

VERBAL BEHAVIOR OF MICE AND MEN: PREFERENCE FOR MULTIPLE  
SCHEDULES OF REINFORCEMENT AS AN INDICATOR  
OF THE EVOLUTION OF VERBAL BEHAVIOR

by

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*“What lies behind us and what lies before us are tiny matters compared to what lies within us”.*

*Ralph Waldo Emerson.*

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## ABSTRACT

# VERBAL BEHAVIOR OF MICE AND MEN: PREFERENCE FOR MULTIPLE SCHEDULES OF REINFORCEMENT AS AN INDICATOR OF THE EVOLUTION OF VERBAL BEHAVIOR

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The evolution of verbal behavior in humans is believed to have appeared in the form of a complex operant behavior. According to behaviorists, the development of verbal behavior which is exclusive to *Homo sapiens* could have been the result of an increased sensitivity to environmental stimuli in the form of another person. Previous animal research by Roark and Kopp (2008) found that sensitivity to environmental stimuli (as indicated by a preference to respond to a multiple schedule of reinforcement) and a preference for responding to additional environmental cues could be a precursor to the evolution of verbal behavior in Sprague Dawley rats. This research extended the aforementioned animal study to assist in establishing a methodology for examining how verbal behavior might have evolved in humans. It was found that like their non-human counterparts, individuals did in fact prefer to respond to additional environmental stimuli when given a choice of concurrent schedules of reinforcement which may be an indication of the development of verbal behavior in its most rudimentary form.

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## CHAPTER 1

### INTRODUCTION

The inception of Psychology was not dependent upon nor the result of the invention of scientific instruments (Skinner, 1953). Psychologists do not require telescopes to peer into the heavens nor do they require microscopes to view the subject matter of interest to them. Instead, human behavior is in plain sight. Why then did it take so long for Psychology to be established as an independent science? Arguably, the answer to this question lies in the complexity of human behavior, which obscures its interpretation. While most Psychologists do not require technical apparatus, all Psychologists require clearly established methodologies for systematically observing and interpreting the complexities of human behavior. Once established as an independent area of scientific inquiry, initial attempts at understanding these complexities adopted an inward focus. Psychology was the science of the *mind*, with researchers attempting to explain human behavior through an examination of inner states, such as motivations, beliefs, feelings, and intentions (James, W., 1884). However, it did not take long before a focus on inner states was challenged.

Unlike the Psychologists who came before them, behaviorists did not look within the minds of their subjects in an attempt to find the causes of human behavior, but rather turned their gaze outwards, toward the external world. They held to a strong belief that with the exception of reflexes, which are controlled by internal mechanisms, *all* human behavior is operant behavior. Building on Thorndike's law of effect (1927), behaviorists posited that behaviors are contingent upon the availability of reinforcement in the environment (Skinner, 1938). Behaviors that result in positive outcomes are more likely to be enacted in the future, whereas behaviors that result in negative outcomes are less likely to be enacted in the future. With their focus on the impact of the environment on an organism, the behaviorists shifted the questions of Psychology away from the role of the internal mechanisms of the *mind* to the role of factors external to the organism. In particular, behaviorists studied the impact of an organism's environment as



well as its history in shaping its behavior. The principles of behaviorism apply to all of human behavior, and higher order behaviors, such a verbal behavior (i.e., language), are no exception. Verbal behavior is of particular interest to Psychologists because it aids humans in solving complex problems. When attempting to solve a problem, human behavior can be mediated by communication with other humans, and humans are uniquely capable of using language to do so. For example, a teacher can communicate to a student in written or verbal form how best to represent a given problem in order to obtain a solution.

Given the importance of language, it has been a topic of great interest for multiple disciplines. Anthropologists (Berlin & Kay, 1969), linguists (Chomsky, 1976), neuroscientists (Wilson & Sullivan, 1994), and psychologists (Skinner, 1953) have all directed considerable attention to understanding how and why humans developed this form of complex behavior while other organisms have not. The focus of this research was to evaluate, from a *behavioral* perspective, the possible basis from which language evolved. Given that a behavioral perspective was adopted, the research focused on what behaviorists termed, verbal behavior, with an overarching goal of establishing a methodology for examining how verbal behavior might have evolved in humans.

Verbal behavior is “behavior reinforced through the mediation of other persons” (Skinner, 1957, p.2). Because exterior stimuli outside of the organism control verbal behavior within the verbal environment, all behavior reinforced by others is verbal, even those behaviors emitted outside of human speech. To illustrate this point consider the following example. Assume an individual (speaker) is thirsty and enters an unfamiliar shopping mall. The problem in this example is thirst (an antecedent stimulus). Because the speaker is not familiar with this particular shopping mall, and has no behavior in his/her repertoire that will produce water, the speaker looks outside of himself/herself for a solution (problem solving in the form of verbal behavior). The speaker notices a sales person (stimulus) in a store, walks over to her (response), and says, “Could you please tell me where I can find a water fountain (verbal response)?” The sales clerk (listener) looks up from her paper work toward the speaker (stimulus) and says, “Go down this hall and take a left, you will see a sign that says “*Restrooms*”, (visual cue) next to the restrooms you will find the water fountain” (reinforcing response for speaker). The speaker smiles

(reinforcing non-verbal response) (discriminative stimulus for the listener) and says “thank you so much for your help” (reinforcing verbal response). The sales clerk also smiles (discriminative & reinforcing stimulus for speaker) and replies, “you are so welcome” (reinforcing verbal response).

This example may seem mundane, but illustrates the complexity of the operant behaviors necessary for the current level of verbal behavior exhibited among human beings. Given its complexity, the example also highlights the difficulty facing Psychologists in ascertaining how problem solving in the form of verbal behavior evolved. From the perspective of behaviorism, it evolved as a complex operant behavior. When an organism operates on its environment by behaving in a way that rearranges the variables within that environment, the organism is exhibiting operant behavior. The consequences that result from the manipulation of the environment directly affect if and how the organism will behave in the future. When the behavioral consequence is reinforcing, the likelihood of emitting the behavior in the future under similar circumstances is increased.

From a strict behaviorist perspective, problem solving is “any behavior which, through the manipulation of variables, makes the appearance of a solution more probable” (Skinner, 1953, p.247). All organisms engage in problem solving for survival. Whether it be in the form of behavior such as, foraging for food, which is a repetitive motor response associated with trial and error searching (Page, Scheiner, Erber, & Amdam, 2006), the instinctive behavior of nest building to attract a mate (Brouwer, & Komdeur, 2004), or two people discussing what materials will best serve to keep out the rain. The distinction between simple personal operant behavior, such as turning a key to unlock a door, and complex verbal operant behavior, such as knocking on the locked door in order to get another person on the other side to open the door, is not dependent upon the behavior itself. Rather, it is dependent upon which organism is behaving (non-human or human) and the nature of the problem being solved.

In regards to personal operant behavior, operant behaviors directed towards solving problems are defined in terms of the *General Operant Paradigm* (Winokur, 1976). According to this paradigm, operants are classes of behavior each with an explicit topography. Within a given topography, individual responses are not considered operants themselves but are components of an operant. A complete operant

consists of a prior condition (antecedent) of deprivation, aversion, and perhaps a discriminative stimulus (“cue”) coupled with a response. When an operant is followed by certain kinds of stimuli (e.g. food, escape, sex,) the operant is strengthened. The reinforcing stimulus then increases the rate of the behavior as well as the strength of its antecedent control. When a behavior is paired with an antecedent condition and a reinforcing consequence thereby increasing response rate, the operant behavior is selected, maintained, and eventually becomes an integral part of the organism’s behavioral repertoire.

In this way, the selection of a novel behavior acquired within the lifetime of an organism (i.e., ontogenic selection) resembles the natural selection of genetic mutations (i.e., phylogenetic selection) (Skinner, 1966; 1975). Genetic mutations are selected because they are advantageous to an organism. A genetic mutation that increases the ability of an organism to reproduce will be more likely to be transmitted to subsequent generations. Similarly, within the lifespan of a single organism, novel behaviors are selected because of the reinforcement properties associated with them (Skinner, 1953; 1981). This assertion implies that, because all operant behaviors exist based on their reinforcement properties, then the evolution of a novel operant behavior first arose as a *behavioral* mutation. The possibility exists that an organism under any circumstance may accidentally emit a behavior that was not previously part of its behavioral repertoire. An organism's behavior may at any time become subject to operant conditioning because environmental conditions and the contingencies associated with them are constantly changing.

Skinner (1969) used the honeybee dance to illustrate this point. By performing the dance, a bee signals to other bees that food has been found. Initially, the dance might have appeared by accident, as a result of fatigue or from excessive excitement. Regardless as to the initial cause of the dance, the topography of the dance (i.e., the behavioral characteristics of the dance) changed based on whether the food source was plentiful or of good quality. This allowed for variations in the foraging bees behaviors to serve as discriminate stimulus that signaled critical information to the observing bees. The reinforcement potential associated with the forager's dance is based solely on the other bees’ response to it. If the other bees actually sought out and found the food source in response to the dance, then the dance was

reinforced. If perhaps the other bees sought out the food only after viewing less active behaviors, then these less active behaviors would have been learned (i.e., ontogenically selected) and the topography of that dance modified accordingly.

According to Skinner, (1969) the emergence of signaling behaviors, such as the dance of the bee, across multiple organisms is unremarkable because the contingencies responsible for the selection of the bees' behavioral responses should reinforce noticeable changes in the "dancing" behaviors emitted by the species as a whole. Therefore, it is logical to assume that the contingencies associated with any organism's behavior need not be the result of naturally occurring environmental stimuli. Instead, an organism's behavior increases the probability that organisms of the same species (i.e., intra-species contingencies) may also arrange the contingencies of reinforcement of a behavior. Similarly, an organism's behavior can also increase the probability that an organism of a different species (i.e., inter-species contingencies) will engage in a given behavior, such as when a human researcher conditions a pigeon to peck a key (operant) in the presence of an illuminated light (discriminative stimulus) in order to receive a food pellet. Under these conditions, the researcher need only reinforce the pigeon with food when it pecks the key in the presence of the light. When the light is off, reinforcement is withheld regardless of the behavior emitted. The organism will eventually learn to "discriminate" the stimuli (illuminated light) and will peck the key (response) for reinforcement (food) only when the light is on.

From the perspective of the behaviorist, operant conditioning can explain all of problem solving. For example, by learning to peck a key when a light is illuminated, the pigeon solved the problem as to how it would acquire food to eat. Yet unlike other animals, humans are uniquely capable of using verbal behavior when solving problems. While not capable of verbal behavior, other animal species might possess preferences for types of stimuli that can provide insight into how verbal behavior evolved in humans. To test this hypothesis, Roark and Kopp (2007) examined if Sprague Dawley rats preferred a multidimensional environmental stimulus when provided with a choice of responding to stimuli that contained either an additional environmental cue or one that did not. Rats were first trained to consistently respond to a tandem fixed ratio one fixed ratio one (FR1 FR1) schedule of reinforcement that

required a two-response chain of repetitive motor responses (see figure C1). The rats received food after pressing a bar once on the left side of the chamber and then pressing a bar on the right side of the chamber once when the light located above each of the bars was illuminated.

Upon learning to respond reliably to this schedule of reinforcement, the rats were then conditioned to respond to a multiple fixed ratio 2 schedule of reinforcement (see figure C2). For this schedule, a single white light randomly appeared above one of the two bars in the chamber requiring the rats to press that particular bar twice to receive a food pellet reinforcer. The tandem FR1 FR1 schedule served as a surrogate form of “personal problem-solving” and a multiple FR2 schedule was used as a surrogate form of “public problem-solving”(Roark & Kopp, 2008, p.13).

After learning both schedules, the rats advanced to the experimental phase and chose for themselves which of the two schedules of reinforcement they would be administered. The critical question of interest was which of the two schedules of reinforcement the rats would opt to experience. When given a choice, the rats opted for the multiple fixed ratio 2 schedule, thus demonstrating a preference for the extra light cue provided by this schedule. Such a preference might serve as the basis for the evolution of verbal learning exhibited by humans.

Organisms less sensitive to environmental antecedents may rely more on repetitive topographically similar motor responses when engaging in problem solving (Roark & Kopp, 2008). This results in the expenditure of more individual resources for the same reinforcers. More importantly, the evolutionary advantage of an organism sensing the antecedents to its operant responses may have favored the selection of individuals who are better at using those antecedents as a guide to more effective problem solving. The evolution of problem-solving behaviors, therefore, may be the result of the appearance of an antecedent in the form of a listener, the ontogenic selection of operant conditioning of verbal responses, and, in turn, the phylogenic selection of verbal behavior in humans.

The goal of this research was to replicate the aforementioned study using human participants in an effort to establish if *Homo sapiens* share the same preference. While much of the previous research on operant behavior utilized animal subjects, such as pigeons and rats, other theorists (Hake, 1982; Baron, et.

al, 1991) continue to affirm the necessity of examining operant behavior in humans. Accordingly, if there is to be improved understanding of human behavior, we must first examine which behaviors are similar to animal behaviors typically observed in the confines of an experimental laboratory and determine how both species responses are affected by environmental stimuli and the contingencies of reinforcement associated with them (Baron, et.al., 1991). In keeping with the premise that the same fundamental laws of nature apply to all behavior no matter which organisms emit them, (Palmer and Donahoe, 1991) this study used the same dependent and independent variables as the Roark and Kopp (2008) study. However, because this experiment involved human subjects, additional stimuli with various topographies were added and a standard personal computer (PC) was used as opposed to an operant chamber panel. It was predicted that when given a choice of concurrent schedules, participants would select the multiple schedule of reinforcement more often than the tandem schedule.

After reviewing the results of the Kopp and Roark (2007) study, it was reasonable to assume that humans would prefer to respond to an environmental cue because verbal behavior is multi-sensory and cues are a ubiquitous characteristic of human behavior. Unlike personal problem solving, which requires precurrent response control, public problem solving involves public stimulus control, which is essential for the existence of verbal behavior. For example, several different defining relationships exist between variables responsible for controlling verbal behavior in that stimuli can be verbal and nonverbal, internal, external, contain establishing operations (that alter the effects of consequences), as well as the behavior itself. Verbal operants can include pointing, touching, signing (as in sign language) gesturing, reading, writing, as well as speaking, in addition to responses in the form of facial expressions and body language. Therefore, it is important to consider the topography of the response in determining the form and function of an individual unit of verbal behavior (Michael, 1985). Further, because the participants' behavioral choices indicated such a preference, this could be an indication that sensitivity to environmental cues may be a precursor to the development of verbal behavior in its current complex form.

In addition, it was predicted that participants who chose the multiple schedule of reinforcement more often would receive more points for doing so. Specifically, a higher correlation between the

frequency of choosing the multiple-schedule (initial-link responses) and number of reinforcers obtained (terminal-link responses) was observed for participants who selected the multiple schedule of reinforcement. This hypothesis was consistent with the theoretical implications associated with Herrnstein's (1964) matching law. The matching law of effect (Herrnstein, 1964) states that, the relative response rate to initial-link responses directly corresponds to the relative magnitude of the terminal-link reinforcer. In other words, when given a choice of two individual behaviors, organisms will choose the behavior that result in higher rates of reinforcement. Moreover, R.A. de Villiers's (1977) research also found the matching law to be applicable across behaviors, conditions, and different species.

In addition, Herrnstein's matching law (1961) has also established that the context in which a reinforcer appears relative to other reinforcers and stimuli present when the organism is behaving can be another variable associated with the strength of an operantly controlled behavior. Therefore, one must consider how reinforcers interact with one another and how that interaction affects the ontogenic selection of a behavior. The natural characteristics of reinforcers and their interactions can be examined in this way by utilizing a concept called substitutability.

Substitutability (based on consumer demand theory) and the matching law are equivalent in that both concepts are indicative of the relationships / interactions associated with each (commodities / reinforcers) and are not based on a single quality or individual trait (Rachlin, 1989). Additionally, choices between commodities (reinforcers) among consumers are also analogous to concurrently available response choices relative to their reinforcement properties that are readily available within an environment and can be easily substituted for other reinforcers. Further, when "two commodities are used jointly, these goods can be considered complimentary" (Baumol, 1972) indicating that the topography of individual stimuli and their controlling reinforcers are not necessarily an important indicator of operantly controlled behaviors. Commodities that are not used jointly are considered to be either independent or substitutes. Specifically, according to economic theory, commodities operate on a continuum based on their relationship properties. For example, goods that can be substituted for one another lay at one end of the continuum (e.g., wool hats and earmuffs; raincoats and umbrellas), while

complimentary commodities (e.g., peanut butter and jelly, beer and peanuts), lay on the extreme opposite pole of the continuum. At the center are commodities that are considered independent, as are oranges and tennis balls (Green & Freed, 1993). According to Green and Freed, (1993) however, these items may be similar in size, shape and weight but independent when considering their nutritional value. However, oranges and tennis balls easily move to the substitutability end of the continuum when considering their value when used for juggling. Due to the complexity and multimodal nature of stimuli and reinforcement properties associated with verbal behavior, additional stimuli were added to the original procedures used in the Roark & Kopp (2008) study.

While the research here replicated the Roark & Kopp (2008) study utilizing the same visual stimuli in the first condition, a linguistic auditory component (recorded voice) replaced the visual stimuli for the second condition followed by the combination of both the visual and linguistic stimuli in condition three. The fourth and final condition included all three stimuli presentations in order to assess a preference for each condition individually by concurrently providing a choice of all three.

The addition of the linguistic (vocal) component as a discriminate stimulus is consistent with employing operant procedures to determine the possible evolution of verbal behavior in that Salzinger, et.al. (1962) were able to obtain operant control of vocal responses in dogs utilizing various schedules of reinforcement. First, they utilized a fixed-ratio schedule of reinforcement to produce topographically similar responses of bar pressing and vocalization, and then were able to control those same vocal responses with an external visual stimulus. They were then able to sustain both a motor response (bar pressing) and a vocal response utilizing a multiple schedule of reinforcement that was then redirected to a FR 10 FR 10 chain, which resulted in concurrent responding. Their results indicate that operant conditioning of vocal responses in lower animals is possible and reiterates our contention that verbal behavior in humans may have initially appeared as a complex operant behavior controlled by external environmental consequences. Considering that additional environmental cues provide organisms with greater ability to discriminate, it was predicted that participants would prefer the visual cue to the linguistic cue when separate, but would choose to respond more often when presented with both visual



and linguistic stimuli. To that extent, it was further suggested that additional cues regardless of individual topographical characteristics increase the probability of behaviors that lead to reinforcement.

One potential concern of porting this research from animals to humans is that humans might become consciously aware of the contingencies, fundamentally altering the nature of the behavior exhibited by humans relative to animals. To account for this possibility, participants were directly questioned about whether or not they became aware of the contingencies. Specifically they were asked, “Were you aware of the contingencies of reinforcement associated with the behaviors required for this experiment?” Questions were presented in the form of a questionnaire presented at the end of the experimental session. It was predicted that participants would answer “No” more often than “Yes” to this question. Furthermore, it was predicted that When asked, “Did you prefer to follow the light and/or voice when responding or did you prefer to press the keys in the specified order to gain points?” participants would indicate a preference for following the light and/or voice (cue).

Because all behavioral responses occur as a result of the standard three-term contingency relationship of (a) antecedent (b) behavior and (c) consequences, participants should find following the light cue and/or voice to be more reinforcing than the repetitive motor responses associated with the tandem schedule alone. Consequently, the majority of everyday human behaviors are prompted by environmental “cues” that have sometimes become so strongly discriminated that many are not aware they are responding to them. For example, most individuals’ do not need to stop and think when approaching a yellow light while driving. The yellow light signals or “cues” the driver that the light is about to turn red and to proceed may have negative or punishing consequences. Further, the use of an alarm clock is typical for most people in that they rely on the negatively reinforcing buzzer to wake in the morning and begin their day. The removal of such a loud annoying stimulus is also reinforcing in that turning off the alarm increases the likelihood of the same behavior when the alarm sounds on another occasion.

## CHAPTER 2

### METHODS

#### *Participants & Design*

Fifty-two (N=52) undergraduate students enrolled at the University of Texas at Arlington participated in the experiment in exchange for partial fulfillment of a course research requirement. One participant was excluded because he/she failed to follow instructions, and one participant failed to complete demographic information. There were approximately an equal number of males and females. The majorities of participants were 18 to 21 years of age, freshmen or sophomores, members of ethnic minority groups, and were right handed (see Table 2.1).

Table 2.1 Demographic Characteristics of the Sample (N=50)

Demographic Variable	N	Percentage
Gender		
Male	24	48%
Female	26	52%
Age		
18-21 Years	39	78%
22-25 Years	11	22%
Education Status		
Freshman	21	42%
Sophomore	17	34%
Junior	9	18%
Senior	3	6%
Handedness		
Right	49	98%
Ambidextrous	1	2%
Ethnicity		
African American	6	12%
Asian	11	22%
Hispanic	11	22%
Caucasian	18	36%
Mixed Race	1	2%
Other Race	3	6%

Participants were randomly assigned to complete one of forty-eight programs in a 3 (condition: level 1= Auditory (Vocal) Stimuli, level 2 =Visual Stimuli, level 3 = a combination of both Auditory

(Vocal) & Visual Stimuli) X 2 (schedule: multiple, tandem) within subjects factorial design in which the modality of stimuli presented was manipulated. All participants were exposed to thirty trials of each of the four conditions. The visual condition exactly replicated the stimuli and procedures used in the Roark and Kopp (2008) study. For the linguistic (auditory) condition, stimuli were presented in the form of an auditory linguistic prompt (recorded voice). The visual and auditory condition presented both visual and auditory stimuli. The multi condition consisted of the presentation of all the stimuli from the three conditions simultaneously and was presented to all participants as the final condition. With the utilization of a random number computer program, the order in which each condition was presented to each participant was randomly assigned. For example, participants were randomly assigned to receive the visual stimuli condition, the auditory, or the combination visual/auditory condition first. The multi condition was always presented last. The experiment was counterbalanced, which resulted in forty-eight different experimental programs.

#### *Materials*

A standard computer and keyboard (PC) along with two speakers attached was used to administer the experiment. The E-Prime software program (Psychology Tools Inc.) was used to present the protocol and collect the data.

#### *Procedure*

Upon arrival, all participants were asked to print their name on a sign in sheet located on a table in the front of the classroom. The assigned participant number was related to the order in which each individual arrived to that particular experimental session. The researcher waited approximately five minutes past the scheduled time to allow late comers. To begin the session, the researcher verified that all individuals were in the correct place and were there to participate in the study entitled “*Verbal Behavior of Mice and Men.*” Following verification participants were asked to read and sign a standard consent form. Those participants who consented to participate in the study were seated in one of eight rooms that contained a desk with a computer, monitor, keyboard, speakers and a single chair. Participants were then asked to complete a general information questionnaire that asked them to provide basic demographic

data: participant number provided by the researcher, their age, major area and year of study, gender, as well as ethnicity. Questionnaires were administered using the E-Prime software program (Psychology Tools Inc.).

Following the completion of the demographic questionnaire, the researcher started the randomly assigned E-prime program used to present all phases of the experiment by individually selecting the specific program loaded appropriate to that participant. The participants were instructed to press the space bar on the computer keyboard after the researcher closed the door behind them. Written instructions were then displayed on a black screen with white type along with a recorded voice reading each of the four conditions' instructions. The initial instructions were as follows;

*Welcome to the experiment!*

*In a moment, you will be presented with the opportunity to earn points by responding to different stimuli under four different conditions.*

*Response instructions will be presented prior to each individual condition, in order to assist you in earning as many points as possible.*

*Your task is to respond by pressing the correct key(s) in the order specific to that condition. You will earn one point for every correct sequence of responses! You will know that you have responded correctly when an animated figure appears signaling "Great Job" followed by a point counter screen that will calculate and track the total number of points earned. If you press the wrong keys for the selected condition, another animated figure will appear signaling "OOPS" followed by black screen. The system will then shut down for approximately (5) seconds after which time the choice screen for that trial will re-appear, giving you another chance to respond correctly and earn points! The goal is to earn as many points as possible before your session ends!*

*Remember, it is completely up to you how you choose to respond!*

**TO BEGIN YOUR FIRST TRIAL PRESS THE SPACEBAR!**

**GOOD LUCK!**

Following the visual and auditory presentation of the instructions, participants completed 10 practice trials before each condition began. The experiment lasted approximately 30 minutes.

### *Visual Condition (SVS)*

Participants completed 30 trials in the visual condition. For the visual condition, the initial link stimuli was presented in the form of a steady green light for the tandem schedule and a blinking green light for the multiple schedule (see *Figure C.3A*). If the participant selected the steady light, the tandem schedule was presented in the form of two white lights (see *Figure C.4 A*). The correct response for this condition was to press the green key on the left side of the keyboard once followed by another single key press on the green key located on the right side of the keyboard (see *Figure C.5*). If the multiple schedule was selected, one white light randomly appeared on either side of the computer screen (see *Figure C.4B*), at which point the participant needed to twice press the green key on the keyboard that corresponded to the location of the light on the screen for reinforcement (see *Figure C.6*).

Correct responses resulted in the presentation of an animated figure signaling “Great Job” (see *Figure C.7A*) followed by the addition of a point to the point counter screen that tracked the total number of points earned. Afterwards, the initial link choice screen for that trial re-appeared. Incorrect responses resulted in the presentation of another animated figure signaling “OOPS” (see *Figure C.7 B*) and a “time-out” black screen (see *Figure C.7C*) that prompted a system shut down for approximately (5) seconds. After 5 seconds lapsed, the initial link choice screen for that trial re-appeared giving the participant another chance to respond correctly and earn points. All reinforcement and punishment screens are depicted in Appendix A

### *Auditory Condition (LS)*

Participants also completed 30 trials in the auditory condition. The procedures for the auditory linguistic condition were the same as the visual condition (SVS) except the visual stimuli presented in the tandem and multiple schedules were omitted and replaced by auditory prompts. For the auditory condition, the initial link stimuli was presented in the form of a steady “red” light for the tandem schedule and a blinking “red” light for the multiple schedule (see *Figure C.3B*). If the participant selected the steady light, the tandem schedule was presented in the form a black screen as depicted in *figure C.4C* and an auditory recording of a voice saying “Left Key, Right Key”. The correct response for this condition was

to press the “red” key on the left side of the keyboard once followed by another single key press on the “red” key located on the right side of the keyboard. If the multiple schedule was selected, the same black screen was presented accompanied by a voice saying either “Left Key, Left Key” or “Right Key, Right Key” depending on which response location was randomly selected by the program. The correct response was to press the indicated red button (left or right) twice.

As in the visual condition, correct responses resulted in the presentation of an animated figure signaling “Great Job” followed by a point counter that calculated and tracked the total number of points earned. Incorrect responses resulted in the presentation of another animated figure signaling “OOPS” and resulted in a “time-out” black screen which prompted a system shut down for approximately (5) seconds. After 5 seconds had lapsed, the initial link choice screen for that trial re-appeared giving the participant another chance to respond correctly and earn points.

#### *Visual and Auditory Condition (CSC)*

The visual and auditory condition combined both the visual (SVS) and the auditory (LS) stimuli from the visual and auditory conditions. In other words, participants responded to both visual cues and auditory (vocal) cues. As shown in *figure C.3C*, the initial link response screen consisted of two “blue” lights of which one was steady and the other was blinking. If the participant selected the steady light, the tandem schedule was presented in the form of two white lights as illustrated in the previously referenced *figure C.4A* with an accompanying vocal cue that stated “left key, right key”. Selection of the blinking light resulted in the presentation of the multiple schedule, and the presentation of one white light (see *Figure C.4 B*) that randomly appeared on either side of the computer screen. In addition, a vocal prompt stated “Left Key, Left Key” or “Right Key, Right Key” dependent upon which response location was randomly assigned by the program was also presented. For the multiple schedule, the participant needed to press the corresponding color key on the keyboard two times for reinforcement. Correct and incorrect responses resulted in the same outcomes as in the conditions described previously.

### *Multiple Stimuli Condition (Multi-CSC)*

For the multiple combination stimulus condition, the initial link stimuli for all conditions were presented concurrently providing participants with the option to choose between previously presented stimuli and schedules. As *figure C.3D* illustrates, the initial link response screen contained two green, two red, and two blue lights each with one of the lights blinking (multiple) and the other steady (tandem).

The two green lights presented stimuli for the visual condition, the two red lights for the auditory linguistic condition and the two blue lights for the combined visual and auditory condition. If the participant selected a blinking light associated with any of the previously described conditions, the corresponding schedule of reinforcement was presented. For example, selection of the blinking “blue” light resulted in the presentation of both visual and auditory stimuli and the multiple schedule of reinforcement. If the steady “red” light was selected, stimuli were presented in auditory form consisting of a vocal prompt save for the accompanying black screen and the tandem schedule. Correct and incorrect responses resulted in the same outcomes as in previous conditions.

As a manipulation check, participants were directly asked “Were you aware of the contingencies of reinforcement associated with the behaviors required for this experiment?” The Chi-square Test of Goodness of Fit for awareness of associated contingencies revealed a significant difference between participants  $\chi^2(1, N=51) = 7.08, p=.008$ , Cohen’s  $W = 0.37$ . As predicted, 69% of the participants indicated that they were unaware of the contingencies of reinforcement directing their behavior while 31% said that they were aware.

The manipulation check in which participants were directly asked whether or not they became aware of the contingencies was significant in that more individuals said they were not aware than those who indicated that they were aware of the contingencies on their behavior. This result is consistent with previous cognitive research on subliminal priming. Specifically, Aarts, Custers, and Marien (2008) found that when participants were subliminally primed with words associated with exertion, individuals displayed more forceful effort when asked to use a handgrip than individuals who were not primed.

Indicating that conscious awareness of the contingencies that govern a behavior is not a necessity in order

to operantly condition. There is however, an alternate explanation. Participants may have been unfamiliar with the terms such as, “contingency of reinforcement,” because it was a forced answer question, they may have simply guessed by answering either yes or no to the question.



## CHAPTER 3

### RESULTS

The measure of choice preference was assessed in two ways; first by the number of initial-link responses per schedule component (multiple vs. tandem) and then by the number of points obtained (terminal-link responses) per schedule component. The number of initial-link “choice” responses for each schedule of reinforcement condition conceptually represents the relative frequency of “choosing” a particular schedule component over the other. These values are provided in Table 3.2. Self-report data describing the participants’ preferences were used to further test the hypotheses. Additionally, examining the correlations between gender and the outcomes, as well as adding gender as an independent variable in the statistical tests of the hypotheses, tested the potential influence of gender on the outcomes of interest. No significant effects of gender were found so the analyses were not reported.

Table 3.1. Number of Trials, Points, Selections & Percentage of Correct Responses

Condition	Number of Points <i>M (SD)</i>	Number of Times Selected <i>M (SD)</i>	Percentage of Correct Trials
<u>Individual Conditions</u>			
Visual (30 Trials)			
Tandem	10.90 (9.08)	10.90 (9.08)	100%
Multiple	18.32 (9.12)	18.52 (9.18)	99%
Audio (30 Trials)			
Tandem	10.94 (8.29)	10.94 (8.29)	100%
Multiple	18.92 (8.37)	18.98 (8.32)	99%
Audio-Visual (30 Trials)			
Tandem	10.74 (8.20)	10.74 (8.20)	100%
Multiple	18.92 (8.28)	19.00 (8.24)	99.5%
<u>Multiple Choice Condition (30 Trials)</u>			
Visual			
Tandem	5.28 (6.01)	5.46 (6.10)	93.7%
Multiple	5.60 (6.21)	5.68 (6.19)	96.5%
Audio			
Tandem	3.30 (3.25)	3.46 (3.47)	97.8%
Multiple	5.28 (6.16)	5.30 (6.15)	99.5%
Audio-Visual			
Tandem	3.36 (4.76)	3.50 (4.89)	96.7%
Multiple	6.60 (8.62)	6.60 (8.62)	100%

*Hypothesis 1.* In regards to the first hypothesis, it was predicted that when given a choice of concurrent schedules, participants would select the multiple schedule of reinforcement more often than the tandem schedule. To test this hypothesis, a 3 (condition: level 1= Auditory (Vocal) Stimuli, level 2 =Visual Stimuli, level 3 = a combination of both Auditory (Vocal) & Visual Stimuli) X 2 (schedule: multiple, tandem) repeated measures ANOVA was performed utilizing the number of selections made for each type of stimuli within each schedule of reinforcement. The test revealed a significant multivariate main effect of schedule,  $F(1, 49) = 22.072$ ,  $p < .001$ , partial  $\eta^2 = .311$ , power = .996. As expected, participants selected the multiple schedule ( $M = 18.833$ ,  $SE = .854$ ) more often than the tandem schedule ( $M = 10.860$ ,  $SE = .846$ ). The multivariate main effect of stimuli was also significant  $F(2, 48) = 5.779$ ,  $p = .006$ , partial  $\eta^2 = .194$ , power = .847. As predicted, participants preferred the combination of visual and auditory ( $M = 14.87$ ,  $SE = .073$ ) over the visual only ( $M = 14.71$ ,  $SE = .086$ ). Contrary to expectations, participants preferred the auditory ( $M = 14.96$ ,  $SE = .024$ ) more so than the visual cues and there were no difference in preference between the auditory and the combination visual and auditory stimuli. Finally, the analysis did not reveal a significant interaction between stimulus type and schedule,  $F(2, 48) = .017$ ,  $p = .984$ , partial  $\eta^2 = .001$ , power = .052.

Self-report data were used to further confirm the first hypothesis. Specifically, it was predicted that when asked, “Did you prefer to follow the light and/or voice when responding or did you prefer to press the keys in the specified order to gain points?” participants would indicate a preference for following the light and/or voice (cue). The Chi-square Test of Goodness of Fit revealed no differences between participants observed and expected preferences for these stimuli,  $X^2(1, N=51) = 2.60$ ,  $p = .46$ , Cohen’s  $W = 0.23$ . Contrary to expectations 29% of the participants preferred to respond to only visual stimuli in the form of a light, 16% preferred to respond to the vocal stimuli, 25% preferred to respond to a combination of both visual and vocal stimuli and 29% indicated a preference for pressing the keys in the specified order to obtain points. These results did not indicate differences between preferences for visual stimuli and pressing the keys in the specified order.

*Hypothesis 2.* It was predicted that participants who chose the multiple schedule of reinforcement more often would receive more points for doing so. Specifically, a higher correlation between the frequency of choosing the multiple-schedule (initial-link responses) and number of reinforcers obtained (terminal-link responses) would be observed. The matching law of effect (Herrnstein, 1964) states that, the relative response rate to initial-link responses directly corresponds to the relative magnitude of the terminal-link reinforcer. In other words, when given a choice of two individual behaviors, organisms will choose the behavior that result in higher rates of reinforcement.

To confirm this hypothesis, a Pearson’s correlation analysis was used to establish if a correlation existed between the number of points obtained and the number of selections for each schedule of reinforcement. As expected, selection of the multiple schedule (initial-link responses) was positively correlated with the number of reinforcers obtained (terminal-link responses) regardless of the mode in which stimuli were presented, see Table 3.2 for correlations.

Table 3.2 Correlations

	Audio Multiple Selection	Visual Multiple Selection	Audio-Visual Multiple Selection	Audio Multiple Points	Visual Multiple Points	Audio-Visual Multiple Points
Audio Multiple Selection	1.00					
Visual Multiple Selection	.25	1.00				
Audio-Visual Multiple Selection	.51**	.00	1.00			
Audio Multiple Points	1.0**	.24	.51**	1.00		
Visual Multiple Points	.26	.99**	.02	0.26	1.00	
Audio-Visual Multiple Points	.51**	.00	.99**	.51**	.02	1.00

\*\* . Correlation is significant at the 0.01 level (2-tailed)

*Hypothesis 3.* Participants were predicted to prefer the visual cue to the auditory linguistic cue when presented separately. However, it was also hypothesized that they would choose to respond more often to a combination of both visual and linguistic stimuli overall rather than either visual or auditory cues presented in isolation.

To test this hypothesis, a 3 (condition: level 1= Auditory (Vocal) Stimuli, level 2 =Visual Stimuli, level 3 = a combination of both Auditory (Vocal) & Visual Stimuli) X 2 (schedule: multiple, tandem) repeated measures ANOVA was performed on the mean number of responses made to each of the condition types in the final multi stimuli condition. For this final condition, all of the previously presented stimuli and their associated schedules were presented simultaneously for selection and reinforcement. In other words, participants were presented with all six conditions and given the option to choose between them. Contrary to predictions, there was no significant difference between stimuli topography and schedule,  $F(2, 48) = 3.486$ ,  $p = 0.68$ , partial  $\eta^2 = .066$ , Power = .449. ns. Participants did not show a preference for auditory and visual stimuli.

## CHAPTER 4

### DISCUSSION

The objective of this research was to test the hypothesis that humans prefer certain forms of environmental cues. Specifically, it was predicted that humans, like other animals, would prefer environmental cues that provided more exacting information. This was tested using an operant conditioning paradigm in which participants were presented with a tandem versus multiple schedule of reinforcement. It was predicted that when given a choice of concurrent schedules, human participants would select the multiple schedule of reinforcement more often than the tandem schedule. As expected, the hypothesis was supported. Like their non-human counterparts from the Roark and Kopp (2008) experiment, human participants selected the multiple schedule more often than the tandem schedule.

It was also predicted that participants who chose the multiple schedule of reinforcement more often would receive more points than those participants who chose the multiple schedule less often. The hypothesis was supported in that the selection of the multiple schedule (initial-link responses) was highly correlated with the number of reinforcers obtained (terminal-link responses) regardless of the mode in which stimuli were presented. Specifically individuals who chose the multiple schedule received more points under all stimulus conditions indicating the multiple schedule was more reinforcing. These results are in line with Herrnstein's law inasmuch as, when given a choice between two behaviors, organisms will choose the behavior that results in the most reinforcers.

For the final condition, all previously presented stimuli and their associated schedules were presented simultaneously for selection and reinforcement. This condition provided a head-to-head test of stimuli preference. Contrary to predictions, there was no significant difference between selections of stimuli based on topography and schedule. The premise was that individuals would prefer visual stimuli more often than auditory (linguistic) stimuli when presented separately because visual stimuli is easier to discern and can be identified from distances both far and near. However, when presented with a

combination of both visual and auditory stimuli it was hypothesized that there would be a preference for this condition more often when given a choice. Unfortunately the hypothesis was not supported in that no significant difference was found between stimuli preference when presented simultaneously. This null result could possibly be due to the number of trials presented at the end of the experiment. In comparison to the other two conditions the multiple presentation condition would have had a third of the statistical power. Thus, ninety trials may have yielded significant differences in the multiple choice condition because participants would have a more comparable number of opportunities to make selections when given the choice of multiple forms of stimuli.

While this research is more theoretical in nature and no definitive claim can be made as to why human participants would prefer to follow a cue when given the choice of concurrent schedules, it is possible that such a preference may be indicative of verbal behavior in its most rudimentary form. For example, the Roark and Kopp (2008) study found that rats more often than not preferred the additional stimuli of the multiple schedule and behaviorists are of the belief that only humans possess verbal behavior, their research posited a possible basis from which verbal behavior may be possible for lower animals through evolution. Thus, it would appear that the presence of additional antecedents coupled with a behavior is by its very nature more reinforcing than repetitive environmental manipulation of stimuli. Therefore, future research on the development of verbal behavior should direct attention to not only the contingencies of reinforcement on behaviors but also the context in which multidimensional stimuli affect behavior when attempting to foster behavior change.

While the present findings are consistent with a behavioral approach to the study of operant conditioning, there are other theories that attempt to explain the acquisition of verbal behavior and language that can also account for these findings. In particular, the results of the present study are consistent with a cognitive perspective. Specifically, an organism would strive to learn information in a fashion that would allow for greater subsequent retrieval of information. Having multiple cues that more concretely specify the specific response would allow for better subsequent retrieval, from the perspective of encoding specificity and transfer appropriate processing. For example, when referencing the use of

cues in recall and recognition studies, Tulving (1973) states “the effectiveness of a particular cue depends on how the to-be-retrieved item was encoded at input...and that the trace itself is simply the link between encoding conditions and the retrieval environment (p 370)”. Furthering the view of other cognitive psychologists who suggest that incidental and intentional learning is dependent upon what stimuli are available within the learning environment (Postman, 1964).

Regardless of the perspective taken, the present study suggests that humans use numerous forms of environmental stimuli, and these forms of stimuli likely allow for improved learning. The present findings provide a theoretical perspective from which to interpret applied research on the remediating oral language deficits in special populations. For example, Choe & Stanton (2011) used a computerized form of speech therapy for individuals with cognitive-language deficiencies, Broca’s aphasia, and apraxia due to a brain injury. In their study, they found that the presentation of stimuli (words) utilizing both visual and auditory representations as opposed to the presentation of either separately enhanced patients’ cognitive retrieval and verbal ability to produce functionally relevant words after continually practicing the words. Exposure to both forms of stimuli concurrently resulted in improved auditory comprehension as well as enhanced vocal expression among patients. One interpretation of these results is from a cognitive perspective. The formation of memories that involve multiple pathways to learned information results in a more robust memorial trace. However, memory is simply another term for learning and these results are readily interpretable from a behavioral perspective. From a behavioral perspective, these individuals responded better to multi-dimensional cues because humans are more predisposed to seek such environmental stimuli out and respond to them.

In conclusions, the present study contributes to the large body of work in the behavioral sciences. Moreover, these data contribute to previous literature in animal behavior by verifying that findings observed in other species are applicable to humans. The current study provides compelling evidence that humans prefer enriched forms of environmental stimuli. Future research investigating the acquisition of language might benefit from adopting a behavioral perspective, in hopes of identifying if this preference is an adaption that facilitated the development of language.

APPENDIX A  
DEMOGRAPHIC QUESTIONNAIRE



Welcome

Please Complete the Following Demographic Questionnaire  
Press the Spacebar to Begin.

Please tell us you're Gender by pressing the appropriate key  
0 = Male 1 = Female

Please tell up your age.

- 1 = 18-21
- 2 = 22-25
- 3 = 26-29
- 4 = 30-34
- 5 = 35-39
- 6 = 40+

Please tell us your current level of education.

- 1 = Freshman
- 2 = Sophomore
- 3 = Junior
- 4 = Senior

Handedness: Which hand do you use most often to  
complete everyday tasks (e.g. writing)?

- 1 = Left
- 2 = Right
- 3 = Ambidextrous (able to use either hand proficiently)

Please tell us your Ethnicity

- 1. African American
- 2. Asian
- 3. Hispanic
- 4. Caucasian
- 5. Mixed Race
- 6. Other \_\_\_\_\_

Thank You

Please press the space bar and inform the Researcher  
that you have completed questionnaire # 1.

APPENDIX B  
EXPERIMENTAL QUESTIONNAIRE

## Experimental Questionnaire

Please answer the following questions regarding your thoughts and opinions about the experiment. When you have finished, please inform the Researcher to receive your credit!

Press the spacebar to begin

- 1) Did you prefer to follow the light and/or voice when responding or did you prefer to press the keys in the specified order to gain points?

1 = Light  
2 = Voice  
3 = Light & Voice  
4 = Press the keys in order

- 2) Which condition did you prefer in order to receive points on the counter?

1 = Green  
2 = Red  
3 = Blue

- 3) Which condition did you prefer for pressing the Keys?

1 = Green  
2 = Red  
3 = Blue

- 4) Which condition do you think provided you with the best opportunity to earn points?

1 = Green  
2 = Red  
3 = Blue

- 5) Do you think there was a pattern associated with each of the conditions?

1 = Yes  
2 = No

- 6) If you answered YES to the previous question, please explain then press the Spacebar.

If you answered NO to the previous question, simply press the Spacebar.

*[SWITCH DISPLAY]*  
Please Press Enter to Continue

Using the scale below, please answer the following questions

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

*I found the experimental task to be...*

<i>Interesting</i>	1	2	3	4	5
<i>Easy</i>	1	2	3	4	5
<i>Difficult</i>	1	2	3	4	5
<i>Boring</i>	1	2	3	4	5
<i>Fun</i>	1	2	3	4	5
<i>Distracting</i>	1	2	3	4	5
<i>Engaging</i>	1	2	3	4	5
<i>Redundant</i>	1	2	3	4	5

I found following the {Written /Vocal Commands} was...

<i>Interesting</i>	1	2	3	4	5
<i>Easy</i>	1	2	3	4	5
<i>Difficult</i>	1	2	3	4	5
<i>Boring</i>	1	2	3	4	5
<i>Fun</i>	1	2	3	4	5
<i>Distracting</i>	1	2	3	4	5
<i>Engaging</i>	1	2	3	4	5
<i>Redundant</i>	1	2	3	4	5

- 7) Were you aware of the contingencies of reinforcement associated with the behaviors required for this experiment?

1 = Yes

2 = No

Thank You for Your Participation

APPENDIX C  
FIGURES

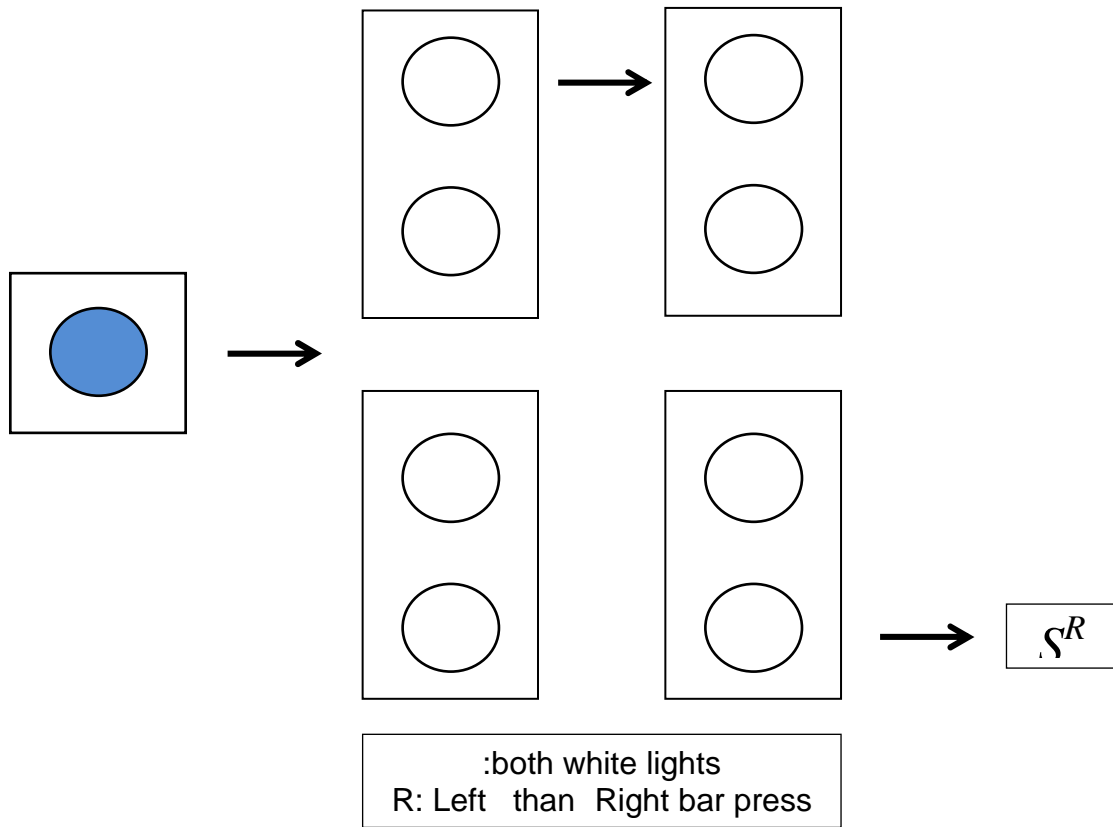


Figure C 1. Tandem FR1 FR1 schedule of reinforcement for standard operant chamber (Roark & Kopp, 2008).

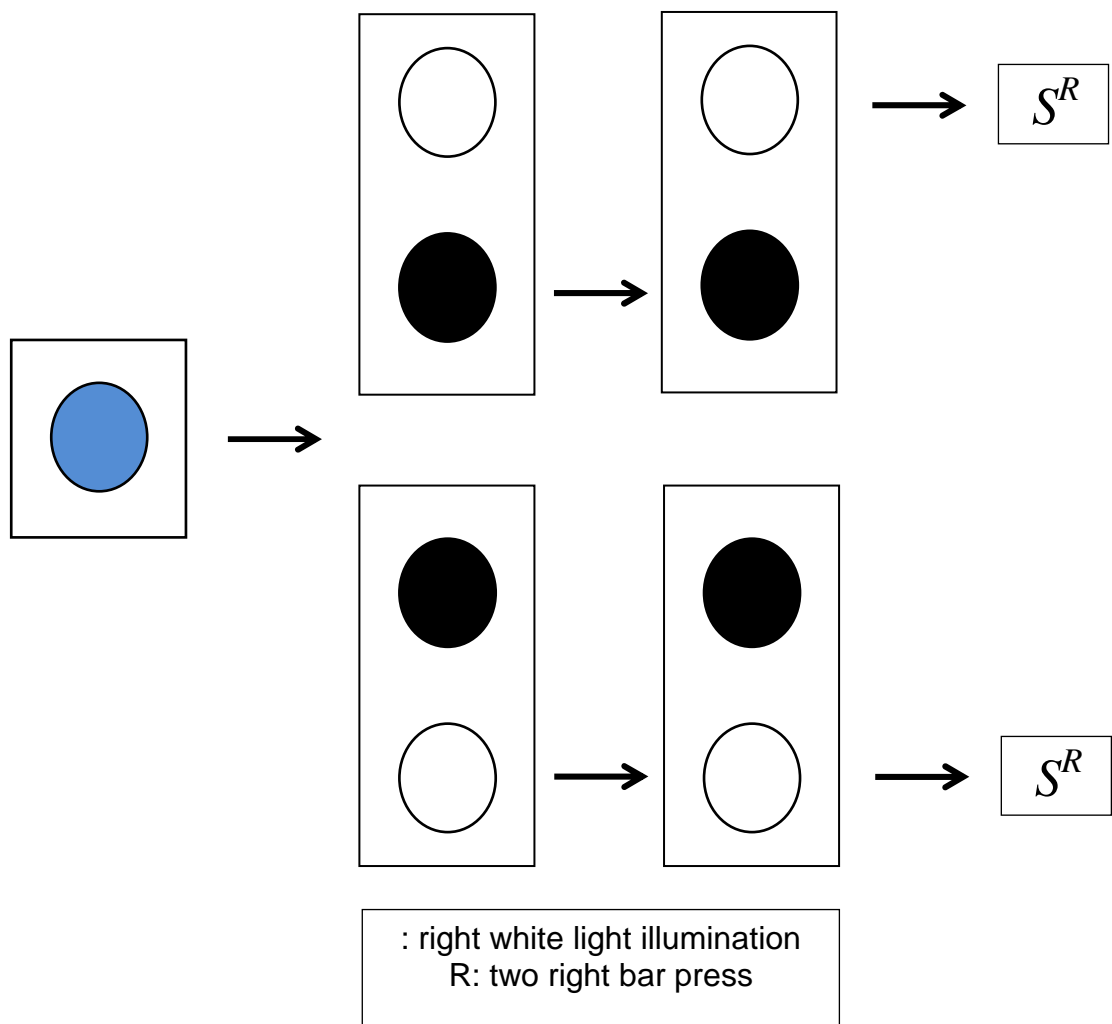


Figure C 2. Multiple FR2 schedule of reinforcement for standard operant chamber (Roark & Kopp, 2008)

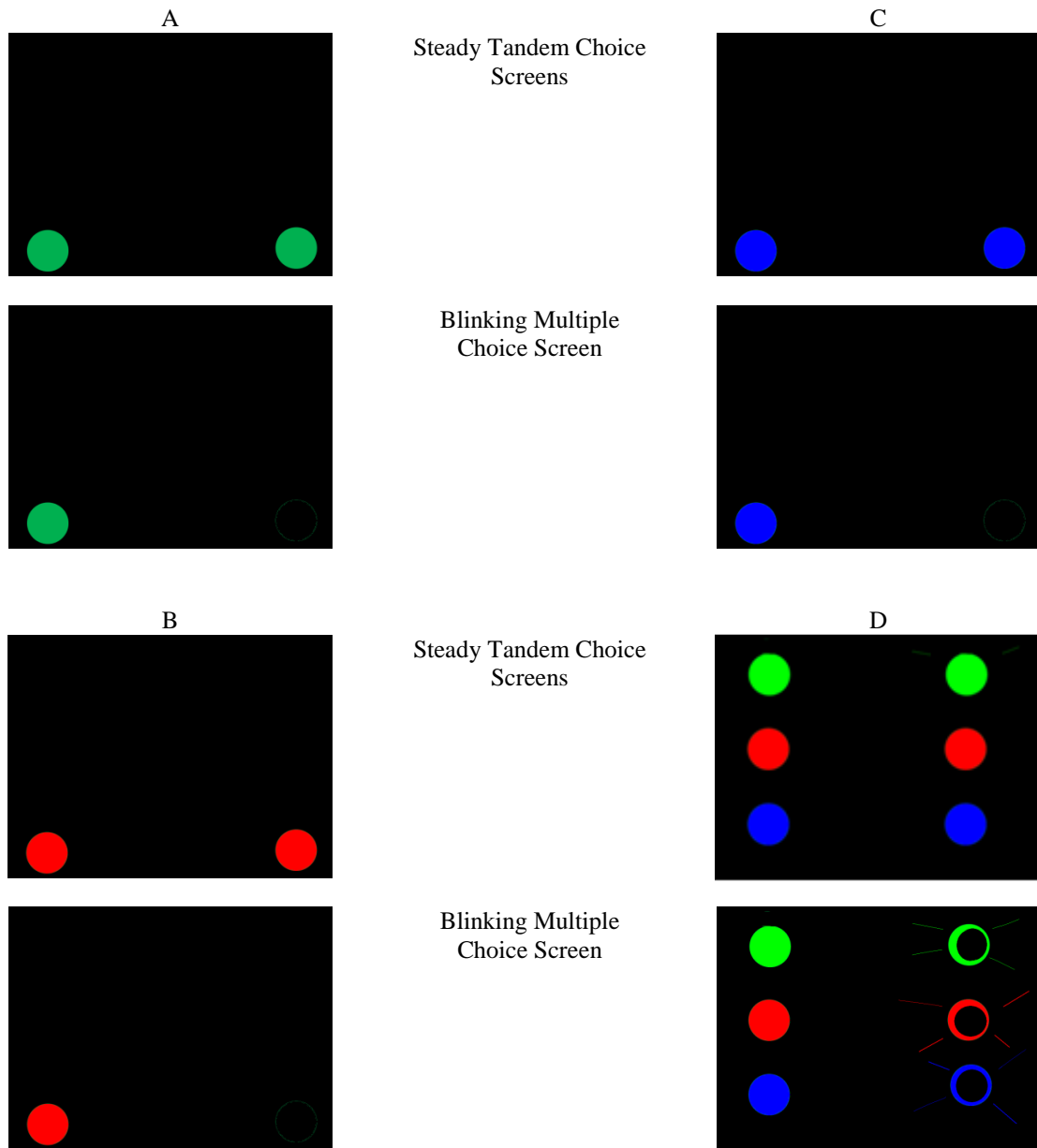
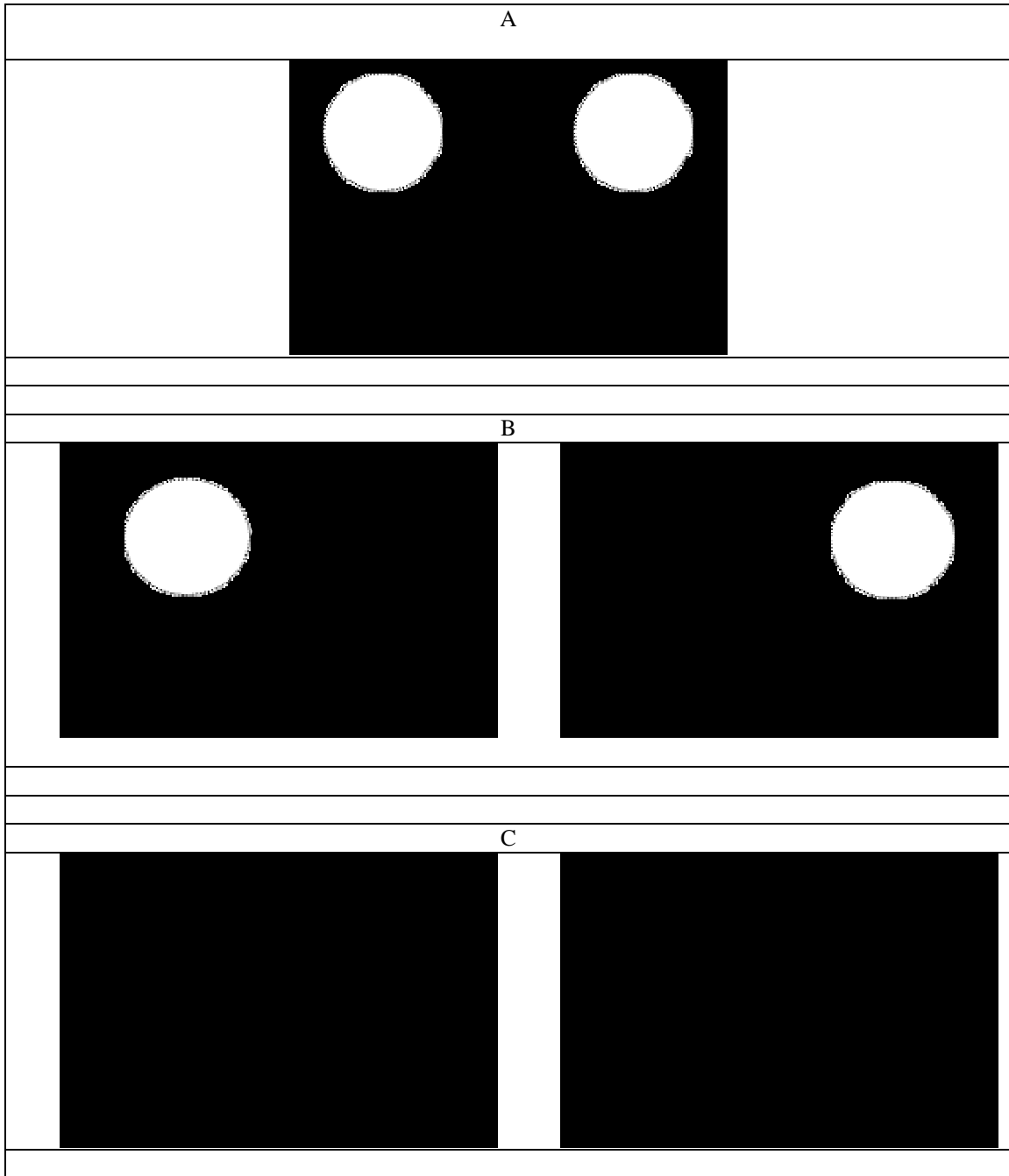


Figure C 3. Initial-link Choice Screens for E-Prime program experimental conditions with (A). Standard Visual Stimulus (SVS), (B) Auditory Linguistic Stimulus (LS), (C) Visual + Auditory Stimulus (CSC), (D) Multiple Condition (Multi-CSC)





*Figure C 4.* E-Prime visual stimulus screens for the (A) Tandem Schedule of Reinforcement, (B) Multiple Schedule of Reinforcement, Randomized, and (C) Linguistic (Auditory) Condition Stimulus (LS) Screens, no visual stimuli.

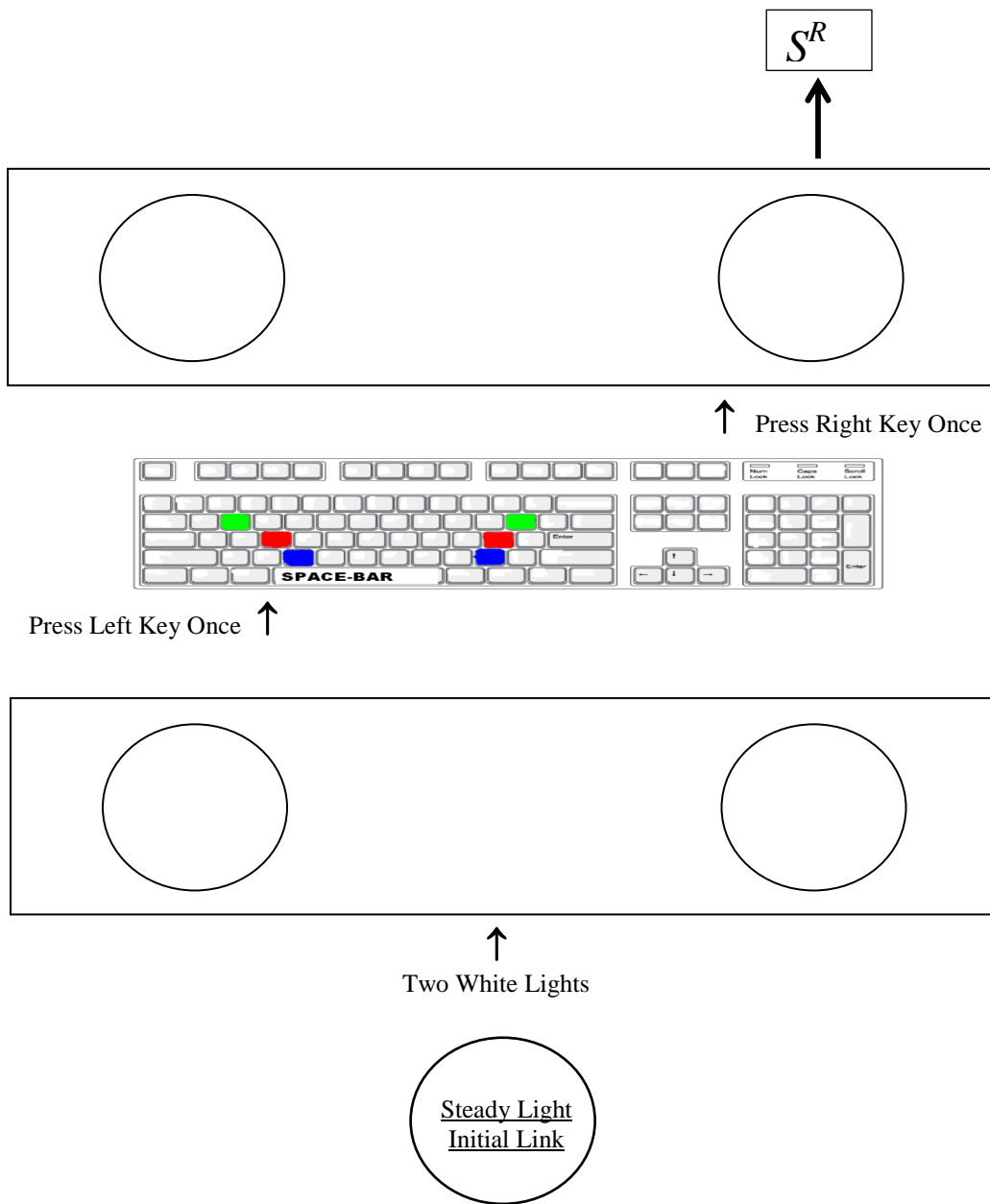


Figure C 5. Terminal link responses for the tandem schedule of reinforcement utilizing E-Prime, standard PC and a standard computer keyboard.

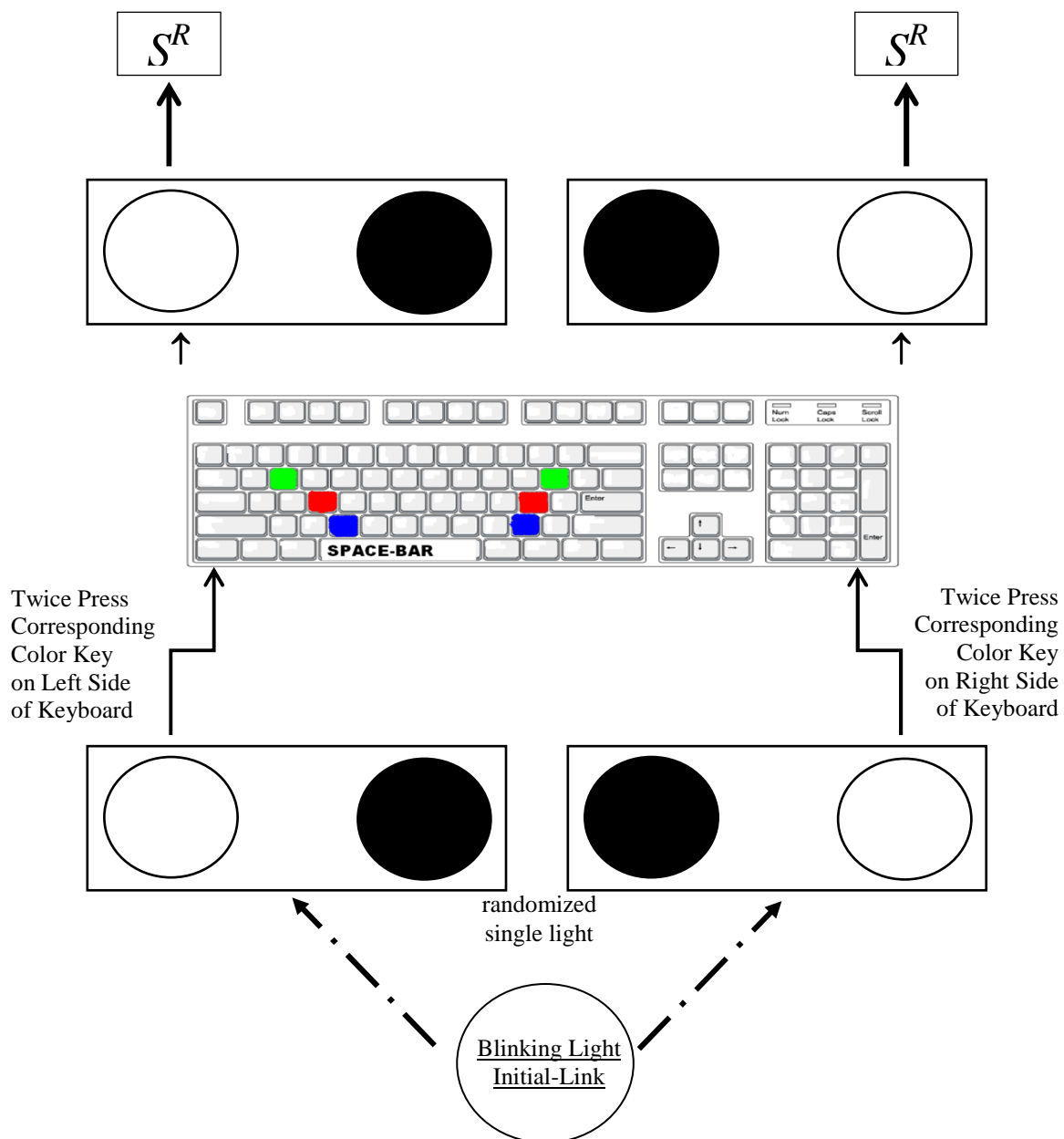


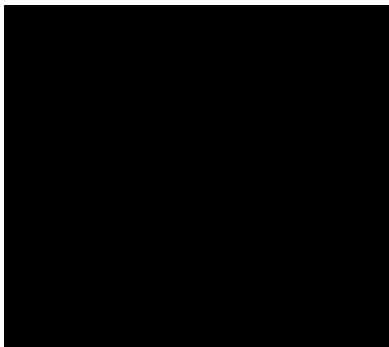
Figure C 6. Terminal link response for the multiple schedule of reinforcement utilizing E-Prime, a standard PC and standard keyboard.



A



B

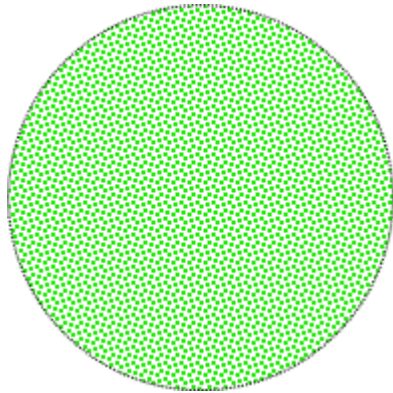


C

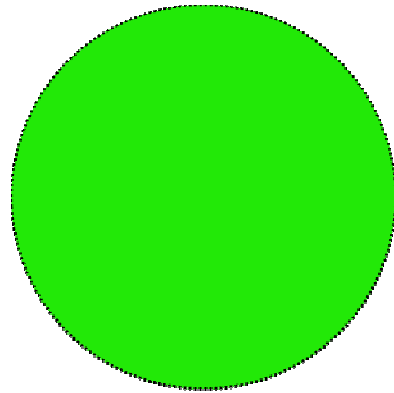
*Figure C 7.* E-Prime visual stimulus screens depicting (A) Positive Reinforcement Screen Followed by Counter Screen, (B) Punish Screen Followed by a five Second Time-out, and (C) Time-out Screen.

APPENDIX D

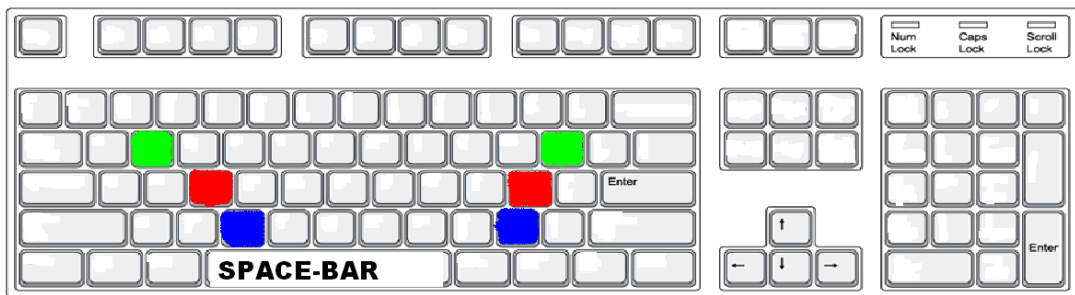
DIGRAMS OF INITIAL-LINK E-PRIME OPERANT SCREEN CONFIGURATIONS



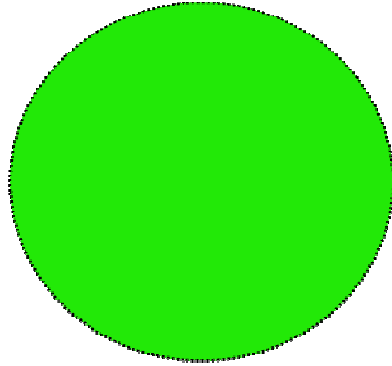
*Flashing Green Visual Condition*



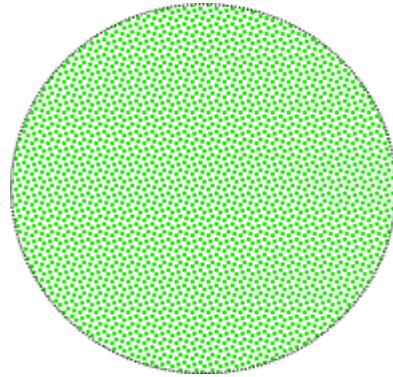
*Steady Green Visual Condition*



*Figure D.1* Concurrent Configuration “A” Condition I Visual Stimuli



Steady Green Visual Condition



Flashing Green Visual Condition

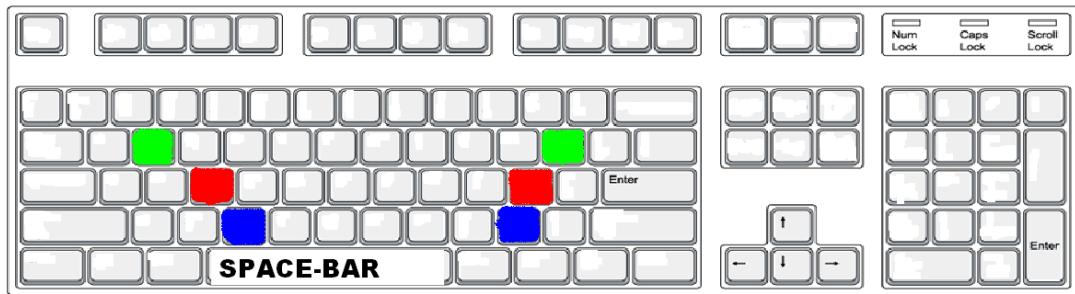
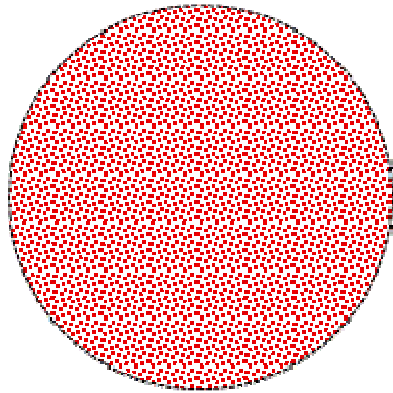
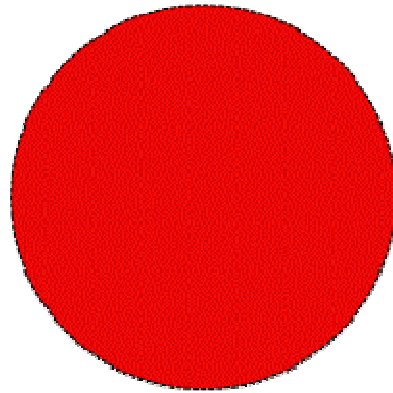


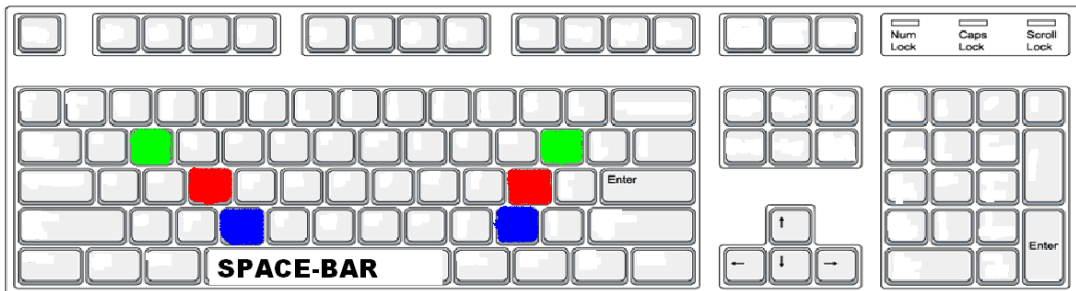
Figure D.2 Concurrent Configuration “B” Condition I Visual Stimuli



*Flashing Red Auditory (Linguistic) Stimulus Condition*

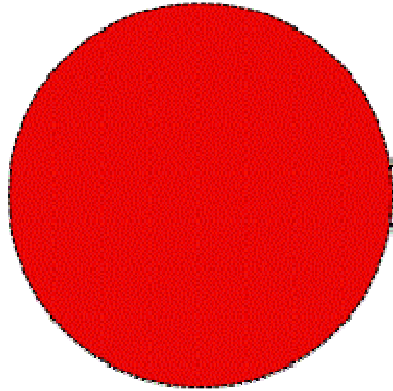


*Steady Flashing Red Auditory (Linguistic) Stimulus Condition*

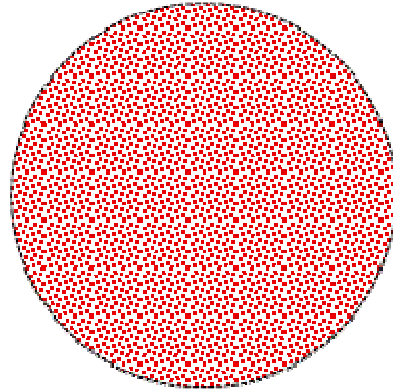


*Figure D.3 Concurrent Configuration “A” Condition II Auditory (Linguistic) Stimuli*

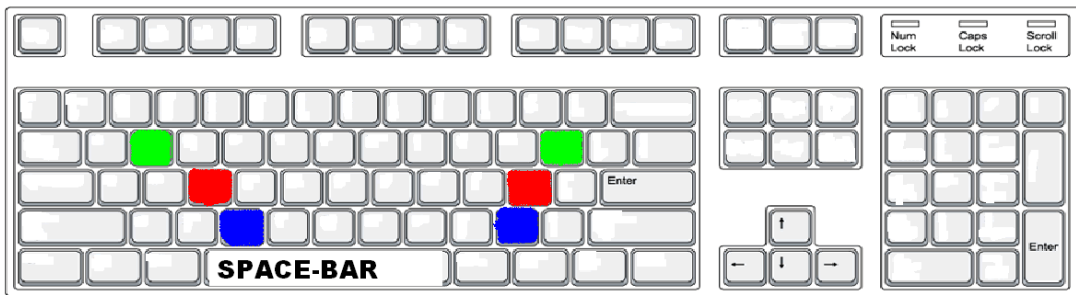




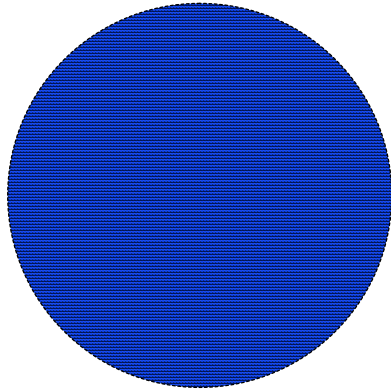
*Steady Flashing Red Auditory (Linguistic) Stimulus Condition*



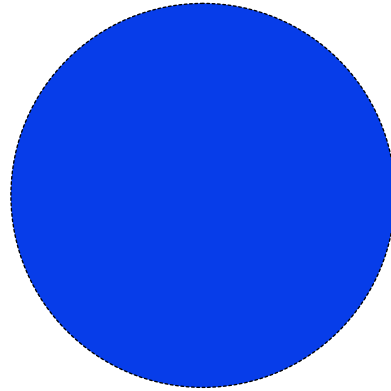
*Flashing Red Auditory (Linguistic) Stimulus Condition*



*Figure D.4* Concurrent Configuration “B” Condition II Auditory (Linguistic) Stimuli



Flashing Blue Visual + Auditory (linguistic)  
Stimulus Condition



Steady Blue Visual + Auditory (linguistic)  
Stimulus Condition

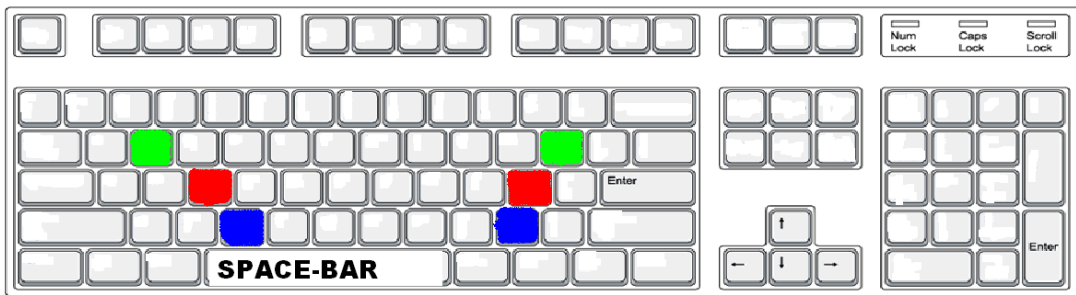
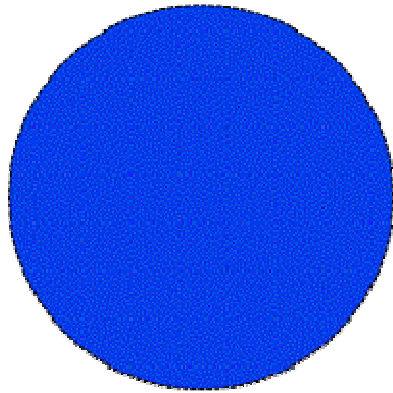
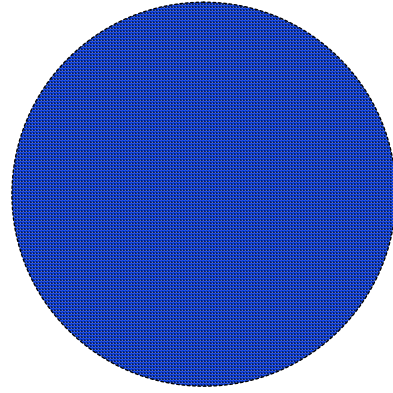


Figure D.5 Concurrent Configuration “A” Condition III Visual + Auditory (Linguistic) Stimuli



Flashing Blue Visual + Auditory (linguistic)  
Stimulus Condition



Steady Blue Visual + Auditory (linguistic)  
Stimulus Condition

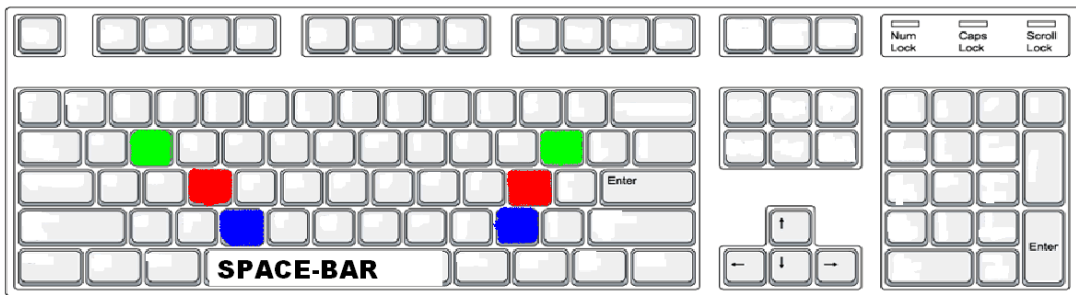
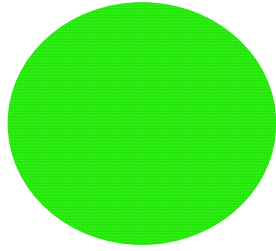
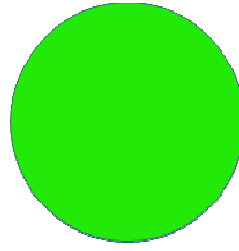


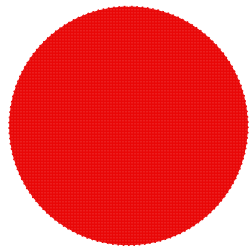
Figure D.6 Concurrent Configuration “B” Condition III Visual + Auditory (Linguistic) Stimuli



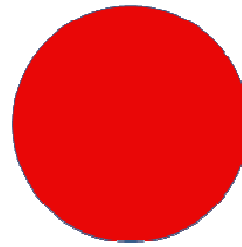
Flashing Green Visual Condition I (SVS)



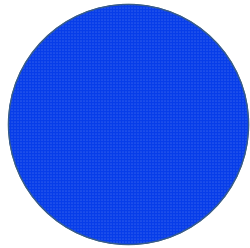
Steady Green Visual Condition I (SVS)



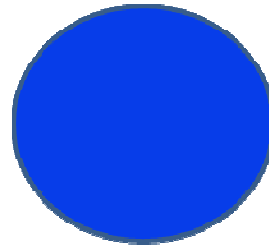
Flashing Red Auditory (Linguistic Condition II (SVS)



Steady Red Auditory (Linguistic Condition II (SVS)

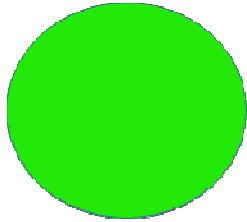


Flashing Blue Visual + Auditory (Multi-CSC)

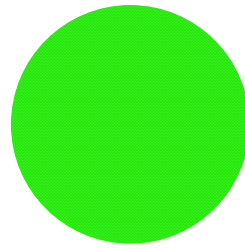


Steady Blue Visual + Auditory (Multi-CSC)

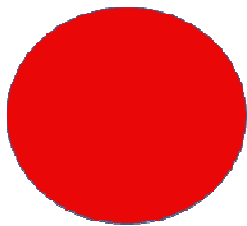
Figure D.7 Concurrent Configuration “A” Multiple Stimulus Initial-Links (Multi-CSC)



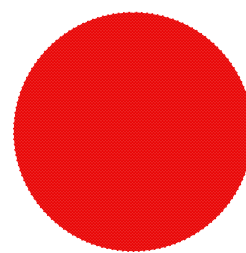
Steady Green Visual Condition I (SVS)



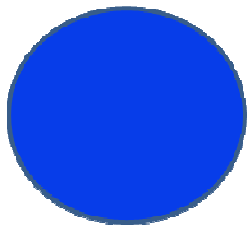
Steady Green Visual Condition I (SVS)



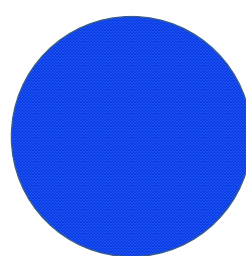
Flashing Red Auditory (Linguistic Condition II (SVS)



Steady Red Auditory (Linguistic Condition II (SVS)



Flashing Blue Visual + Auditory (Multi-CSC)



Steady Blue Visual + Auditory (Multi-CSC)

*Figure D.8* Concurrent Configuration “B” Multiple Stimulus Initial-Links (Multi-CSC)

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## BIOGRAPHICAL INFORMATION

Adrienne Eileen Lewis matriculated from The University of Texas at Arlington with a Bachelor of Arts Degree in 2006. She graduated Magna Cum Laude. Adrienne was unconditionally accepted into the Graduate Program in Psychology at UTA in the fall of 2006. Her initial work with Dr. James Kopp led to her increased interest in behavior modification. Behavior modification as it relates to chronic diseases such as diabetes and hypertension among minority groups became the corner stone of her educational interest and prompted her becoming a mentee of Dr. Andrew Baum whose area of expertise was Health Psychology. Adrienne continued to work under the supervision of both Dr. Kopp and Dr. Baum until their untimely deaths in the fall of 2010. Adrienne completed her Masters of Science Degree in Psychology in the fall of 2011 under the supervision of Dr. Timothy Odegard to whom she is eternally grateful. Adrienne plans to pursue a career in higher education and training. Adrienne's research interests primarily involve stress related cognitive impairment of learning and memory, health disparities among minority populations and the establishment of behavioral interventions to combat metabolic syndrome, hypertension, heart disease and associated comorbidities. Research in these areas are particularly necessary among these populations because minority groups such as African Americans and Hispanic Americans are both biologically and culturally predisposed to the aforementioned diseases.