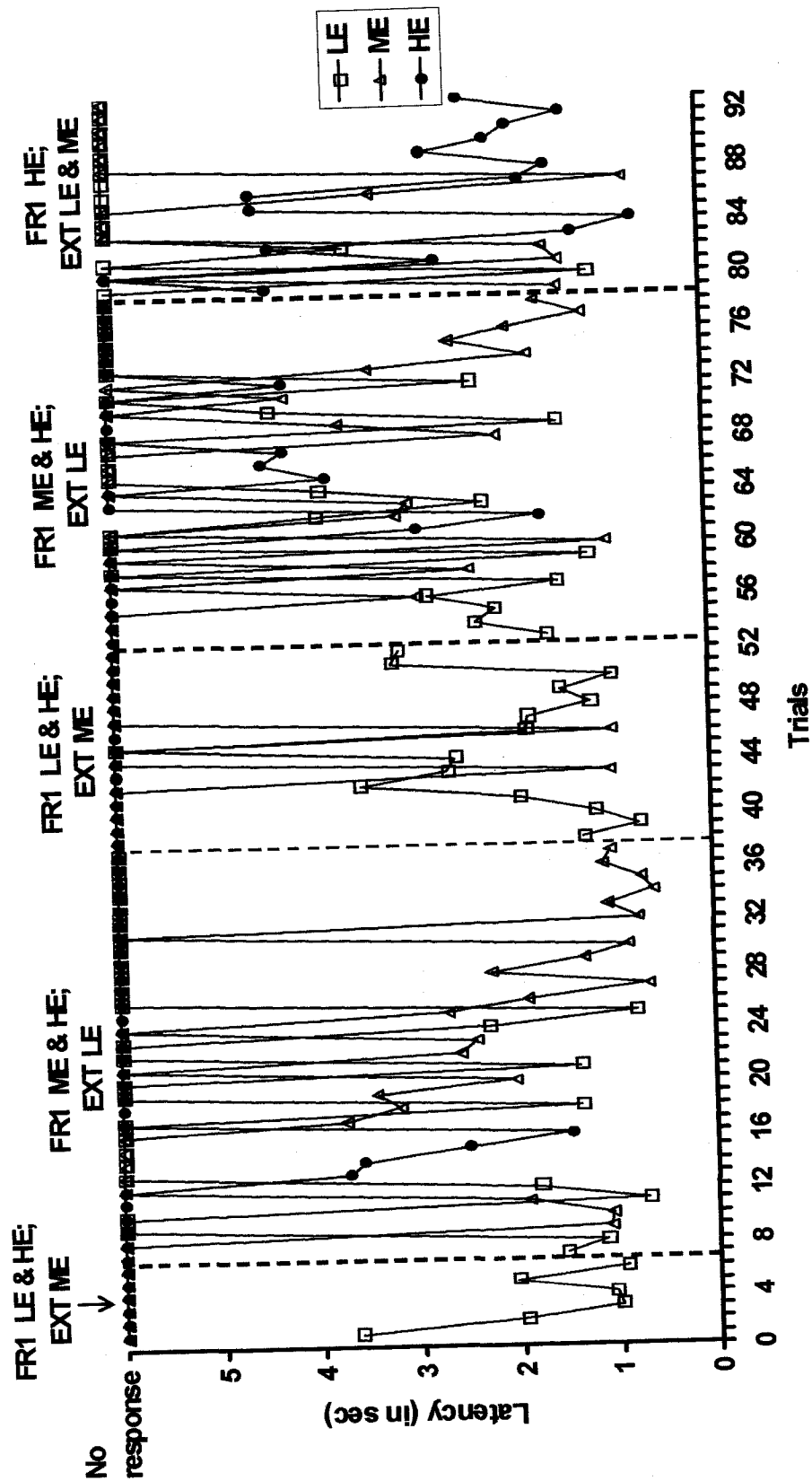


Figure 7. Trial-by-trial data of Gwen's latency to button pressing across conditions.

button first in only 10 out of 26 trials. Furthermore, she pressed the LE and HE buttons first in 11 and 5 trials, respectively. In the final phase (i.e., FR1 HE, EXT LE & ME), hierarchically related responses would suggest that Gwen would begin to press the HE button after coming in contact with the extinction contingency in effect on the other buttons. Results indicated that she pressed the HE button first in 9 out of 15 trials. Gwen's transitions between LE, ME, and HE buttons were slightly more consistent when moving from LE to ME and ME to LE buttons. In order to meet stability criteria, Gwen consistently required more trials when the transitions involved moving from the LE to ME button. Transition from the LE to ME button in phase 2 required 26 trials and transition from LE to ME button in phase 4 required 22 trials. Conversely, transition from the ME to LE button in phase 3 required only 10 trials. In addition, the final transition from the ME to HE button required only 10 trials.

In summary, a majority of Gwen's button pressing was not allocated towards the least effortful button available for reinforcement. When the LE button was available for reinforcement she pressed this button first in a total of 18 out of 21 trials. However, when the ME button was available for reinforcement, she pressed this button first in only a total of 28 out of 57 trials. Instead, she continued to press the LE button first in a total of 19 out of 57 trials. Her transitions between buttons seemed more consistent when transitioning from the LE to ME button and the ME to LE button; however, her transition from ME to HE did not conform to this pattern. Gwen's results may have been

influenced by the initial adjustments introduced during the development of the response class in Study 1. During Study 1, Gwen required additional training before the response class could be reliably demonstrated and a relation between response rate and effort established.

4.2.3 Hillary

Results from Hillary's response-class hierarchy analysis are presented below in Figure 8. During the first phase, all three buttons were present; however, only button presses on the ME and HE buttons resulted in reinforcement. Results indicated that Hillary pressed the ME button exclusively (i.e., 7 out of 7 trials). In the next phase (i.e., FR1 LE & HE, EXT ME), hierarchically related responses would suggest that Hillary quickly switch responding to the LE button after contacting the extinction contingency for the ME button. During the first 6 trials of this condition (i.e., trials 8-13), Hillary continued to press the ME button first. During 5 of these trials she pressed the LE button second. During trial 14 she switched to pressing the LE button first. Overall, she pressed the LE button first in 7 out of 13 trials. Next, the initial phase was replicated and hierarchically related responses would suggest that Hillary switch back to pressing the ME button first. During the first 8 trials (i.e., trials 21-28) she continued to press the LE button first. She also pressed the ME button second in 7 of these trials. During trial 29 she switched to pressing the ME button first. Overall, she pressed the ME button first in 7 out of 15 trials. However, she also pressed the LE button first in 8 out of 15 trials. The FR1 LE & HE, EXT ME phase was

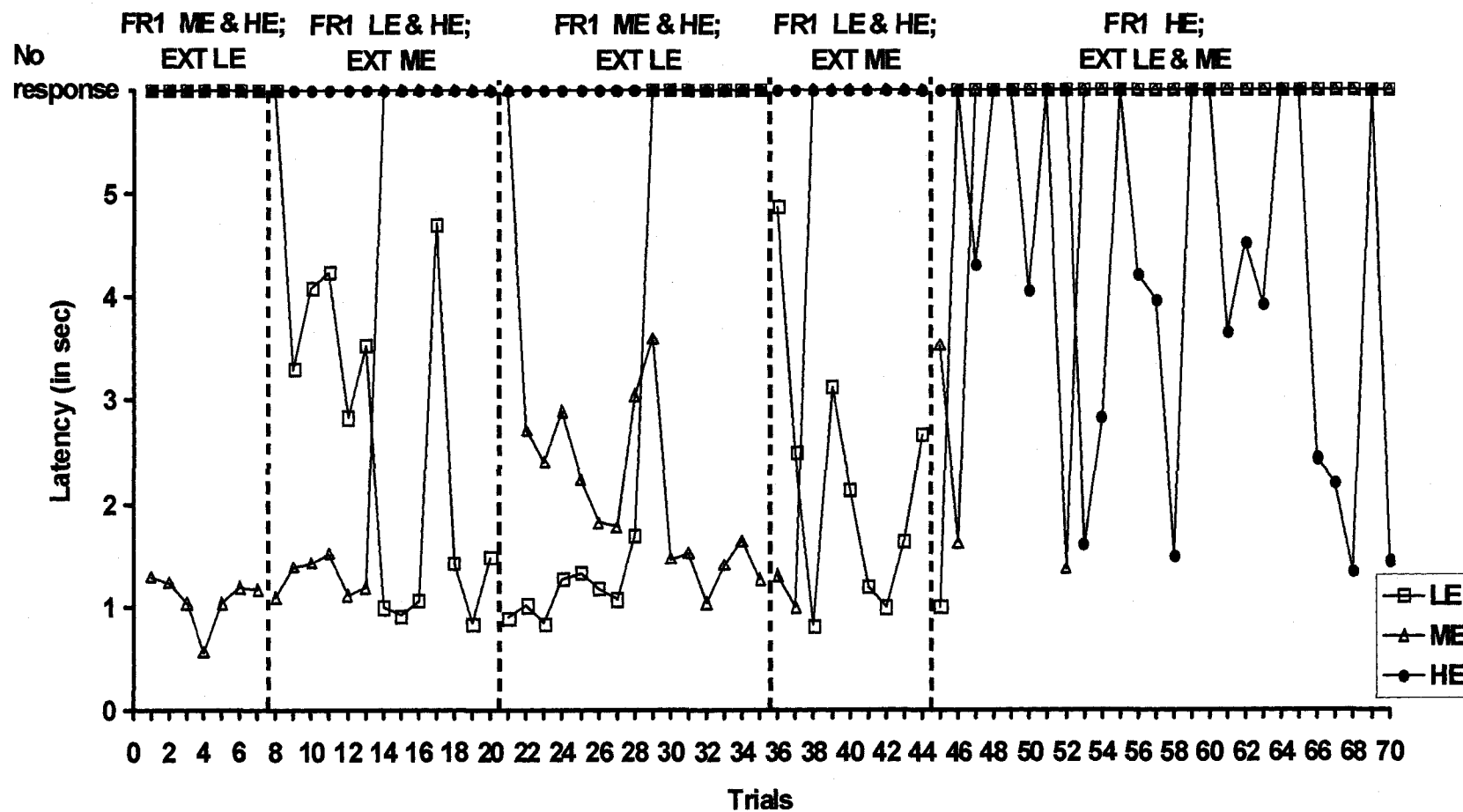


Figure 8. Trial-by-trial data of Hillary's latency to button pressing across conditions.

replicated next and if responses were hierarchically related Hillary should quickly switch to pressing the LE button first. During the first 2 trials (i.e., trials 36 and 37) she pressed the ME button first and the LE button second. During trial 38 she switched to pressing the LE button first. Overall, she pressed the LE button first in 7 out of 9 trials. In the final phase, only button presses on the HE button resulted in programmed consequences and hierarchically related responses would suggest that Hillary quickly begin pressing the HE button first. Results indicated that Hillary pressed the LE and ME buttons during the first 2 trials (i.e., trials 45 and 46) and then switched to pressing the HE button first during trial 48. Although Hillary pressed the HE button in 14 out of 26 trials, there were a high percentage of non-responses during this phase. During 9 of the 26 trials, Hillary did not respond on any of the buttons.

Hillary's transitions between LE, ME, and HE buttons were consistent across phases when moving to more effortful buttons. In order to meet stability criteria, Hillary consistently required more trials when the transitions involved moving from the LE to ME or HE buttons. Transition from the LE to ME button in phase 3 required 9 trials and transition from the LE to HE button required 9 trials in phase 5. Conversely, transitions from the ME to LE button in phase 2 and 4 required 7 and 3 trials, respectively.

In summary, a majority of Hillary's button pressing was allocated towards the least effortful button available for reinforcement. In other words, when the LE button was available for reinforcement she responded to this button first in a total of 14 out of 22 trials. When the ME button was available for reinforcement,

she responded to this button first in a total of 14 out of 22 trials. Furthermore, she quickly switched to the least effortful button available for reinforcement across conditions and her transitions from the ME to LE button were consistently quicker than her transitions from the LE to ME or HE buttons.

4.2.4 James

Results from James's response-class hierarchy analysis are presented below in Figure 9. During the initial FR1 LE & HE, EXT ME condition, James pressed the LE button first in a majority of trials (i.e., 11 out of 12 trials). During the subsequent phase (FR1 ME & HE, EXT LE), hierarchically related responses would suggest that James quickly begin pressing the ME button. However, James continued to press the LE first in a majority of the first 16 trials (i.e., trials 13-28). It was not until trial 29 that he began to press the ME button first. Overall, he pressed the ME button first in 16 out of 35 trials; however, he also pressed the LE button first in 17 trials. Next, the initial phase was replicated and if responses were hierarchically related James should have begun to press the LE button first. Results indicated that he pressed the LE button exclusively in 7 out of 7 trials. The second phase was replicated next and hierarchically related responses would suggest James begin pressing the ME button first. He began by pressing the LE button first and then intermittently switched to pressing the ME button first (i.e., trials 57 and 59). Overall, he pressed the ME first in 9 out of 16 trials; however, he also pressed the LE button first in 7 trials. In the final

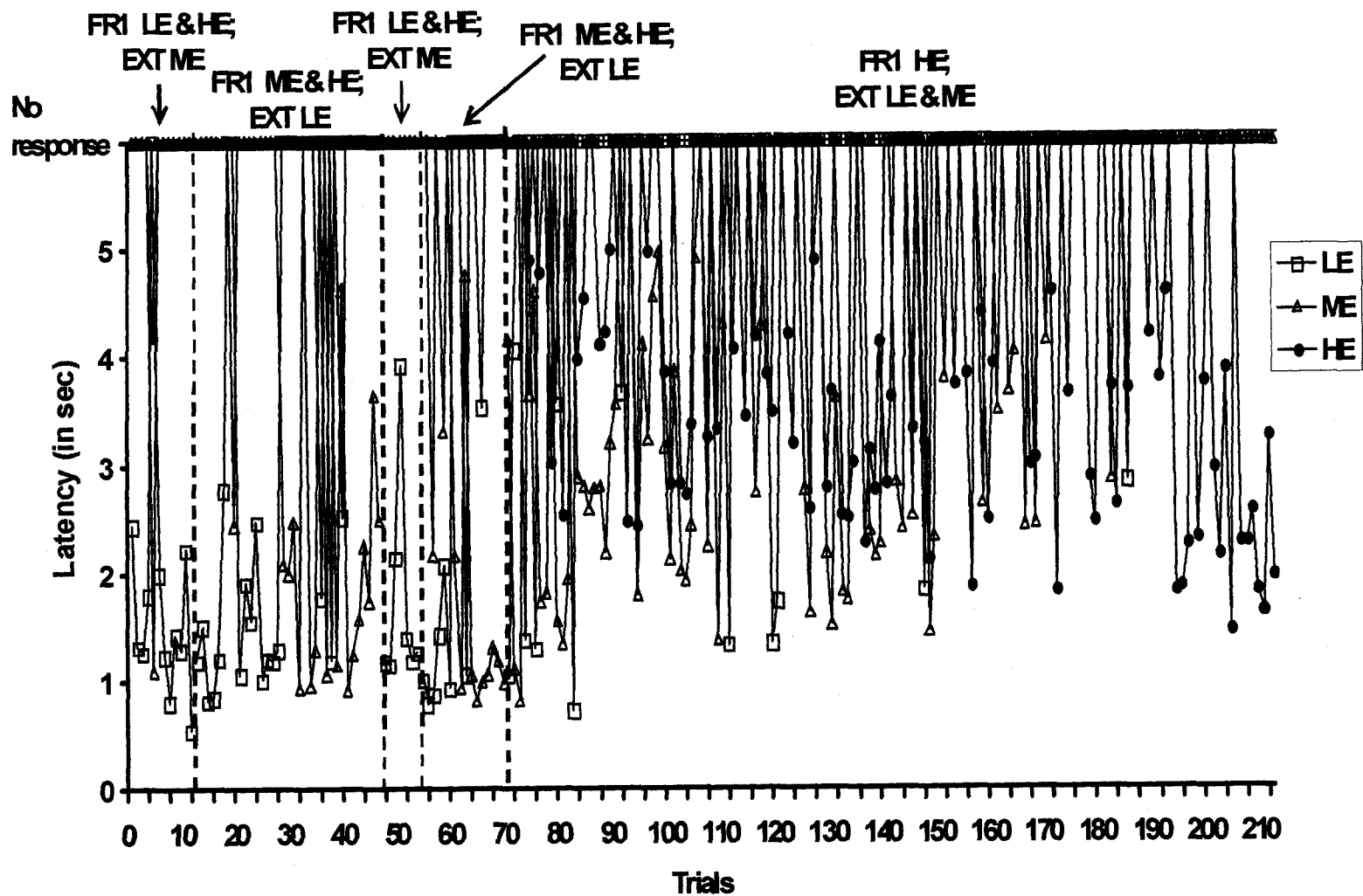


Figure 9. Trial-by-trial data of James's latency to button pressing across conditions.

phase (i.e., FR1 HE, EXT LE & ME), hierarchically related responses would suggest that James quickly begin to press the HE button. However, James continued to press the ME button first in 57 out of 143 trials. In addition, he began to press the ME and HE buttons in an ordered sequence (i.e., ME → HE) for 31 trials. It was not until trial 172 (i.e., 102 trials after the final phase was initiated) that James began to more consistently press the HE button first. In addition, there were a high percentage of non-responses during this phase. During 32 of the 143 trials, James did not respond on any of the buttons.

James's transitions between LE, ME, and HE buttons was similar to Hillary's in that he required more trials to meet stability criteria when moving to more effortful buttons. In order to meet criteria, James consistently required more trials when the transitions involved moving from the LE to ME or HE buttons. Transitions from the LE to ME button required 29 and 10 trials in phases 2 and 4, respectively. Transition from the ME to HE button in the final phase required 137 trials before stability criteria were met. Conversely, transitions from the ME to LE button in phase 3 occurred immediately.

In summary, James's button pressing was gradually allocated towards the least effortful button available for reinforcement; however the switchover to the least effortful button available for reinforcement required numerous exposures to the extinction contingency. When the LE button was available for reinforcement he responded to this button first in a total of 18 out of 19 trials. However, when the ME button was available for reinforcement, he responded to this button first in only a total of 25 out of 51 trials. Instead, he continued to contact the LE

button extinction contingency by pressing the LE button in a total of 24 out of 51 trials. This pattern was consistent with James's transition data in that he required significantly more trials to meet stability criteria when transitioning from the ME to HE button.

4.2.5 Rick

Results from Rick's response-class hierarchy analysis are not presented because Rick failed to meet stability criteria for the initial phase of Study 2 following a total of 90 trials. During the initial FR1 ME & HE, EXT LE condition, Rick pressed the ME button first in only 25 out of 90 trials. He pressed the LE button first in 36 of these trials and failed to press any button in 29 trials. Overall, Rick's button pressing was not allocated towards the least effortful button available for reinforcement during the initial phase of Study 2. Instead, he continued to press the button on extinction (i.e., LE button) for a high percentage of trials. Although no data were collected on his stereotypy during trials of Study 2, Rick frequently engaged in high rates of squinting, hand flapping, and rocking during trials. These intervening behaviors appeared to interfere with Rick's responding. As a result, Study 2 was discontinued with Rick following a total of 90 trials in which button pressing did not stabilize.

Chapter 5

Discussion

5.1 Study 1

During Study 1, participants were taught three behaviors in an attempt to develop a response class. Each behavior in the response class required a differential amount of effort to perform (i.e., LE, ME, and HE). Three participants acquired the response class without procedural modification (i.e., Dora, Hillary, James). For the remaining 2 participants, Gwen and Rick, forced-choice trials and an additional extinction phase (Gwen only) were required before the response class was developed. Although adjustments were made in order to facilitate the development of the response class for 2 participants, the response class was successfully demonstrated and modified for all participants. These results suggested 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.

During the first 3 button training phases, participants reliably pressed the one button available for reinforcement. For example, during FR1 ME, EXT LE & HE, participants pressed the ME button at a higher rate than the LE and HE buttons. Interestingly, participants pressed lower effort buttons at low, but non-zero rates when more effortful buttons were available for reinforcement. When

reinforcement was available for the LE button only, a majority of button presses were allocated towards this button and near zero rates were observed for the ME and HE button. However, during ME button training, participants also allocated their responding primarily to the ME button; however, rates of button presses on the LE were not near zero. This pattern was even more pronounced during the HE button training. Again, a majority of responding was allocated to the HE button; however, rates of button presses on the LE and ME button were not near zero. This pattern of responding was replicated during the class modification phase (i.e., FR1 ME & HE, EXT LE). While the average rate of button pressing was highest on the ME button, rates of pressing the LE button remained relatively stable. Furthermore, results from Study 2 indicated that Gwen, Hillary, and James all continued to press the LE buttons during a high percentage of trials in which only the ME and HE buttons were available for reinforcement. In summary, these results suggested that lower effort responses were slightly more resistant to extinction than ME or HE responses. However, it is a possible that other variables may have affected this pattern of results.

Physical effort has been shown to influence resistance to extinction, however effortful responses may be more resistant to extinction because of the effects of additional variables such as different reinforcement or punishment histories, different delays to reinforcement, the number of reinforcers delivered during acquisition, or a combination of these variables (for a review of these issues, see Lerman & Iwata, 1996). Previous research has demonstrated

extinction-like decrements in behavior following increases in physical effort (e.g., Van Houten, 1993). Horner and Day (1991) found that a functionally equivalent alternative behavior had to more efficient (i.e., fixed-ratio 1 vs. fixed-ratio 3 reinforcement schedule, 1-s vs. 20-s delay to reinforcement, low vs. high effort) than previously reinforced aggressive or self-injurious behaviors in order to effectively decrease or replace problem behavior. In the current investigation, pressing the ME or HE buttons could be considered inefficient when reinforcement was previously available for LE button pressing. Although delays to reinforcement were not systematically evaluated in Study 1, the physical effort associated with pressing each button did include a built in delay to reinforcement. For example, after reaching to press the HE button, there was a slight delay to reinforcement as participants had to reposition themselves in order to press the orienting button that initiated another button pressing sequence (i.e., interresponse time; IRT). Pressing the LE button resulted in a slightly shorter delay and IRT. Research on delayed reinforcement has shown that delays can influence the allocation of responses (e.g., Neef et al., 1992) and results of previous research on IRT's demonstrated that, in general, longer IRT's result in lower rates of responding (Staddon, 1965). This is consistent with the results of Study 1 where rates of responding were lower as IRT's increased. In summary, physical effort, or a combination of effort and other variables, may have influenced resistance to extinction; however additional research is required

in order to clarify how interactions between different variables influence responding under extinction.

Another variable that may have influenced the current pattern of results is differential histories of reinforcement. For example, during the class demonstration phase with Rick, he continued to press the HE button at high rates. This was most likely due to his most recent reinforcement history with the HE button. It was not until the implementation of a pre-session forced-choice trial that Rick began pressing the LE button. Different reinforcement histories may therefore affect the sequence of responses in a response class (Lalli et al., 1995). More specifically, the results for Rick suggest that the most *recent* reinforcement history influences responding. Interestingly, Rick did press the LE button before forced-choice trials were implemented during the class demonstration phase; however, he continued to allocate a majority of his responding to the HE button even after contacting the LE button contingency. This was also the case for Gwen, who not only contacted the LE button contingency during her initial class demonstration phase, but was also exposed to a series of pre-session forced-choice trials. Rick began pressing the LE button after one pre-session forced-choice trial, however Gwen continued to press the ME button even after several forced-choice trials. These results suggested that Rick's initial responding was under the control of a recent history of reinforcement for the HE button; however, Gwen's responding came under the control of some other stimulus.

A possible explanation for Gwen's pattern of responding during the class demonstration phase is the role of rule-governed behavior. Her button pressing during the first class demonstration phase was insensitive to the schedule of contingencies in place. Therefore, she may have been following a rule that made the contingencies associated with different buttons ineffective. Previous research has shown that key-pressing established in humans by instructions instead of shaping resulted in a pattern of responding that was insensitive to the schedule of contingencies in place (Matthews, Shimoff, Catania, & Sagvolden, 1977). Although no specific instructions about which button to press were given, Gwen's own verbal behavior may have affected button presses on the ME button during the initial class demonstration phase. Anecdotally, Gwen indicated that the LE button was hardest for her to press and the HE button was easiest for her to press. The introduction of an additional extinction phase (i.e., FR1 LE & HE, EXT ME) was necessary before button pressing was finally allocated to the LE button. This suggested that Gwen's behavior was sensitive to its consequences only after reinforcement was no longer available for the ME button. In summary, although Gwen's pattern of responding eventually came under the control of the contingencies in place, her behavior did appear to be consistent with previous research on the effectiveness of verbal behavior as an instructional stimulus (e.g., Baer, Detrich, & Weninger, 1988; Lovaas, 1964).

5.2 *Study 2*

The purpose of Study 2 was to determine whether responses in the functional class established in Study 1 were organized in a hierarchical structure. Although the response patterns evident in the class modification phase in Study 1 might seem to suggest the existence of a hierarchy, these patterns are insufficient evidence. The response covariation (switching from the LE to ME buttons) observed in Study 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. A within-session analysis is necessary to confirm the existence of a hierarchy so that the first response made after contacting an extinction contingency can be observed. In Study 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. Results indicated that hierarchies existed within the previously developed response classes of Dora, Hillary, and James. James did require a longer switchover time between phases; however he did gradually begin to respond on the least effortful button available for reinforcement. 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 when compared to her transition to the ME button. This pattern of responding suggested that a hierarchy did not exist within the established

response class. The persistence of her responding on the ME button when the LE button was available for reinforcement and the subsequent addition of an extinction contingency in Study 1 may have also influenced the demonstration of the hierarchy. In other words, her initial insensitivity to response effort in Study 1 might have hindered the development of a hierarchical relation between the responses. For Rick, Study 2 was discontinued when consistent responding on the ME button failed to emerge over the course of 90 trials. His high rate of stereotypy may have also played a role in the failure of the hierarchy to develop because these intervening behaviors appeared to effectively compete with reinforcers delivered for button pressing. Therefore, the results for Gwen and Rick suggested that although a functional response class of button pressing had been established in Study 1, there was not an ordinal temporal relation between the different members of the response class.

The failure to develop this relation may have been due to the effort manipulation utilized in the current investigation. The difference in effort between the LE and ME button may have been too small to result in any discernable 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.

The results for Dora, Hillary, and James suggested that an ordinal temporal relation existed between different members of the response class developed in Study 1. Compared to the results for Gwen and Rick, Dora, Hillary, and James's transitions between button presses were more efficient. They required fewer trials to meet criterion across most phases of Study 2 and frequently switched to pressing the least effortful button available for reinforcement when the schedule of contingencies were changed.

5.3 General Discussion

The purpose of the current investigation was to evaluate a methodology 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 stimulate a line a research that may lead to a better understanding of how members of a response class relate to one another. Additionally, 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.

Individuals with a variety of clinical diagnoses commonly engage in multiple problem behaviors. However, treatments are typically developed and prescribed for single behavior problems (Carr et al., 2002). The limited

response-class hierarchy literature indicates that eliminating only one of the members from a response class might lead to the emergence of others. Furthermore, research on response class theory suggests that treatments should be designed to affect the entire response class and not just individual topographies of problem behavior (Sprague, 2005).

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 we can produce a response-class hierarchy under laboratory conditions. When the experimental preparation developed in this study is modified to become more reliable, it 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 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 analyze what happens 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 are possibly more likely to affect the entire response class. Furthermore, this type of preparation could be used to evaluate the effects of

function-based versus arbitrary/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 in order 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 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 of reinforcement. The result of this training may actually establish the alternative response as a member of the response-class hierarchy. The methodology 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.

Two additional areas that may be investigated using the preparation developed in this study include 1) the effects of punishment on different members of a response class, and 2) the effects of treating one response class on a separate, independent response class. With respect to punishment, it would be interesting to evaluate how punishment of one member of a response class affects other members of the same response class. Furthermore, the affect of punishment on the development of a hierarchy within the punished response class could also be investigated. This may lead to implications about how to treat severe or life-threatening forms of problem behaviors that are commonly preceded by the occurrence of precursor behaviors (e.g., Smith & Churchill, 2002). Since more severe forms of self-injury may not be allowed to occur, investigations that include punishment of precursor or less severe forms of problem behavior may provide some insight into how punishment affects the entire response class. Specifically, it would be interesting to evaluate if punishment of one member of a response class transfers to other members of the same response class.

A final area that may be evaluated using the methodology developed in the current study includes an investigation into how treating one response class influences the occurrence of behaviors that are members of a separate, independent response class. This could be accomplished by developing two

separate response classes using different sets of response panels (i.e., two different sets of LE, ME, and HE buttons). The effects of extinction for responding on one response panel could then be measured on both panels. It would be interesting to evaluate how extinction affects the occurrence of behaviors that are members of the response class not exposed to extinction. Clinically, these arrangements may provide us with a method for investigating how treating one response class affects a separate, independent response class.

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, it is possible that button-pressing chains were still reinforced. This may have precluded the development of a response-class hierarchy for Gwen and Rick. During Study 2, participants could press a sequence of buttons during the allotted 5 s after the cover was lifted off the response panel. In the initial phase of Study 2 for Rick (i.e., FR1 ME & HE, EXT LE), Rick pressed the LE button first and the ME button second in a high percentage of trials. This resulted in contacting the reinforcement contingency for the ME button; however, it is possible that a chain of button pressing was inadvertently reinforced given that Rick frequently pressed the LE button before pressing the ME button. Future research 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 in order to facilitate the development of a hierarchy. Alternatively, we may have not given participants adequate histories with the buttons in Study 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. Through additional investigations, this preparation 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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Appendix A

WESTERN MICHIGAN UNIVERSITY



Human Subjects Institutional Review Board

Date: January 16, 2004

To: James Carr, Principal Investigator
Daniel Shabani, Student Investigator for dissertation

From: Mary Lagerwey, Ph.D., Chair

A handwritten signature in cursive script, reading "Mary Lagerwey".

Re: HSIRB Project Number: 03-12-03

This letter will serve as confirmation that your research project entitled "Development of a Model of a Response-Class Hierarchy" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: December 17, 2004