THE EFFECTS OF COMMON AND UNCOMMON ELEMENTS ON THE EMERGENCE OF SIMPLE DISCRIMINATIONS

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A computerized program was designed to test whether arranging a common element in two, otherwise independent, 2-term correlations (stimulus-stimulus and response-stimulus) would result in emergent simple discriminative-stimulus properties for the antecedent stimulus relative to an arrangement with no common elements programmed. Data from 8 adult participants in this experiment indicate that common element arrangements led to relatively high rates of responding in the presence of the putative discriminative stimulus and relatively low rates or no responding in the presence of the putative s-delta during testing in extinction. Conversely, the uncommon element arrangements produced no clear discriminative control. The current data reflect a comparison of arrangements across subjects. These data support Sidman's (2000) suggestion that common elements among contingencies are sufficient to produce stimulus classes and cause class mergers. The data also have implications for thinking about the mechanism by which and the conditions under which discriminative control develops. Finally, these data have the potential to inform the programming and implementation of reinforcement contingencies in applied settings.

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CHAPTER 1

INTRODUCTION

Stimulus control contributes to nearly every behavior an individual engages in on a daily basis. From simple to complex performances, we are constantly responding with respect to the stimuli in our environment. Loosely speaking, we use the stimuli in our environment as indicators of whether or not a particular behavior will be reinforced in that moment. Over time, we learn which stimuli in our environment maximize reinforcement and which do not. The behavior of responding to a stimulus because in the past it has been correlated with reinforcement is called a discriminated operant (Catania, 2012, p. 136). Discrimination learning is the process by which any organism learns which stimuli in their environment they should be responding to in order to access reinforcement, and those they can ignore because they have either not been correlated with reinforcement or are correlated with an aversive consequence (Catania, 2012, p. 136).

An organism's behavior is described as being discriminated when it is observed to reliably change with respect to the presence or absence of a specific stimulus, called a discriminative stimulus. Discriminative stimuli are those stimuli that "set the occasion upon which a specific response will be reinforced" (Skinner, 1938, p.178). This means that the presence of that particular stimulus indicates to the organism that reinforcement is available contingent on a specific response. Stimuli that are correlated with extinction, or the absence of reinforcement, are called s-deltas (Catania, 2012, p. 137-138).

A stimulus is said to function as discriminative when, given the necessary motivating conditions, a specific response is observed to occur reliably in the presence of that stimulus, and not in its absence. Discriminative stimuli acquire their function via the establishment of a correlation between the presence of that stimulus and an existing response-reinforcer relation (Catania, 2012, p. 128; Skinner, 1938 p.178-179). It is typically discussed in both basic and applied behavior analytic literature that the correlation develops when a response is only reinforced in the presence of the intended discriminative stimulus, and not in its absence (Dinsmoor, 1995; Saunders and Williams, 1998). Whether this kind of a teaching arrangement is implemented more systematically though explicit discrimination training procedures or occurs more naturally as opportunities present themselves in the everyday environment, repeated delivery of reinforcement contingent on a particular response in the presence of some stimulus has proven reliable for establishing that stimulus as discriminative for that response (Catania, 2012; Cooper, Heron, and Heward, 2007, p. 395-396; Skinner, 1938, p. 177).

However, studies have demonstrated that a stimulus will function as discriminative for a particular response via alternative teaching methods in which the response is never reinforced in the presence of the intended discriminative stimulus (Bower and Kaufman, 1963; Colwill and Rescorla, 1988; Estes, 1943; Estes, 1948; Morse and Skinner, 1958; Walker 1942). For example, Morse and Skinner (1958) conducted an experiment to determine whether establishing separate relations between stimulus-food and response-food would be sufficient for that stimulus to exert some control over the response with which it shared a relation to food. This experiment was conducted in three phases.

In Phase 1, a pigeon was placed in an operant chamber with a light that alternated between red and green. Food was delivered on a variable interval (VI)* 1-minute schedule in the presence of one colored light, independent of the pigeon's behavior. No response mechanism

* In Phase 1 of Morse and Skinner (1958) the schedule of food delivery was described as a variable interval 1-minute schedule, indicating that food was delivered contingent on some behavior following a predetermined interval of one minute. However, food was not delivered contingent on any behavior from the pigeon; therefore, the schedule is more accurately described as a variable time 1-minute schedule of food delivery.

(e.g. key) was present during this phase. Two pigeons received food in the presence of the red light, and two pigeons received food in the presence of the green light. In Phase 2, the pigeons were placed in a chamber containing a white light and a key. The light remained white for the entire duration of this phase, and food was delivered on a VI 1-minute schedule contingent on key pecking. In Phase 3, the pigeons were placed in the chamber with the key present and the light that alternated between red and green. No food was delivered during Phase 3.

The dependent variable in this experiment was the rate of responding in the presence of the red and green lights in Phase 3. Morse and Skinner (1958) found that for all four pigeons responding occurred at a higher rate and was more resistant to extinction in the presence of the colored light that was associated with food in Phase 1, indicating that that stimulus functioned as discriminative in the absence of direct training. Relatively lower rates of responding and some extinguished responding was observed to occur in the presence of the colored light that was not correlated with food. It was apparent that the establishment of separate light-food and key peck-food correlations was sufficient for one colored light to function as a discriminative stimulus for the key peck despite that response never having been reinforced previously in the presence of that color light. Although the authors acknowledged that although their preparation did not result in as clear of discriminated responding as the more commonly used preparations (reinforce key pecking in the presence of one colored light and extinguish key pecking in the presence of the other color) might have, the finding was nonetheless significant for the study of stimulus control of operant behavior. The results of this study are fascinating because the three-term antecedent-behavior-consequence contingency was never in effect, yet when the different colored light stimuli were presented in extinction Morse and Skinner (1958) observed discriminated responding.

Traditionally, when stimuli have been observed to function as discriminative following the establishment of separate stimulus-stimulus and response-stimulus associations that share a common element they have been discussed in terms of an interaction between Pavlovian and instrumental associations (Colwill and Rescorla, 1988; Rescorla, 1994a). The pairing of a neutral stimulus and unconditioned stimulus (Phase 1) combined with the separate conditioning of a response using the same unconditioned stimulus (Phase 2) results in the neutral stimulus transforming into a discriminative stimulus that exerts control over the response in the absence of direct training (Phase 3). The common element among the two relations has been discussed as the mediator by which the transformation of stimulus function occurs; however, the exact process by which that transformation occurs has yet to be empirically identified (Rescorla, 1994b).

An example of the process by which emergent stimulus control may develop has been provided by Sidman (2000) who suggests that contingencies of reinforcement are sufficient to establish relations between all elements of the environment that interact directly with the contingency, including the response and the reinforcer. For example, when two seemingly separate contingencies share common elements (e.g. two three-term contingencies with the same response) all of the positive elements of those contingencies become related and functionally equivalent to one another. These shared relations become the mechanism by which many untrained performances can emerge.

The implication of Sidman's (2000) theory is that when two correlations are established between stimulus-food and response-food, the sharing of a common elements between those two two-term units results in an indirect relation between the stimulus and response. According to Sidman's account, emergent simple discriminative control by that stimulus over that specific response is to be expected when the two are independently correlated with the same element (i.e. food). However, when the two correlations do not share a relation to a common element, no emergent simple discriminative control is to be expected. If Sidman's account is accurate, it would provide the mechanism by which the transformation of function described by Rescorla (1994b) occurs.

There is one study which has explored the effects of stimulus and response relations to uncommon elements in a manner similar to that used by Morse and Skinner (1958). Bower and Kaufman (1963) conducted a phase-style experiment with rats in which a lack of emergent simple discriminative control was found following the establishment of stimulus-stimulus and response-stimulus correlations that did not share common elements. In Phase 1, they alternated between auditory stimuli (tone and click) while delivering food pellets in the presence of only one of the auditory stimuli. During Phase 2, they delivered water as reinforcement for lever pressing. In Phase 3, water was delivered contingent on the first lever press in the absence of any auditory stimuli followed by extinction for all responding as the same auditory stimuli presented in Phase 1 alternated.

Again, the dependent variable in this study (Bower and Kaufman, 1963) was the rate of responding during Phase 3 in the presence of both stimuli. They found that when uncommon elements (food and water) were correlated with the stimulus and the response respectively in Phases 1 and 2, the discriminative control exerted by the stimulus correlated with food in Phase 1 was weak for the response conditioned with water in Phase 2. The data indicate only a 28 percent difference in the rate of responding in the presence of both stimuli. However, that number may even have been inflated slightly as Bower and Kaufmann suspected that some of the differentiation could likely be attributed to the close proximity of the manipulandum to the feeder. The significance of these results in contrast to the results of Morse and Skinner (1958) are that the two found very large differences in the frequency and allocation of responding with respect to the two stimuli presented in Phase 3, with the principle difference in their preparations being the use of either common or uncommon elements among the two-term correlations. These findings are consistent with the mechanism that Sidman (2000) proposes could be responsible for emergent simple discriminative properties because according to that theory, no clear discriminated responding is to be expected when the stimulus and response do not share a relation to a common element.

The effects of common and uncommon elements across two-term units has yet to be explored within the same experiment or with human populations. The purpose of this experiment was to further examine the effects of stimulus and response relations to common and uncommon elements to determine whether common elements facilitate emergent simple discriminations as Sidman (2000) predicts. using similar methods to those described by Morse and Skinner (1958) with a human population.

CHAPTER 2

METHOD

Participants, Setting, and Materials

This experiment was reviewed and approved by the University of North Texas Institutional Review Board. Participants in this experiment consisted of 8 undergraduate and graduate students, three males and five females, recruited from the University of North Texas. All participation was voluntary, and participants received $5.00 in monetary compensation for their participation in this experiment following the completion of the experimental session. Participants were screened and eliminated if they had extensive familiarity with the experimental literature on stimulus equivalence or behavior analysis. Informed consent was obtained from all individual participants included in the study.

The entire experiment was completed in one session for each participant. The total time to complete the experimental session was approximately 30 minutes. Experimental sessions were conducted in an experimental running room containing one table, two chairs, one tripod, one camera, one cordless computer mouse, a desktop computer, and a portable laptop computer within the Department of Behavior Analysis. The tripod and camera were used to record all experimental sessions. The desktop computer was inactive and placed in an area on the table furthest from the participant during experimental sessions. All experimental sessions were run using a laptop computer. During sessions, participants sat at the table with the laptop placed directly in front of them. The keyboard of the computer was covered completely using white cardstock paper that was affixed to the border of the keyboard with adhesive material.

Apparatus

The experiment was entirely automated using Microsoft Office 365 ProPlus Powerpoint on the laptop computer that operated on Windows 10 software. A cordless computer mouse was also used during some phases of the experiment. The structure of the computer mouse was such that the left and right click buttons on the mouse were slightly raised, and depression of the buttons resulted in visible leveling of the top of the button with the body of the computer mouse. Only the left click button was accessible to participants during the session. The right click and scroll buttons on the mouse were disabled and covered with clear adhesive material to make them inactive and inaccessible to participants during the experiment. When present, the mouse was immobilized using the same adhesive material to affix it to one position on the table in front and to the right of the participant.

Dependent Measure and Data Collection

The dependent variable was the rate of left mouse clicks during Phase 3 of the experiment. Left mouse clicks were defined as any time the participant used any finger to depress the left click button of the cordless mouse so that it resulted in visible leveling of the top of the button with the body of the computer mouse. The computer mouse also made an audible clicking sound when the left button was depressed, however that was not included in the behavioral definition because the clicking sound was sometimes masked due to the simultaneous playing of auditory stimuli used in the experiment.

Responses were recorded using the video camera zoomed in so that only the participant's hand on the computer mouse and the computer monitor were visible in the frame. Following the experimental session, the experimenter reviewed the video of the session to collect a total count of responses per second within each 15 second interval in Phase 3.

The experimenter viewed each video slowed down to .25 speed, meaning one second in recorded time lasted four seconds when the video was reviewed. This slow-motion review allowed for a more precise and accurate count of responses during the experimental session. All videos could also be viewed in real time if necessary to acquire an accurate count. Data were collected using pencil and paper and later transcribed into Microsoft Excel to automate calculations.

General Procedure

In this experiment, visual stimuli were used as analogues of the food delivered in Morse and Skinner (1958) and auditory stimuli served as the putative discriminative stimulus and s-delta. The experiment was conducted using a between groups design. Participants were assigned to either the common element or uncommon element group. Placement of participants within groups was semi-random as we alternated individual placement in a group beginning with the common element group. Regardless of their group, the experiment was conducted in three consecutive phases: alternation of two auditory stimuli with visual stimuli appearing during the presentation of only one of the auditory stimuli (Phase 1), mouse click response conditioning with visual stimuli as reinforcement (Phase 2), and auditory stimulus alternation with no feedback to test for the emergence of simple discriminative properties of either stimulus (Phase 3).

The same auditory samples were used in the experimental preparation for both the common and uncommon elements groups. The auditory stimuli used were two music samples (Music One and Music Two), that were clearly distinguishable from each other. Music One was a high pitched, electronic style music, and Music Two was a low pitched, bass and drum style music. No pre-experiment test of participant’s ability to discriminate between these two auditory stimuli was conducted.

The only difference between the experimental preparations for the two groups was the visual stimuli that were presented in Phases 1 and 2. Individuals in the common elements group were exposed to visual stimuli in the form of images from a common category (Transportation, e.g. car, train, bus) in both phases. Individuals in the uncommon elements group were exposed to visual stimuli in the form of images from different categories in Phases 1 (Plants, e.g. tree, flower, shrub) and 2 (Animals, e.g. porcupine, cat, turtle). No categorical pretraining was conducted because the experimenters were confident in the ability of the participants involved to categorize stimuli without additional training. Brief, anecdotal post-experiment interviews indicated that all participants were able to accurately provide a category label for the categories of stimuli to which they were exposed. However, this method does not control for the possibility that categorization might have developed as a result of the experimental conditions.

The choice to use categorically related visual stimuli rather than the exact same visual stimulus presented in Phases 1 and 2 in the common elements preparation or two different visual stimuli in Phases 1 and 2 the uncommon elements preparation was informed by data and anecdotal post-experimentation interviews of pilot participants in the uncommon elements group. This information indicated that even when two visually dissimilar uncommon stimuli were presented in Phases 1 and 2, participants would still find ways to relate the two stimuli based on arbitrary features, the experimental context in which they appeared, or perceived sameness. Therefore, the use of categorical stimuli was selected to increase the likelihood that participants would relate only those stimuli that were members of the same category

Visual stimuli were presented individually at scheduled times during the experiment. The background of each image was white, and the size of each image was between one and two inches in width and one and two inches in height. The location of each image on the computer screen was determined semi-randomly so that no two pictures could appear in the same location on the screen successively. No images were repeated at any time during the entire experiment.

Common Elements Procedure

Phase 1

Following the informed consent procedures, the experimenter stated, “For this experiment you will be interacting with the laptop computer. Some instructions will be presented to you there at various points during the experiment.” Phase 1 of the experiment began immediately following this statement.

The background of the computer monitor remained white for the entire duration of Phase 1. Music One and Music Two alternated on average every 32 seconds with no pause in between until the participant was exposed to each auditory stimulus a total number of 12 times, for a combined total of 24 auditory stimulus presentations. This number of alternations and the duration of each auditory stimulus presentation was selected to allow for fulfillment of the visual stimulus presentation schedule.

Forty total images of different modes of transportation (e.g. car, plane, bicycle) were presented one at a time on a variable time (VT) 8 second schedule for a duration of one second each during the times that Music One was presented. The decision to present forty visual stimuli in this phase was selected to yoke the number of visual stimulus presentations across Phases 1 and 2. The rationale for this number of visual stimuli will be further discussed in the methods description of Phase 2. During the time that Music Two was presented, the background of the computer remained white, and no images ever appeared. Phase 1 ended after the participant was exposed to each auditory stimulus 12 times.

Phase 2

The beginning of Phase 2 was marked by a pink screen with black text reading “Please wait.” that appeared for six seconds. During this time, the experimenter placed the cordless computer mouse on the table in front of and slightly to the right of the participant. After 6 seconds had elapsed, the computer screen returned to white. No audio played during the entire duration of Phase 2.

Forty total images of different modes of transportation were scheduled to appear individually on the screen on a variable ratio (VR) schedule of 6 left mouse clicks. The choice to continue with Phase 2 until the participant had been exposed to 40 different visual stimuli was selected based on pilot participant performance. These performances indicated that twenty exposures the response-reinforcer contingency was not sufficient for a stable mouse clicking response to be conditioned. Some participants continued to engage in superstitious clicking behavior which included lengthy pauses or lengthy mouse button depressions. Thus, the number of exposures to the contingency was doubled, which anecdotally was sufficient to condition a stable mouse clicking response and extinguish any superstitious response patterns. As in Phase 1, each image was presented for a duration of one second. Phase 2 ended after the participant had been exposed to all 40 visual stimuli contingent on left mouse clicks.

Phase 3

The beginning of Phase 3 was marked by a pink screen with black text reading “Please wait. In this phase of the experiment you will receive no feedback. It is up to you to figure out what to do.” This message was displayed for a total duration of 12 seconds, after which time the computer screen returned to white. The computer mouse remained present throughout the entirety of Phase 3. Music One and Music Two alternated for fixed time (FT) intervals of 15 seconds each with no pauses between intervals. The decision to use eight brief, 15 second intervals was made in an attempt to allow for repeated replication of the stimulus effects and combat the likelihood that any extinguished responding would carry over from one stimulus interval to the next.

Phase 3 ended after eight total intervals, four 15-second presentations of each stimulus alternating, had elapsed. No consequences were provided for mouse clicks in the presence of either music sample. After all eight intervals had elapsed, the music stopped, and the experimenter ended the session.

Uncommon Elements Procedure

The procedures in the uncommon elements preparation were identical to the common elements preparation except that the images presented in Phase 1 were of the plants and the images presented in Phase 2 were of animals.

Interobserver Agreement

An independent observer collected data on the frequency of left mouse clicks during Phase 3 for a combined total of 37.5 percent of discriminative stimulus and s-delta intervals. Mean count-per-interval interobserver agreement was calculated for both types of intervals. The total percent of agreement for discriminative stimulus or s-delta interval was combined and divided by the total number of intervals of that type scored. Interobserver agreement for discriminative stimulus intervals was 90 percent agreement. Interobserver agreement for s-delta intervals was 97 percent agreement.

CHAPTER 3

RESULTS

Figure 1 depicts the cumulative frequency of responding for participants in the common elements group on a semi-logarithmic scale graph. The x-axis shows the total number of seconds (60) that each stimulus was presented. The y-axis shows the cumulative frequency of responding. The y-axis has been scaled logarithmically to allow for better visual representation and inspection of these data sets containing such a large range of values. Generally, much higher rates of responding were observed in the presence of the putative discriminative stimulus relative to responding in the presence of the putative s-delta for across all four participants in the common elements group.

Figure 2 depicts the same data presented non-cumulatively in one-second bins for participants in the common elements group where the allocation of responding across time as the two auditory stimuli alternated can be better observed. Putative discriminative stimulus intervals are shaded gray to distinguish them from putative s-delta intervals with no shading. On the x-axis is the total number of seconds in Phase 3 (120), and on the y-axis is the frequency of responding. In general, we would expect high frequencies of responding in the shaded intervals and little to no responding during the white (s-delta) intervals. With some exception in Participant 3’s responding which will be discussed in detail later, responding for these participants occurred at high frequencies throughout each putative discriminative stimulus interval and relatively low frequencies for shorter durations at the beginning of three of the four putative s-delta intervals.

Session data from participants in both groups is presented in Figure 3 to show the percentage of seconds during which a response was recorded for each of the eight 15-second intervals. The x-axis represents the interval number, and the y-axis shows the percentage from 0 to 100. Putative discriminative stimulus intervals are shaded gray and putative s-delta intervals are white. For example, if a response occurred during all 15 of the total 15 seconds in interval 1, the graph would reflect that a response was present 100 percent of seconds in interval one. The decision to include Figure 3 in addition to all other figures representing the frequency of the same data was made because it more clearly depicts the overall allocation of responding throughout each interval. In general, we observed a higher percentage of seconds containing a response for putative discriminative stimulus intervals as compared to putative s-delta intervals for each participant in the common elements group. Loosely speaking, this means that participants were responding more frequently and for longer durations throughout the putative discriminative stimulus intervals, and if responding occurred during s-delta intervals it was for shorter durations.

Participant 1 responded nearly exclusively in the presence of the putative discriminative stimulus at a mean rate of 4.46 responses per second. Responses in the presence of the s-delta occurred only during the first second of the intervals (see Figure 3).

Participant 2 also responded nearly exclusively in the presence of the putative discriminative stimulus at a mean rate of 1.70 responses per second, with a short pause in responding during the middle of the first interval (see Figures 1 and 2). Responding maintained at a high rate for the remainder of the session. A total of two responses to the putative s-delta were recorded, one occurring within the first second of the first presentation similar to participant 1, and the other occurring in the sixth second of the second presentation (see Figure 3).

Participant 3 began the session responding at a high rate in the presence of the putative discriminative stimulus (see Figure 1). Despite a lengthy pause in responding in the middle of the session, this participant responded in the presence of the putative discriminative stimulus at a mean rate of 1.75 responses per second and ended the session with accelerated rate of responding that began in the fourth discriminative stimulus interval (see Figures 2 and 3). More responding was observed in the presence of the putative s-delta during this participant's session as compared to the other participants in this group (mean rate = .88/s). Visual inspection of participant 3's non-cumulative data shows responses in the presence of the putative s-delta occurring only during the first half of the 15-second interval (see Figure 2).

Participant 4 responded at a significantly lower rate in the presence of the putative discriminative stimulus than the other participants in this group, averaging 0.36 responses per second; however, these data were consistent with those of the other participants because this participant responded almost exclusively in the presence of the putative discriminative stimulus (see Figure 1). One response in the presence of the putative s-delta occurred during the first half of the first presentation interval (see Figures 2 and 3).

Figure 4 depicts the cumulative frequency of responding for participants in the uncommon elements group in the same manner that Figure 1 did for the common elements group. Overall, higher cumulative frequencies of responding were observed in the presence of the putative s-delta relative to the common elements group. Additionally, the data paths for each participant in the uncommon elements group overlap at some point and responding extinguishes early in the experimental session. Both of these features were not present in any of the common elements data sets.

Figure 5 depicts the same frequency data for participants in the uncommon elements group on a non-cumulative graph in the same manner that Figure 2 did for participants in the common elements group. In general, we see low frequency responding that carries on across multiple intervals in the presence of both stimuli. Overall, no clear discriminated behavior can be interpreted from the frequency of responding for any of the participant's data in shown in Figure 5.

Figure 3 also depicts the percentage of seconds during each interval that a response was recorded for participants in the uncommon elements group. These data show that none of the participants in the uncommon elements group responded consistently in or throughout the putative discriminative stimulus intervals. Likewise, no clear discriminated behavior can be interpreted from the allocation of responding for individuals in the uncommon elements group presented in Figure 3.

Participant 5 began the session by responding at a high rate in the presence of both the putative discriminative stimulus and s-delta for the first three intervals, followed by a long pause in responding in the presence of both stimuli (see Figures 4 and 5). Relatively few responses occurred in the presence of both stimuli for the remaining five intervals, however more responses were recorded in the presence of the putative s-delta. Overall, responding during the session occurred at a mean rate of 0.73 and 0.40 responses per second in the presence of putative discriminative stimulus and s-delta respectively.

Participant 6 emitted zero responses during the first interval in the presence of the putative discriminative stimulus (see Figures 4 and 5). However, during the first presentation interval of the putative s-delta this participant began to respond at a high rate, and these responses carried over throughout the subsequent interval. Similar to participant 1, relatively few responses occurred following the end of the third interval. Overall, responding during the session occurred at a mean rate of 0.88 and 0.68 responses per second in the presence of putative discriminative stimulus and s-delta respectively.

Participant 7 began the session with only a single response during the first presentation of the putative discriminative stimulus, followed by a high rate of responding during the first presentation of the putative s-delta (see Figures 4 and 5). During the third interval, responding initially occurs at a high rate, followed by a pause in the presence of both stimuli. During the second half of the session, responding occurs consistently in the presence of both stimuli, followed by a pause during the final interval in the presence of the putative s-delta. Overall, responding during the session occurred at a mean rate of 0.28 and 0.25 responses per second in the presence of putative discriminative stimulus and s-delta respectively.

Participant 8 engaged in only two responses during the first half of the experimental session, one in the presence of each stimulus (see Figures 4 and 5). Responding accelerates during the second half of the fifth interval in the presence of the putative discriminative stimulus and continues in the sixth interval during the s-delta presentation. No responding occurs during the final presentation of the putative discriminative stimulus. Responding accelerates during the final interval in the presence of the putative s-delta (Figures 3 and 5). Overall, responding during the session occurred at a mean rate of 0.32 and 0.58 responses per second in the presence of putative discriminative stimulus and s-delta respectively.

Discrimination ratios were calculated for each participant (see Table 1). This ratio indicates what portion of the total number of responses were emitted in the presence of the putative discriminate stimulus. The closer the discrimination ratio value is to 1.0, the stronger the discriminative control is by that stimulus. Discrimination ratios closer to 0.50 indicate that responding in the presence of both stimuli occurred roughly equally, therefore discriminative control by ether stimulus is weak. This ratio was calculated by dividing the number of responses to the putative discriminative stimulus (S^D) by the total number of responses (S^D + S-delta). The mean discrimination ratio for participants exposed to the common elements arrangement was 0.89. The mean discrimination ratio for participants exposed to the uncommon elements arrangement was 0.52. These values are indicative of stronger discriminative control being exerted by the putative discriminative stimulus for the common elements group as compared to the uncommon elements group.

CHAPTER 4

DISCUSSON

The purpose of this experiment was to examine the effects of stimulus and response correlations to common and uncommon elements on the emergence of simple discriminations and relate those findings to Sidman's (2000) prediction that a relation to common elements is the mechanism by which emergent simple discriminative control develops. To summarize, the data for participants in the common elements group indicate that the auditory stimulus that was correlated with the same elements as the response conditioned in Phase 2 functioned as discriminative for that response in the absence of direct training. All participants in the common elements group exhibited high rates of responding in the presence of the putative discriminative stimulus and relatively low rates of responding in the presence of the putative s-delta. Visual inspection of participant three's linear session data (see Figure 2) suggests that some additional control may have been exerted by a sudden change in stimulus conditions. Another possibility may be that the putative s-delta exerted some discriminative properties due to perceived similar stimulus properties (e.g. musical characteristics). Participant 3's allocation of responding throughout the entire duration of discriminative stimulus intervals as compared to short durations of responding during the beginning of s-delta intervals provide some support for the possibility of the former conclusion (Figure 3).

The data from participants in the uncommon elements group indicate that when the auditory stimulus from Phase 1 and the response conditioned in Phase 2 do not share a relation to a common element, neither of the auditory stimuli acquire any discriminative properties for that response. Although some high rates of responding were observed, and a higher overall frequency of responding was recorded in the presence of the putative discriminative stimulus as compared to the putative s-delta for participants 5, 6, and 7, a linear analysis of responding clearly indicates a complete lack of any discriminated behavior. Participants responded indiscriminately in the presence of both stimuli for short durations and often ceased responding altogether for lengthy durations across multiple intervals which suggests that neither of the stimuli functioned as discriminative for any of the participants in this group.

This comparison of the effects of common and uncommon elements among two-term relations indicates that common elements are critical in facilitating emergent simple discriminations. When the established relations shared common elements, emergent simple discriminative performances were observed. When the established relations did not share common elements, no clear discriminated behavior was observed. This finding is consistent with Sidman's (2000) suggestion that common elements among relations facilitate emergent behavior, in this case emergent simple discriminations.

Sidman's (2000) theory of goes well beyond providing an account of emergent simple-discriminative properties as the product of a mysterious transformation of stimulus function as suggested by Rescorla (1994b). Sidman provides a detailed and useful account of the mechanism by which he predicts emergent discriminative properties can develop that is consistent with the results described by Rescorla (1994b). Even better, his account is accompanied by descriptions of a vast number of experimental preparations by which his interpretation could be supported or contradicted.

The data from this study, along with Sidman's (2000) account of emergent behavior are useful in a variety of ways. Most importantly, they help to broaden our understanding of the ways in which stimulus control of operant behavior develops. It has been well established that stimuli can acquire their discriminative function through repeated and direct exposure of an organisms to a three-term contingency of reinforcement (Catania, 2012, p. 136). However, little discussion regarding other potential means by which these stimuli acquire control has occurred despite our knowledge that the world seldom presents itself as a simple three-term contingency of reinforcement.

The finding that common elements, even among two-term concatenations, can facilitate emergent simple discriminative control by some stimuli vastly expands the possibilities of environment arrangements which may result in an organism learning certain discriminations. With that knowledge, we can also begin to understand how some seemingly spontaneous or untrained discriminated behavior may be a function of common elements among groups of related stimuli. What is more, these data lend themselves to further empirical exploration of how we might be able to teach discriminations using new or innovative methods.

The findings from this study can also be used to inform some common reinforcement procedures in applied practice. There is some evidence to suggest that differential outcomes of contingences of reinforcement result in more rapid acquisition of new skills for learners (Urcuioli, 2005; Wiist & Vaidya, 2017). Meaning, when different reinforcers (i.e. uncommon elements) are used to teach two conditional discriminations, the acquisition of those skills occurs more quickly as compared to methods which utilize the same reinforcer among contingencies (i.e. common elements). The present study found that common elements among contingencies facilitate relations between all elements of those contingencies. Given these results, it may be the case that the use of common elements procedures during teaching may cause confusion for the learner and hinder acquisition of certain skills. Thus, differential outcomes procedures may be useful for teaching in some circumstances because no conflicting between-contingency relations can be established. Ultimately, these data are consistent with the recommendation that reinforcement procedures in applied practice require serious consideration before implementation, and when possible, differential outcomes procedures should be employed to maximize learning outcomes.

CHAPTER 5

FUTURE RESEARCH AND LIMITATIONS

Future research should attempt to replicate the results of this study to determine the external validity of these findings across additional participants and experimental arrangements. Additionally, future research should explore the replicability of these findings within subject.

This study is not without limitations. No data was collected on whether participants oriented towards the computer screen or attended to the presentation of visual stimuli during any of the phases of the experiment. The results of this kind of preparation rely heavily on the participant attending to the apparatus, therefore, future research should explore the possibility of collecting data on this behavior or employing methods to increase the likelihood that participants are attending to the computer screen.

A second limitation of this study was the high rates of responding that occurred during the early seconds of some s-delta intervals for individuals exposed to the common elements arrangement suggest that an even clearer picture of the discriminated behavior might be obtained by implementing an inter-trial interval (ITI) (Figure 2). Short, 15-second stimulus presentation intervals with no ITIs were originally chosen for this experiment to mimic the methods used by Morse and Skinner (1958). However, the implementation of an ITI could potentially eliminate responses emitted during the time it takes the participant to attend to a change in stimulus or responding occasioned by the sudden change in auditory stimulus. Potential carryover effects from one stimulus to another might also be eliminated if an ITI were to be programmed into the experiment.

Finally, the decision not to test for the participant’s ability to discriminate between Music One and Music Two prior to beginning the experiment was a limitation. In light of participant

3's data (see Figure 2), the implementation of this kind of pre-assessment may have provided an overall clearer indication of the exact source of stimulus control for their responding. Any future research that employs auditory stimuli as discriminative and s-delta stimuli should ensure that the stimuli selected are discriminable by all participants.

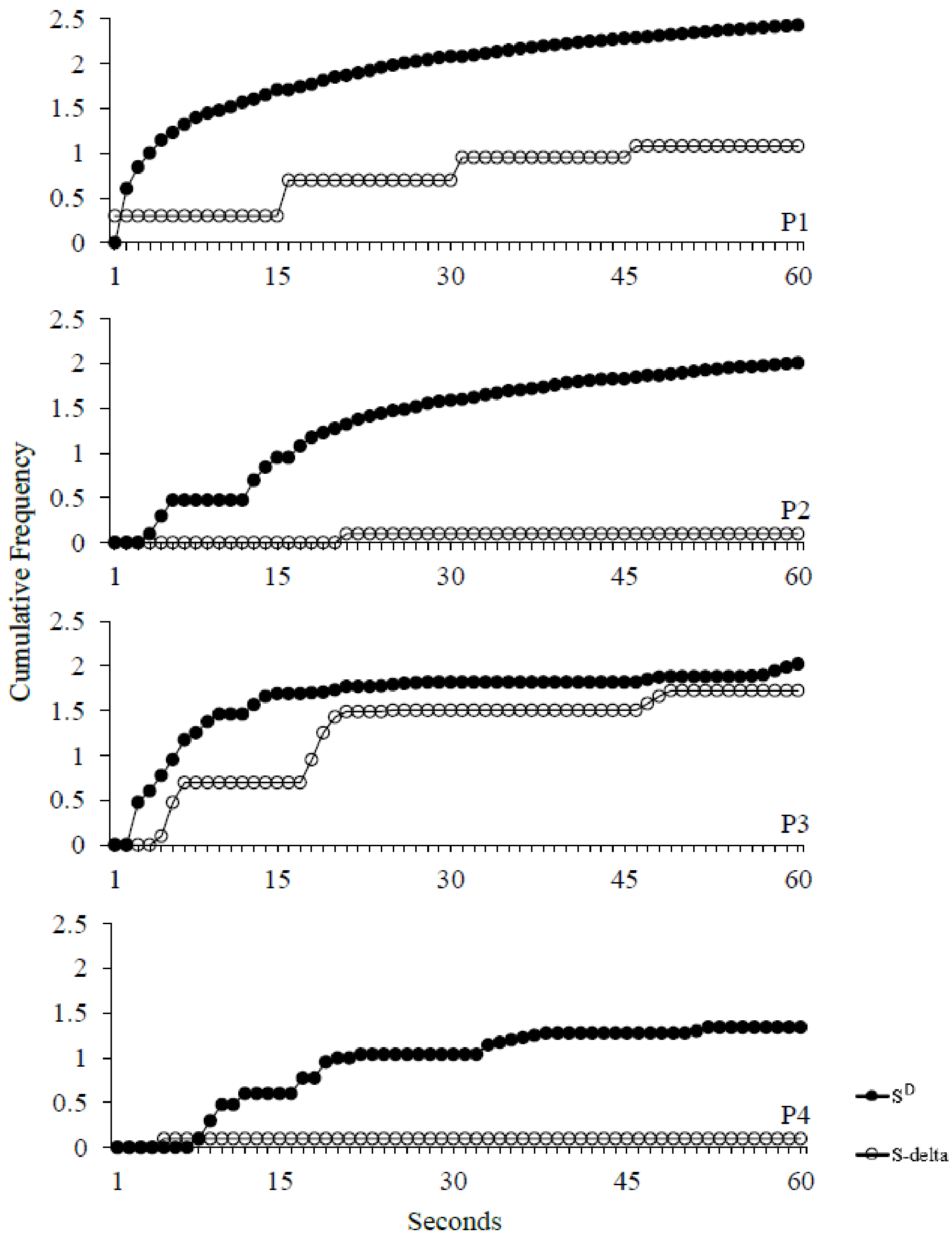

Figure 1. Graph depicting cumulative frequency of responding within putative discriminative stimulus (S^D) and s-delta intervals during Phase 3 for participants in the common elements group. The y-axis is scaled logarithmically where log10 of 1 is represented by 0.10 and log10 of 0 is represented by .001.

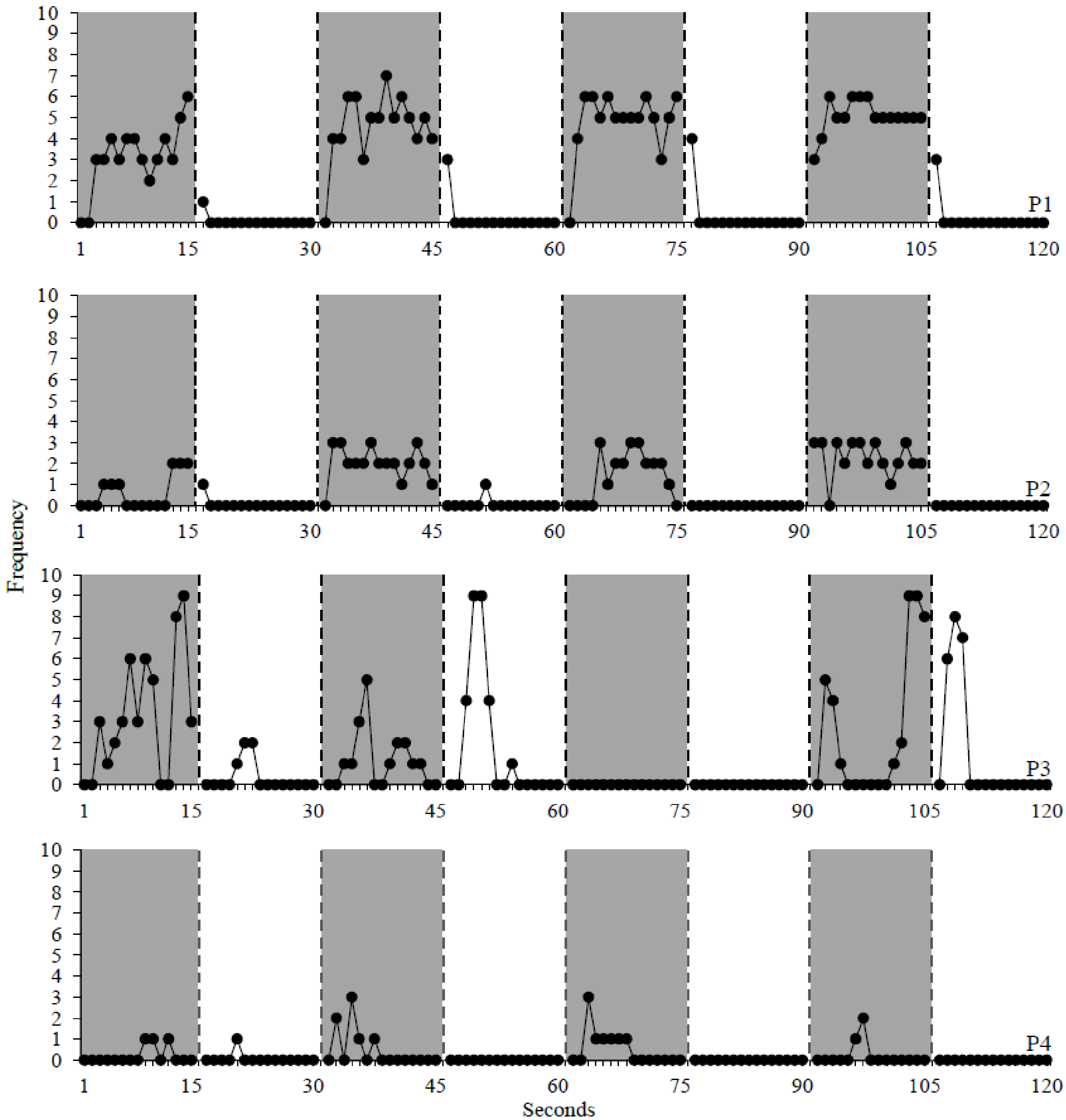

Figure 2. Graph depicting the non-cumulative frequency of responding for participants in the common elements group across the total number of seconds in Phase 3. Putative discriminative stimulus intervals are shaded, and putative s-delta intervals are white.

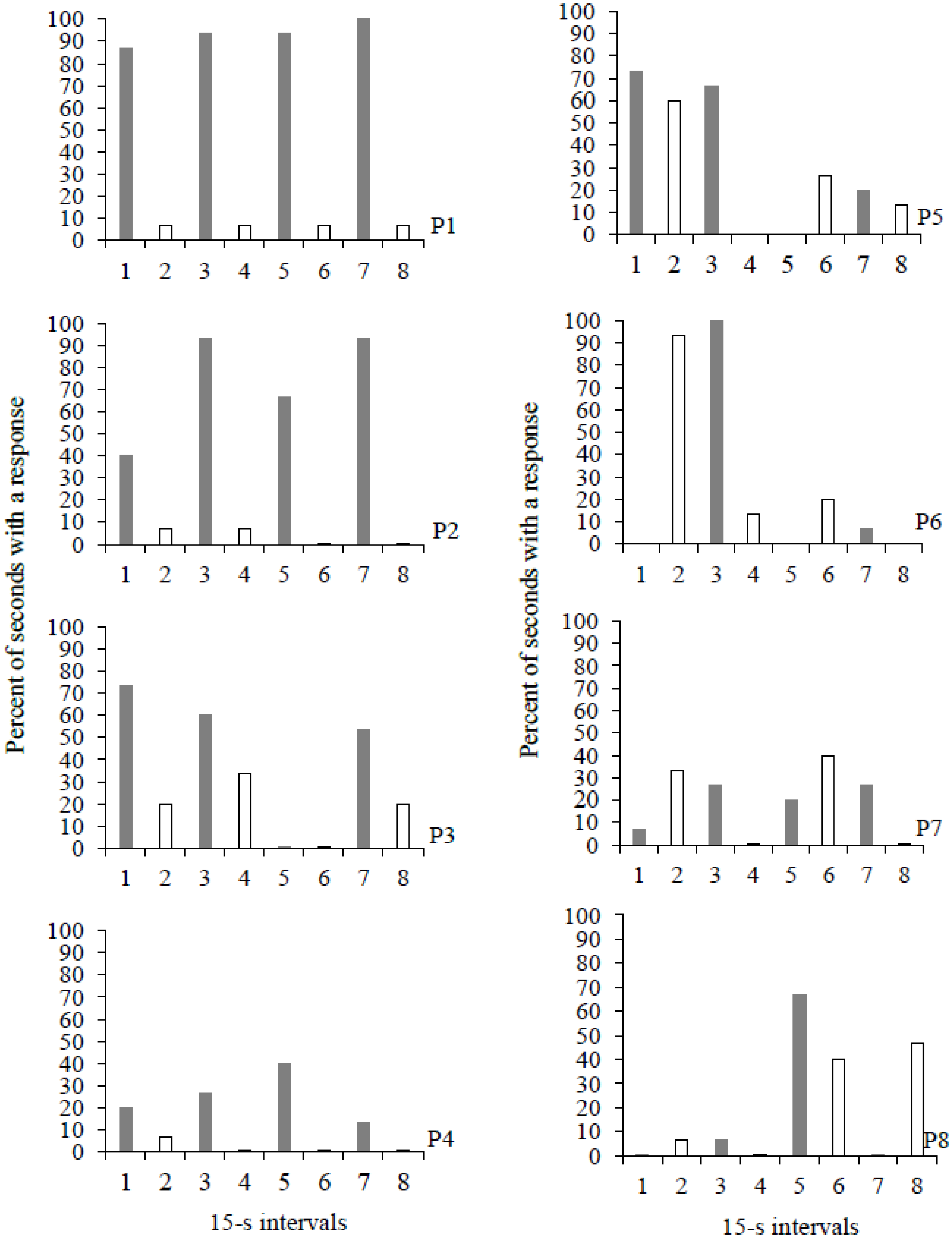

Figure 3. Graph depicting the percent of seconds during each interval in Phase 3 that a response was present for participants in the common and uncommon elements group. Discriminative stimulus intervals are shaded, and s-delta intervals are white.

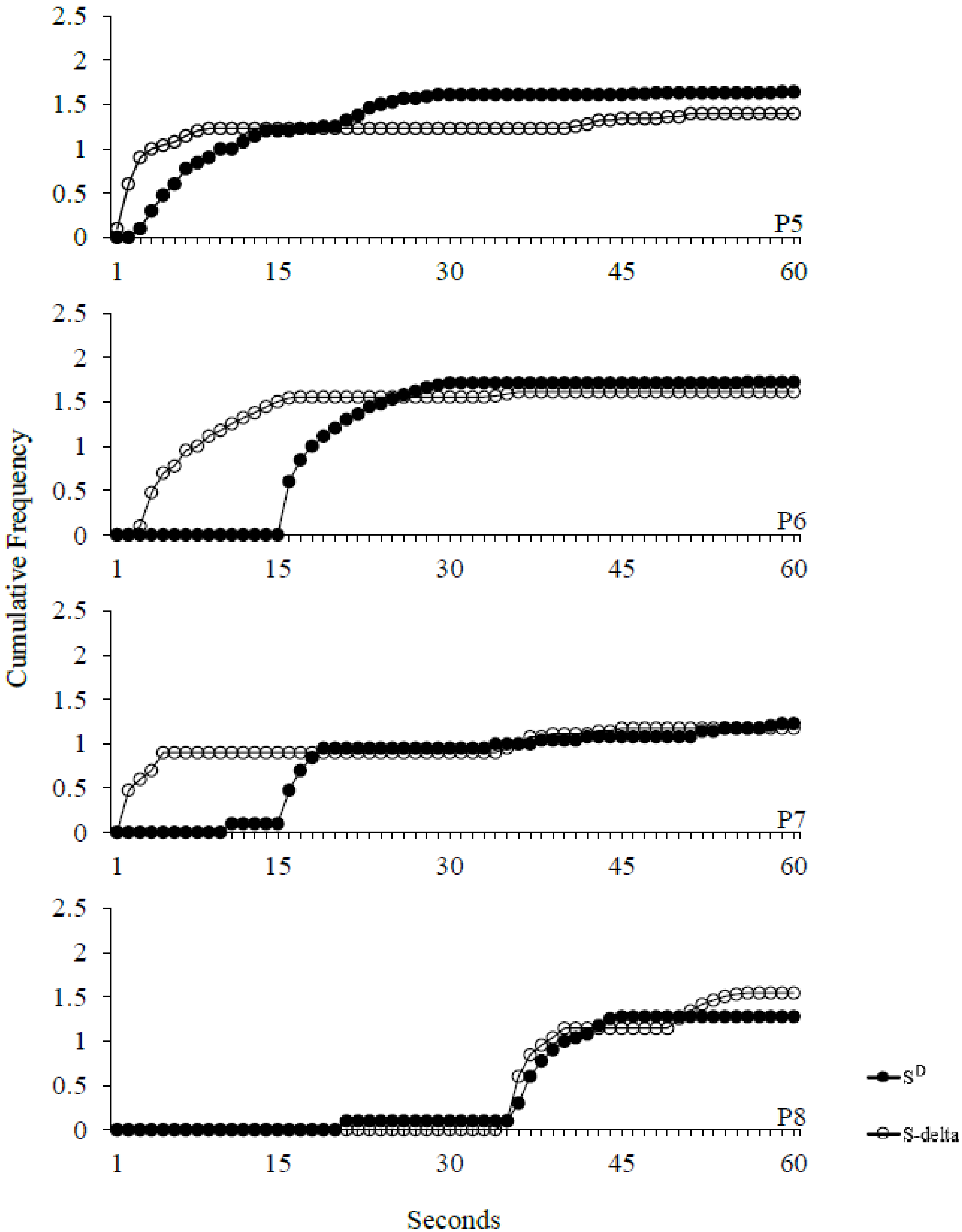

Figure 4. Graph depicting cumulative frequency of responding within putative discriminative stimulus (S^D) and s-delta intervals during Phase 3 for participants in the uncommon elements group. The y-axis is scaled logarithmically where log10 of 1 is represented by 0.10 and log10 of 0 is represented by .001.

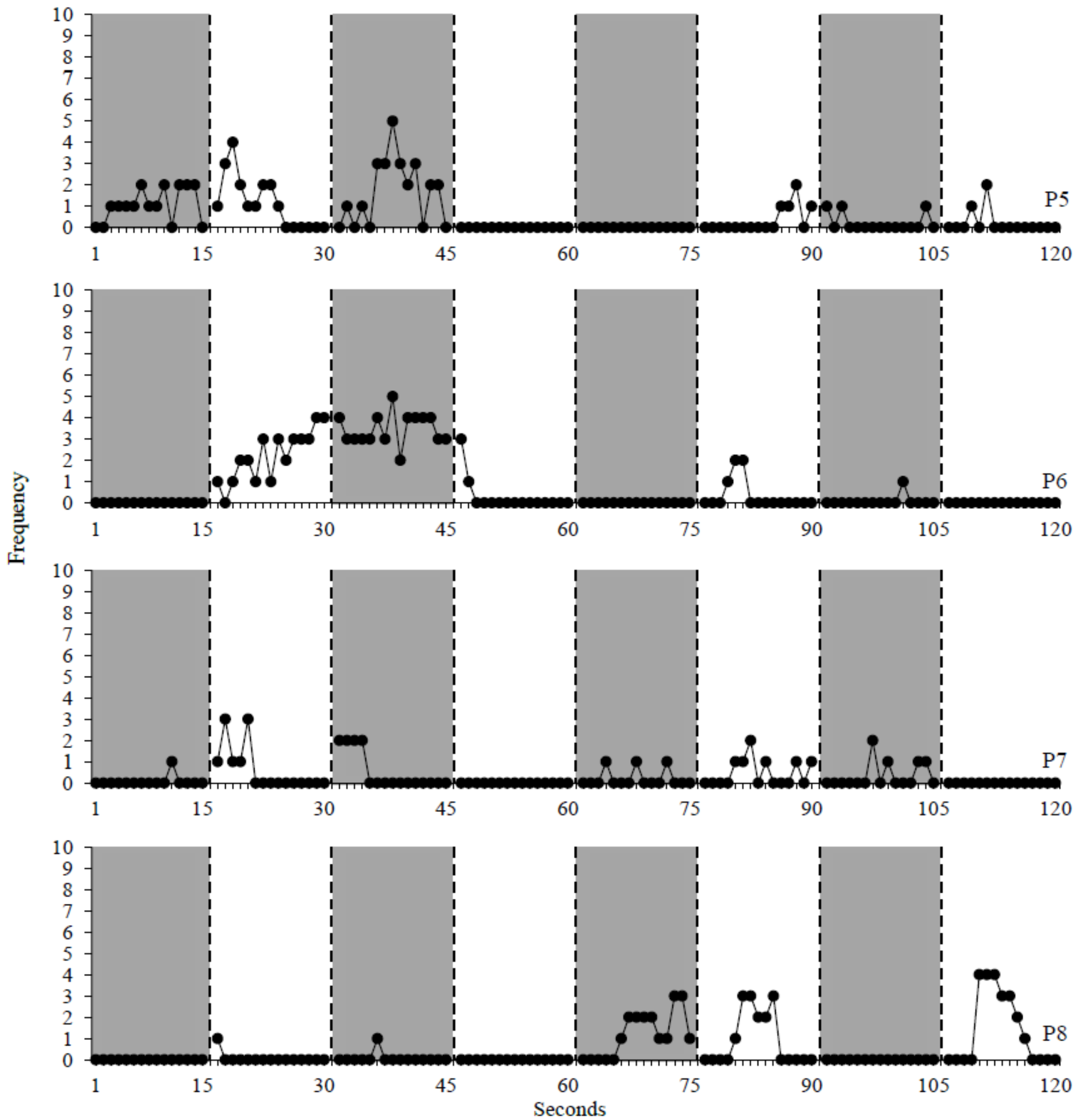

Figure 5. Graph depicting the non-cumulative frequency of responding for participants in the common elements group across the total number of seconds in Phase 3. Putative discriminative stimulus intervals are shaded, and putative s-delta intervals are white.

Table 1

Summary of Discrimination Ratios of Participants Across Common and Uncommon Elements Arrangements

	Common Elements			
Participant No.	1	2	3	4
Discrimination Ratio	0.96	0.99	0.66	0.96
	Uncommon Elements			
Participant No.	5	6	7	8
Discrimination Ratio	0.64	0.56	0.53	0.35

Note. Participant No. = Participant Number

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