

TRANSFER OF “GOOD” AND “BAD” FUNCTIONS WITHIN
STIMULUS EQUIVALENCE CLASSES

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This study compared results of two experiments that tested transfer of function in stimulus equivalence classes in a task dissimilar to (in Experiment I) and similar to (in Experiment II) the task that trained functional responding. Eleven students from UNT participated in return for monetary compensation. Phase 1 and 2 were identical in the two experiments, in which they established stimulus equivalence classes and functional responding, respectively. Each experiment then used different tasks in the third phase to test differential responding. Only participants in Experiment II demonstrated consistent transfer of function. Results are discussed in terms of how task similarity may function as a type of contextual control when there is limited experience with the task.

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INTRODUCTION

Every day humans encounter countless numbers of stimuli that participate in relational networks that continue to grow and change with experience. Human verbal behavior may add to their capacity for learning new relationships in ways not possible for the rest of the animal kingdom. The verbal abilities of humans may contribute to survival but verbal behavior could also play a role in some of the behavioral mishaps seen in humans. Some researchers investigating verbal behavior have focused on the emergence of untrained derived relations from a small number of trained conditional discriminations to explain the process in which humans begin to relate stimuli.

Consider a person who acts fearful toward a particular stimulus with which the person has no history, for example a person with a fear of bees who has had no direct contact with bees. A rough explanation may be as follows. This person has felt pain from direct experiences, and then learns to label this sensation as “hurt.” As a child, this person was told that bees are insects that sting you, which hurts. Through this person’s verbal ability, painful stimulation and bee stings have both been associated with the label “hurt.” If this person has also learned to avoid painful stimulation, things that can be labeled as “hurtful” may also be avoided. Stimuli that are also associated with one of the stimuli in this relationship may also be avoided despite its inability to inflict pain. If bees are highly associated with flowers or trashcans, the person may also avoid these things as well. Avoidant behavior such as this can become problematic when it restricts behavior to the point a person is no longer able to function effectively (e.g., in school, professional, or social settings).

The emergent relations between the stimuli and their shared function have been suggested as the basic process underlying verbal behavior, and has been called stimulus

equivalence (Sidman, 1986). Briefly, stimulus equivalence refers to the emergence of untrained relations among topographically differing stimuli after a series of conditional discriminations with the same stimuli have been directly trained. Consider an example of training relations among three stimuli, A_1 , B_1 , and C_1 where a participant is trained to respond to B_1 (and not other options, such as B_2) when given A_1 , and to respond to C_1 (and not other options, such as C_2) when given B_1 . In addition, the participant also receives training to respond to B_2 (and not other options, such as B_1) when given A_2 , and to respond to C_2 (and not other options, such as C_1) when given B_2 (See Figure 1 for an example). Once these conditional discriminations have been established, adult humans typically display emergence of several untrained relations. Some examples of the emergent relations include when given A_1 the participant responds to A_1 (and not A_2), referred to as reflexivity. In addition, when given B_2 the participant responds to A_2 (and not A_1), referred to as symmetry. Though the participant has never been presented with the A and C stimuli together, when given A_1 the participant responds to C_1 (and not C_2), referred to as transitivity; and when given C_2 responds to A_2 (and not A_1), referred to as symmetrical transitivity or equivalence. As an everyday example, take the relations trained among the written word *dog* (A), a picture of a dog (B), and the written word *perro* (C). When given the written word *dog*, pointing to the picture of a dog (and not a picture of a cat) is reinforced. Similarly, when presented with a picture of a dog, pointing to the written word *perro* (and not *gato*) is reinforced. After a person learns these relations, symmetry is observed when the person points to the written word *dog* (and not *cat*) when shown the picture of a dog. Given the written word *dog*, pointing to the written word *perro* (and not *gato*) would be evidence of transitivity. Given the written word *perro* and then pointing to the written word *dog* (and not *cat*) is evidence of equivalence.

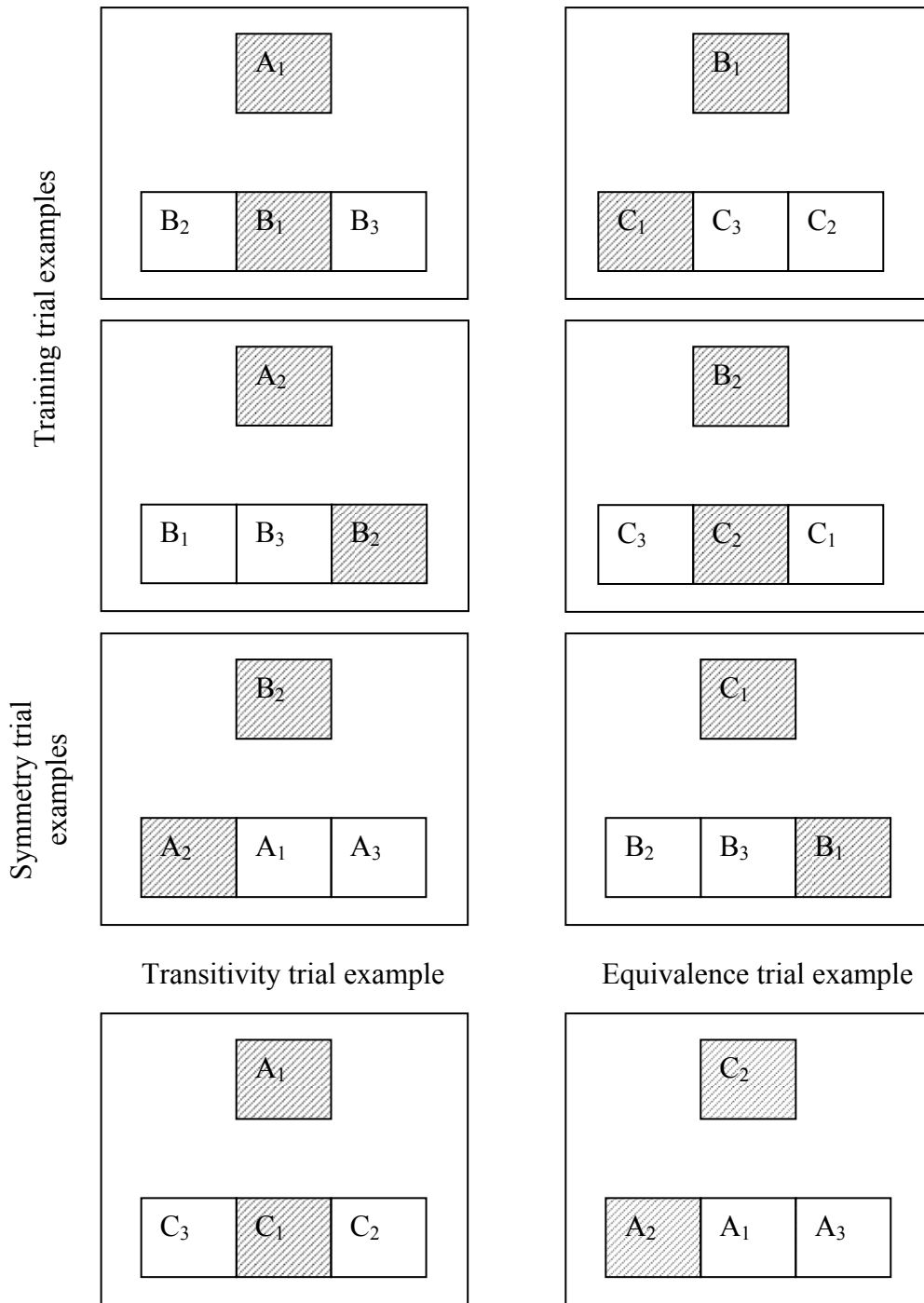


Figure 1. Examples of training and testing conditional discriminations. Alpha-numeric samples (top center) and comparison (array of three at bottom) are used to demonstrate possible configurations. Correct comparisons for a given sample are shaded.

In the experimental analysis of human behavior, conditional discriminations are often trained using nonsense words or symbols in a match-to-sample task. Nonsense words or symbols are used to minimize the chances of the person's having a history with those stimuli, so that the history with such stimuli is developed within the experiment. The stimulus classes trained are "arbitrary" because the experimenter designates them arbitrarily. The participant's job is to learn when shown a particular sample (bok) to point to a particular comparison (mig) as a result of feedback provided (e.g., "correct" flashing on the computer monitor with a tone). After training the participant to make these conditional discriminations, a probe trial presents a sample stimulus that was used as a comparison stimulus during training trials with comparisons that were formerly samples. A derived relation may then emerge, when a participant responds to "bok" when given "mig" without receiving feedback, thereby demonstrating symmetry.

Could stimulus equivalence play a role in clinical phenomena? One interesting feature of stimulus equivalence is transfer of function. After directly training conditional relations and the emergence of derived relations, training a function to one member in an equivalence class can produce a functional equivalence among all members of the class without direct training (Augustson, Dougher, & Markham, 2000; Bones et al., 2001). Functional equivalence occurs when topographically different stimuli have the same behavioral function for a particular person. For example, a red light, a stop sign, and a traffic officer holding up his/her hand all have the same effect on my driving behavior, which is to evoke pressing the brake pedal until the car comes to a stop.

Transfer of function across stimuli in an equivalence class offers an explanation for stimuli that share psychological functions without direct training. Dougher (1998) defines psychological functions as referring to the collective effects of antecedent and consequent stimuli

on behavior, including conditional, discriminative, eliciting, motivating, reinforcing, and punishing functions (p. 577). In experimental procedures, transfer of function is generally tested by first establishing conditional discriminations as described above, demonstrating the emergence of derived relations, and then training a behavioral function for one member of a class. The remaining members of all the classes are then tested to find if the function has transferred to other stimuli. If the members of the class in which the one member acquired a function also have that behavioral function, and the members of other classes do not, transfer of function is assumed to have occurred. This process may offer an explanation as to why symbols (such as words) affect behavior similarly to their referents (Dougher, 1998).

In the case of emotional responses, such as learned fear, classical conditioning has been hypothesized as a cause. In 1952, Wolpe investigated the role of conditioning in neuroses and developed the behavioral treatment of “reciprocal inhibition” to counteract such learned responses (cited in Wolpe & Plaud, 1997). In a review of behavioral theories on emotion, Forsyth (1996) discussed the limitation of classical conditioning in explaining situations in which a fear is learned or unlearned without direct conditioning experiences. In spite of the knowledge gained from classical and operant conditioning, behavior therapists and researchers had no clear explanation for those fears not directly conditioned. Language-emotive relations are thought to be crucial in understanding emotion, and examining verbal behavior, specifically in terms of theories such as stimulus equivalence, is essential to understanding emotion in behavioral terms (Follette, 1998; Forsyth, 1996). One major focal point of stimulus equivalence research related to clinical phenomenon has been transfer of function.

Transfer of function has been found to occur for many stimulus functions, such as discriminative, consequential, respondent-elicitation, extinction, and operant functions. Wulfert

and Hayes (1988) trained two 4-member classes and then trained a sequence task (respond to one stimulus and then another in a particular order), and found that the sequential response was able to transfer across class members. They also introduced conditional control and second-order conditional control over the sequencing task and found that the sequential transfer responded in an orderly manner without explicit training. The consequential function of reinforcement and punishment has also been found to transfer across class members, no matter the order in which the class formation or function training are delivered (Greenway, Dougher, & Wulfert, 1996; Hayes, Kohlenberg, & Hayes, 1991). Dougher, Augustson, Markham, Greenway, and Wulfert (1994) trained two 4-member classes and then classically conditioned one stimulus as the positive conditioned stimulus (CS+) with shock and another as the negative conditioned stimulus (CS-). They found that the fear-eliciting stimulus control transferred across class members without direct training. After this, they then extinguished the response, and found that the extinction also transferred.

Some researchers have emphasized the clinical importance of function transfer by examining transfer of mood, emotive, and avoidance functions. Barnes-Holmes, Barnes-Holmes, Smeets, and Luciano (2004) paired two stimuli with music that elicited a “happy” and “sad” mood state. Participants were also asked to focus on either happy or sad events at the same time as the stimulus presentation. The researchers found that not only were the two stimuli able to elicit the mood states successfully, but that the mood elicitation function transferred across class members. Barnes-Holmes, Keane, Barnes-Holmes, and Smeets (2000) trained participants to match nonsense syllables to two emotive words (i.e., “cancer” and “holidays”) and two brands of soda, “X” and “Y”, forming two classes consisting of one emotive word, one brand name, and two nonsense syllables each. Participants were then presented with two samples of the same

soda, each with one of the brand names on it, and asked to rate their preference. The researchers found that emotive functions were able to transfer across class members and participants preferred one sample of soda (that in the “holiday” class), over the other, even after a reversal procedure for brand name class membership. Augustson and Dougher (1997) classically conditioned a CS+ and CS- with shock and then trained participants to avoid shock with a key press task on a fixed ratio 20 schedule. They found that participants demonstrated avoidance to class members in which the CS+ belonged, but not to class members of the CS-.

Contextual control has also been found to transfer across class members. While some of the above mentioned studies have already demonstrated transfer of function that occurs under conditional or second-order conditional control, other researchers have explicitly examined transfer of contextual control. Gatch and Osborne (1989) trained two 3-member classes in which class membership depended on the contextual stimulus present (i.e., X1: A1-B1-C1, A2-B2-C2 and X2: A1-B2-C2, A2-B1-C1). They then trained conditional discrimination relations between the contextual stimuli and four novel stimuli (X1-Y1-Z1, and X2-Y2-Z2). The researchers found that the Y and Z stimuli acquired the same contextual control function as the X stimuli without direct training. In a series of studies, Dougher, Perkins, Greenway, Koons, and Chiasson (2002) demonstrated contextual control over specific type of transfer of function, which generalized to novel equivalence classes. The significance of control over type of transfer of function is that contextual control maintains distinctions between classes and prevents classes from merging into one giant class. Transfer of function has also been found to generalize to different testing contexts (Greenway et al., 1996).

Relational frame theory (RFT) is similar to stimulus equivalence, but defines such phenomenon is a slightly different way to account for perceived weaknesses in the stimulus

equivalence theory (Hayes, 1989). RFT addresses the bidirectional relations that are formed from conditional discrimination training and derived relations, as well as transfer of function (also referred to as transformation of function). The way relations between stimuli are defined in RFT allows theorists to discuss relations other than equivalence (referred to in RFT as coordination), such as opposition, distinction, and comparison relations (Hayes, 1989). Transfer of function is also seen as one of the defining factors in RFT. While an appropriate review of RFT is beyond the scope of the current paper, it is important to note that much of the research in stimulus equivalence and transfer of function have been conducted by RFT theorists, some of whom have been cited in this paper. RFT research has contributed greatly to understanding the functions of verbal behavior in clinical phenomena.

Wilson & Blackledge (2000) suggested that the painfulness of reporting events in therapeutic sessions may be due to transfer of function, perhaps because of a functional equivalence between the report and the event. They provided an example of a victim of sexual abuse. People who have experienced such a traumatic event often find it difficult to speak about this history. Clients often re-experience the event while talking about the event, often seen in post-traumatic stress disorder. This may occur if the words used in the report share features of the psychological functions with stimuli directly associated with the event due to transfer of function across class members. Could the pain involved in reporting events be due to contemporary variables (within therapeutic session conditions) rather than historical variables (the event being reported)? Neither classical nor operant conditioning can explain the pain seen in reporting the event.

Wilson and Blackledge (2000) provided two experimental animal analogues to demonstrate the direction of conditioning in response to reporting an aversive event. In the first

analogue, a food deprived pigeon in an operant chamber with a red and green key was presented with a tone that was followed by shock 50% of the time. Pecking the red key was reinforced if pecking followed tone with shock. Pecking the green key was reinforced if pecking followed tone without shock. While the tone takes on some aversive features of the shock, both the red and green keys take on the stimulus functions of the food. In other words, the pigeon does not find it more aversive to report shock than to report no shock. In the second analogue, a water and food deprived pigeon is placed in the same chamber as the first analogue. It received food for pecking the red key to report shock following the tone and water for pecking the green key to report no shock. In this case, there is differential responding in terms of topography of the response, but it is due to the reinforcer that follows rather than event that proceeds. Although there is differential responding in this case, the pigeon still does not find it aversive to report shock as in the first example.

These examples suggest that the aversive function in reporting a traumatic event is not due to the consequence that follows reporting the event. We would also hope that the therapist would not punish the reporting behavior of a person in need. Another difference between human and animal responding that the authors allude to is that there is no bidirectional relating of the tone and shock (i.e., the tone may come to elicit some functions of the shock, but the shock does not elicit functions of the tone). Shock followed by tone would most likely not elicit a conditioned response, as backward conditioning is not as strong as other types of conditioning. The absence of bidirectional relating and transfer of function in animal responding, suggesting they do not find it aversive to report painful events, is one reason researchers think that stimulus equivalence and similar theories are important in explaining such responding seen in humans. The clinical significance of derived relations and transfer of function is seen in how such

acquired responding affects an individual's performance in daily demands. Cases in which derived relations emerge between aversive events and seemingly innocuous stimuli could prove to be problematic for a person who then works to avoid this unpleasant class. This experiential avoidance will greatly reduce what a person is willing to do in life.

In light of the significance to clinical settings that stimulus equivalence and transfer of function research provides, there are still many details that have yet to be examined. Limitations inherent in research do not allow us to say that the literature is conclusive, so while such things as mood, emotive, and other functions have been suggested as transferable, stronger support is needed. Some procedural weaknesses in past research include the use of only two comparisons in conditional discrimination tasks or only two options of responding in tests for transfer of function. The need for additional information on procedural factors also leads us to look at participants' histories. The role of history in people's performance is significant, which is why experimenters control the type of stimuli used or the amount of exposure to a contingency. When examining the ability for consequential functions to generalize to different testing contexts (Greenway et al., 1996), the participants had already performed tasks that were used to test for transfer. Without this prior experience, would they still be able to perform as they did? The current study examines the role of task similarity versus task dissimilarity in procedures used to train and test for transfer of function.

The current experiments utilize a one-to-many (OTM) training structure for the conditional discrimination tasks. As opposed to the training structure mentioned above, referred to as linearly trained (LS), the OTM procedure has been argued to be more efficient at training conditional discriminations (see Saunders & Green, 1999 for a review). In the OTM procedure, relations are trained by keeping one set of stimuli as the samples and presenting them with each

of the other sets of stimuli as comparisons (e.g., A-B, A-C, and A-D). In another training structure, referred to as the many-to-one procedure (MTO), one set of stimuli serves as the comparison for several sets of stimuli that serve as samples (e.g., A-B, C-B, and D-B). Arntzen and Holth (2000) compared the three different training structures in a within-subject design and found that OTM was the most effective, MTO as second most effective, and LS was the least effective in producing equivalence. Other procedures, such as the sequential introduction of conditional discriminations in training and testing, have also been utilized due to their ability to reliably increase the probability of emergent relations (Fields et al., 1997).

Three classes of four members each underwent conditional discrimination training in a match-to-sample task. After stimulus equivalence relations (symmetry and equivalence) emerged, a procedure designed to establish the B_1 stimulus as “good” and the B_2 stimulus as “bad” was implemented. In this successive discrimination procedure, a VR20-FR5 multiple schedule of reinforcement and punishment, respectively, was in effect for teaching responses to B_1 and avoidance of B_2 . The third class was used as a “neutral” class that the participants had no direct experience with in the successive discrimination procedure (i.e., there was no exposure to class 3 in this task). After the discrimination was trained participants were given a simple simultaneous discrimination task in which stimuli were presented together two at a time with one or both being members of the classes in the previous multiple schedule. The experimental question was how would the discriminative function established by the successive discrimination task affect choices made to other members of the equivalence class? A second experiment repeated the conditional discrimination training and successive discrimination procedures, but then presented another successive discrimination task to test for transfer. Would the discriminative function affect response rates to other members of the class? How would

participant responding differ between the two experiments, where the first experiment tested transfer in a task dissimilar to the one used to train function control and in the second experiment, transfer was tested in a similar task?

EXPERIMENT I

Method

Participants

Five verbally competent volunteers from the University of North Texas participated in return for a monetary reward based on performance. Their ages ranged from 22 to 27 years of age. There were four undergraduate students, two female and two male, and one female graduate student. Ethnic distribution included two African Americans and three Caucasians.

Apparatus

Tasks used in this experiment ran on a desktop computer. Participants were seated in a 4'x6' room at a desk facing a monitor with a touch-screen adaptor. They made responses by touching the touch-screen adapter. The computer recorded stimuli presented, responses, and time measurements. There were 12 stimuli consisting of nonsense symbols (see Figure 2).

Procedure

The experiment consisted of three phases of training and testing. The first phase was the initial training and testing of conditional discriminations in a match-to-sample task. The second phase was exposure to the mult. VR20 FR5 schedule for two of the stimuli, one from each of the first two classes. The third phase was a simultaneous discrimination task involving all of the stimuli from each of the three classes, presented two at a time (see Figure 3).

Before the participant started the conditional discrimination task, he/she was first presented with 12 cards; one for each stimulus used, and asked if any of the stimuli were familiar. Then the participant was asked if he/she felt that he/she liked any of the stimuli. After this, the participant began Phase 1.

Phase 1. Conditional discrimination training occurred in a match-to-sample task. Three stimulus classes (designated 1, 2, and 3) with four members each (nonsense symbols referred to as A, B, C, and D) were trained (see Figure 3 upper panel). Participants received instructions to “Please use the touch-screen to make your response. It is up to you to decide how best to respond.” A trial began when the participant touched the sample stimulus and the comparison stimuli immediately appeared on the screen with the sample. Participants then responded by touching a comparison stimulus. Correct responses were followed immediately by the replacement of the sample and comparisons with the written verbal stimulus “correct” presented at the center of the screen accompanied by a chime. An incorrect response did not receive feedback. A variable .5 – 1.5-second intertrial interval (ITI) began with the participant’s touching either an incorrect comparison or the “correct” feedback stimulus. A new sample was presented after the ITI. Stimuli were presented in a quasi-random order so that the same sample stimulus did not appear as a sample more than twice in a row and the correct comparison stimulus did not appear in the same position more than twice in a row.

In the first training condition A stimuli were presented one per trial with three B stimuli as comparisons. Each comparison stimulus was presented in each position (i.e., bottom left, bottom center, and bottom right) to train conditional discriminations to the stimuli rather than to position. Participants were trained via feedback to pick the B comparison that the experimenter had designated as correct, (e.g., when given A₁ as a sample, pick B₁). Stimuli were presented in blocks of 72 trials (each of the three possible stimuli was presented with all possible orders of comparisons – six – four times each). An accuracy criterion of 90% (65 out of 72 trials) was required to move on to the next training condition, in which the A stimuli were again presented as samples and the C stimuli as comparisons. Participants were again presented with 72 trials per

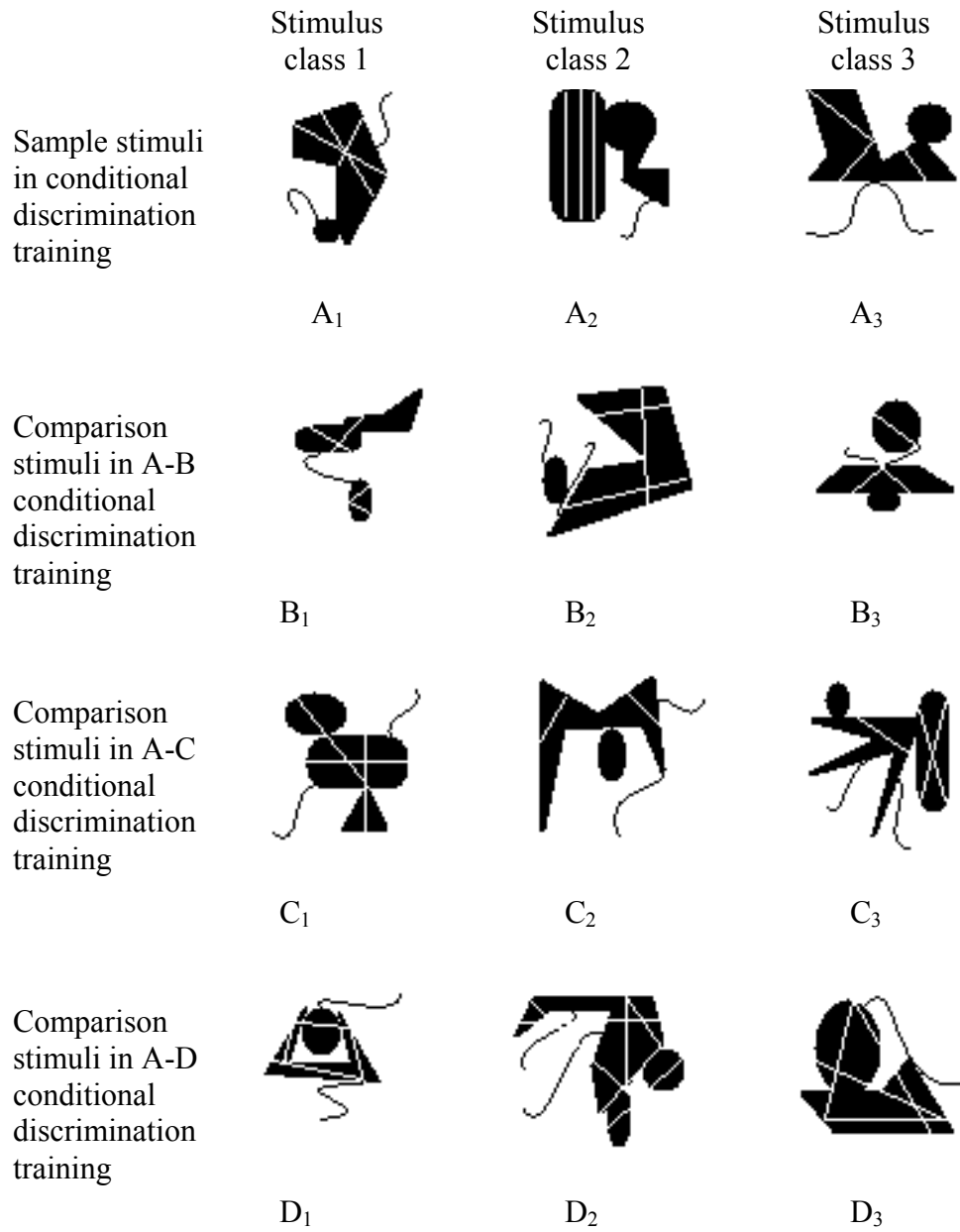


Figure 2. The stimuli used in Experiment I and II, with the corresponding alpha-numeric labels designated by the experimenter.

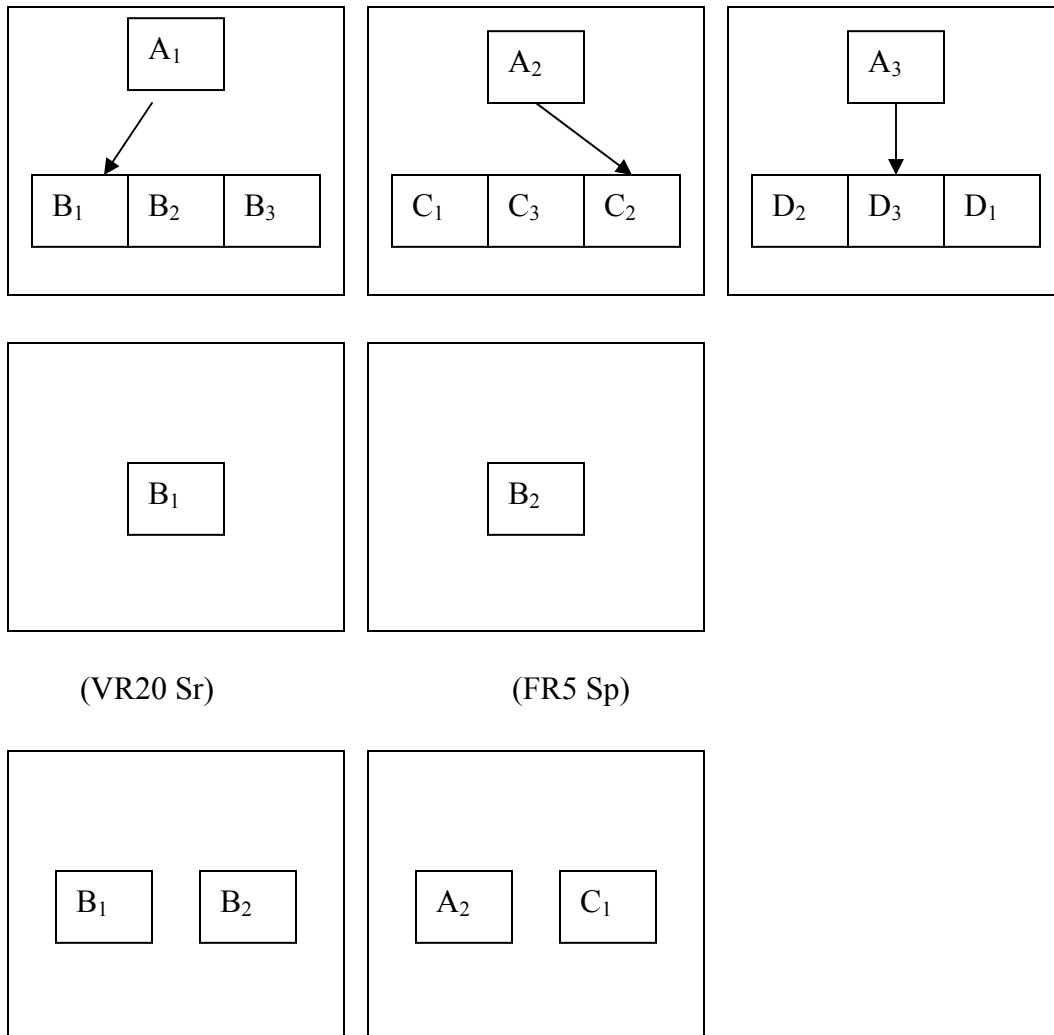


Figure 3. Examples of some of the stimuli presentations in the conditional discrimination (match-to-sample) task, the simple successive discrimination task, and the simple simultaneous discrimination task, respectively. The top three represent samples from the training procedure with the arrow signifying which comparison is the correct choice (the arrow is not presented to participants). The schedules for the simple successive discrimination task is listed beneath the corresponding stimulus presentation.

block. Once training criterion was met the participant was then presented with mixed training trials, presenting A as samples and either B or C stimuli as comparisons. There were 108 trials per block in mixed training sessions. To move on from the mixed trials the participant was required to obtain 90% correct (i.e., 97 out of 108). Next, the participants were presented with the A stimuli as samples and the D stimuli as comparisons in 72-trial blocks. After an accuracy criterion of 90% was met, the participant moved on to mixed trial blocks, in which 108 trials were presented, mixing A-B, A-C, and A-D trial types. An accuracy criterion of 90% allowed the participant to move on to the final training task. In the final conditional discrimination training task, the participant was again presented with mixed trials as previously, but this time the participant only received feedback on 1/12 of the trials. Before exposure to intermittent feedback, the experimenter instructed the participant to “Please use the touch-screen to make your responses. In this part of the experiment, correct responding will only get feedback sometimes.” There were 216 trials per block during this reduced feedback portion. After the participant reached the 90% accuracy criterion, the testing for emergent relations was conducted.

Testing used the same match-to-sample format and test conditions had 108 trials. Of the 108 trials, 27 tested for emergent relations of symmetry and 54 tested for equivalence (symmetrical transitivity). The remaining 27 trials were originally trained relation trials. Stimuli were again presented in a quasi-random order as during training. During testing sessions, participants did not receive feedback. Instructions were “Please use the touch-screen to make your responses. In this part of the experiment, correct responding will not get feedback.”

In test sessions, each originally trained relation trial was presented nine times. In symmetry trials, B sample stimuli were presented with A stimuli comparisons, C sample stimuli with A comparisons, and D sample stimuli with A comparisons. Testing for equivalence

presented B stimuli as samples and the C or D stimuli as comparisons, C stimuli as samples with B or D stimuli as comparisons, and D stimuli as samples with B or C stimuli as comparisons. An accuracy criterion of 90% correct (97 out of 108) was met before subjects moved on to the next phase.

Phase 2. Participants were exposed to one member of each of the first two equivalence classes in a successive discrimination procedure (see Figure 3 middle panel). When B₁ was presented participants earned points in increments of \$0.25 on a variable ratio (VR) 20 schedule by touching the stimulus on the screen. To encourage initial responding, B₁ started on VR1 schedule, and then moved to a VR2, VR3, VR6, and VR9 with each successive schedule change following point increments. When B₂ was present touching B₂ subtracted \$0.25 on a fixed ratio (FR) 5 punishment schedule. Stimulus presentations varied between 10-seconds and 30-seconds in length and each stimulus was presented 15 times (for a total of five minutes exposure to each stimulus). The two stimuli were presented in a quasi-random order so that the same stimulus did not appear more than twice in a row. Participants were given instructions to “Please use the touch-screen to make your response. It is up to you to decide how best to respond.” Cumulative points were shown continuously at the top center of the screen. The total number of points updated after the required number of responses had occurred in the presence of a particular stimulus and points accumulated throughout the session. As points were added while responding to the B₁ stimulus a chime sounded and “+\$0.25” appeared in green at the top right section of the screen. In the punishment procedure for B₂ a buzzer sounded as points were subtracted and “-\$0.25” appeared in red at the top right section of the screen. Participants were exposed to this task until there were two consecutive sessions in which there was little or no responding to B₂.

Evidence of discriminated behavior was defined as low or zero response rates in the punishment schedule and steady responding in the VR20 schedule.

Phase 3. The final task was a simultaneous discrimination task in which two stimuli (each from a different class) were presented, on the left and right sides of the screen (see Figure 3 lower panel). Participants responded by touching one of the two stimuli. Instructions were given to “Please respond by using the touch-screen. It is up to you to decide how best to respond. You will be given no feedback.” The experimenter also informed participants that this portion of the experiment could be a bit frustrating or confusing, but they were to use their best judgment in how to respond. Stimuli from any stimulus set were presented in pairs, but stimuli were always from a different class (e.g., A₁ and C₂, or B₁ and B₃). Stimuli were presented in quasi-random order so that the same stimulus did not appear in the same position more than twice in a row with a total of 192 trials with each trial type presented four times each.

After the participant finished with Phase 3, he/she was given the 12 stimulus cards with three sheets of paper laid out and asked to “Organize these pictures in a way that makes sense to you.” One sheet of paper was blank, another had a smiley face on top, and the last one had a frowning face on top. Once the participant arranged the cards, he/she was then asked, “In what way would you describe these according to the way you have organized them?” If the participant did not volunteer a response that conveys valence, he/she was then asked, “Do you have a preference for any of these pictures?”

Results

For match to sample trials and simultaneous discrimination trials the computer program recorded stimuli presented, selection choice, and latency of the comparison selections. In successive discrimination conditions, the computer program recorded the stimulus present,

reinforcement schedule, latency of responses (both the latency of first response as well as the interresponse times of those following the first), and rate of responding during each component.

In the first phase of the experiment, the first participant did not meet the accuracy criterion and was dismissed after achieving 33% correct in 36 attempts of the first block of trials. Participants 2 through 5 each met the accuracy criterion in the conditional discrimination training, as well as the accuracy criterion in the test with an average of 96% correct and a range of 94% to 98% (see Figure 4). The derived relations test was also checked across class and relation type. Participants generally scored highest on both baseline and symmetry relations, with all relations above the 90% criterion except for Participant 2's baseline score, which was 89%. Response latencies showed the same pattern, with the shortest latencies in baseline relations, then symmetry, and then equivalence. Accuracies across classes tended to vary, but one class was not consistently higher than any other class. The same was true for response latencies.

The successive discrimination task produced differential responding rapidly (see Figure 5). Participants were run through this task at least three times, so that each participant went through the whole task on a VR20 schedule for responding to B₁ (the first time in this task the schedule was increased from VR1 to VR20). Three of the participants required three runs to meet criterion, the fourth requiring four runs to meet criterion. On average participants responded to the B₁ stimulus 54 times more than to the B₂ stimulus, ranging from 45 to 69 times more than B₂. Participants responded to the B₂ stimulus in the last 60 trials an average of 2.17 times and to the B₁ stimulus an average of 113.69 times. Participants responded on average in the last 60 trials 0.13 times per second to B₂ and 5.57 times per second to B₁.

The simultaneous discrimination task analyzed transfer of “good”, “bad”, and “neutral” functions to other stimuli in the equivalence classes. The stimuli from the neutral class (class 3)

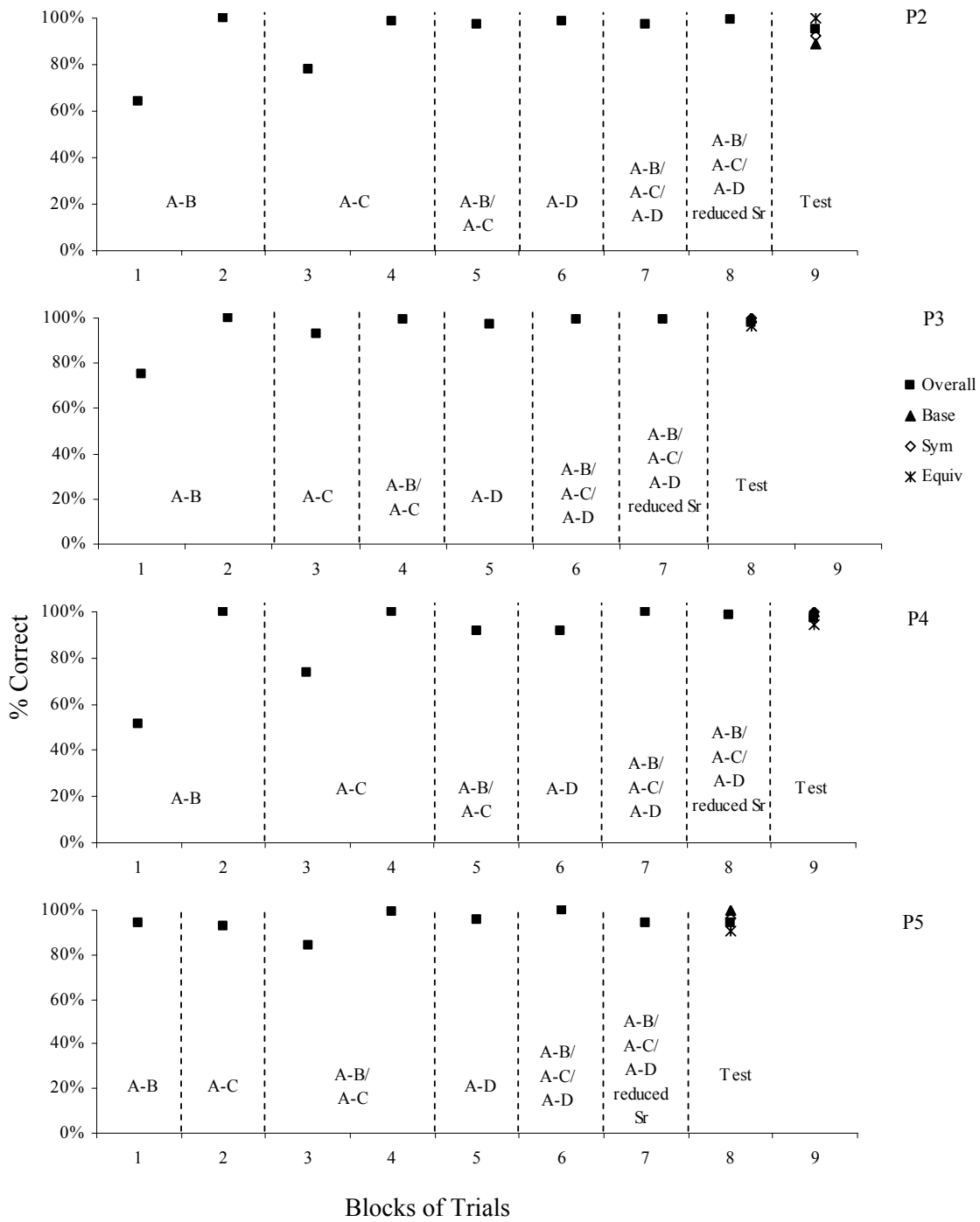


Figure 4. Participant overall percent correct across blocks of trials.

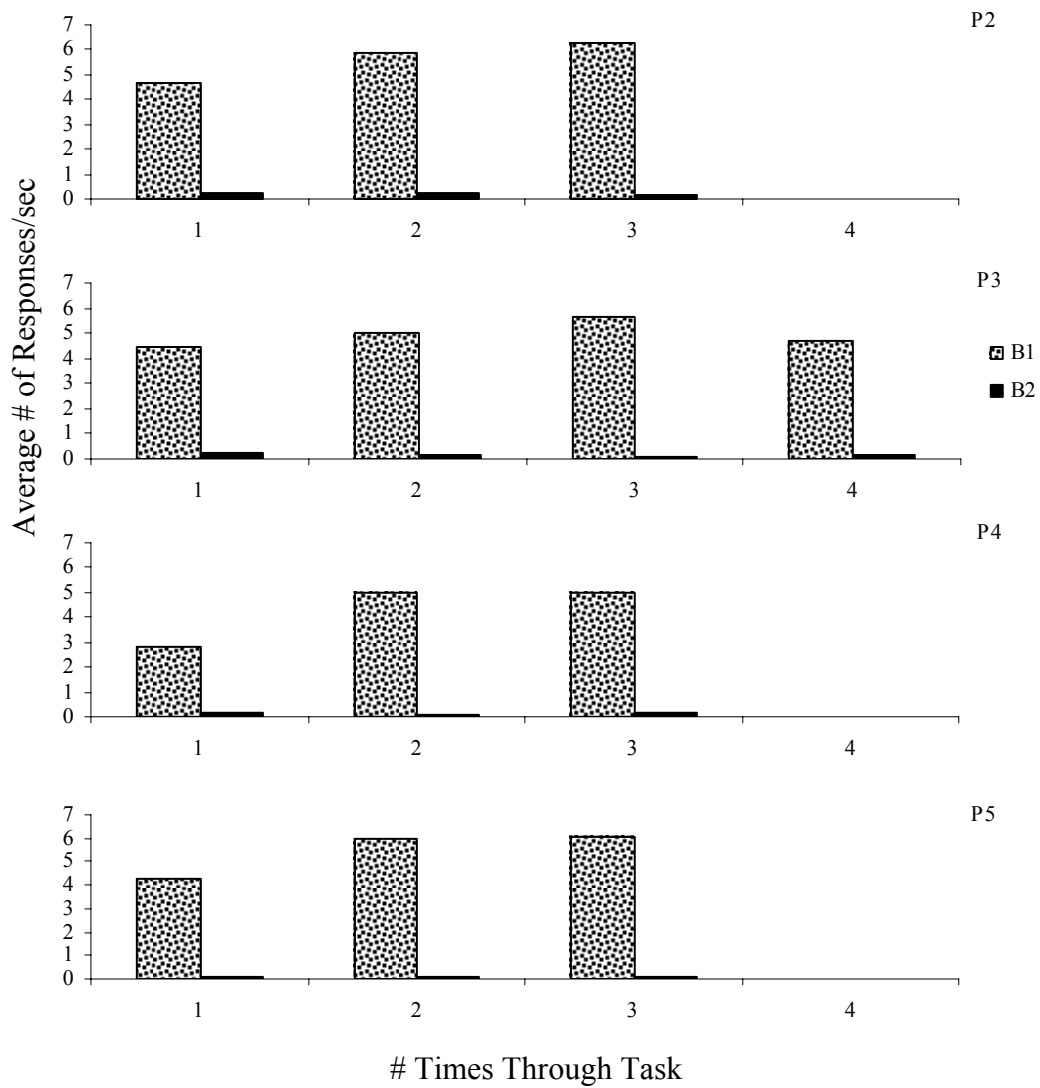


Figure 5. Average response rate ratios for the successive discrimination task.

were examined to see if responses to the neutral stimuli were a function of whether the other stimulus was “good” or “bad”. In other words, did the participant choose class 1 stimuli over class 3, class 3 over class 2, and class 1 over class 2? One participant performed as expected, making selections of good (class 1) more frequently than bad (class 2) and neutral (class 3), neutral more often than bad, and the fewest selections of bad stimuli. One participant performed the opposite of expected, selecting bad most frequently, then neutral, then good. Two of the participants selected bad most frequently, then good, and then neutral (see Figure 6). Participant responses were examined to check for transfer of function during trials that presented stimuli from the same stimulus set (e.g., stimuli from the A set, such as A₁ and A₃ presented together). This was done to check if a familiarity of stimulus grouping, such as a stimulus set that is presented together as comparisons, facilitated transfer of function in this case. Even after separating the class selection rates into stimulus set consistent pairs, transfer of function did not appear to occur (see Figure 7).

Discussion

All of the four participants completing the experiment demonstrated emergence of stimulus equivalence relations, however, transfer of function did not occur as expected. Although participants differentially responded to class members in the simultaneous discrimination task, the majority of the participants selected stimuli from the “bad” class over the others. The unexpected outcomes led to speculations of the role of dissimilarity of conditions of the transfer test (Phase 3) to function training conducted in Phase 2. Participants often reported after the experiment debriefing that they had no idea what was expected of them in the simultaneous discrimination task. Although differential responding was observed, further examination of patterns of responding often revealed alternating responses based on location (i.e., left, right, left

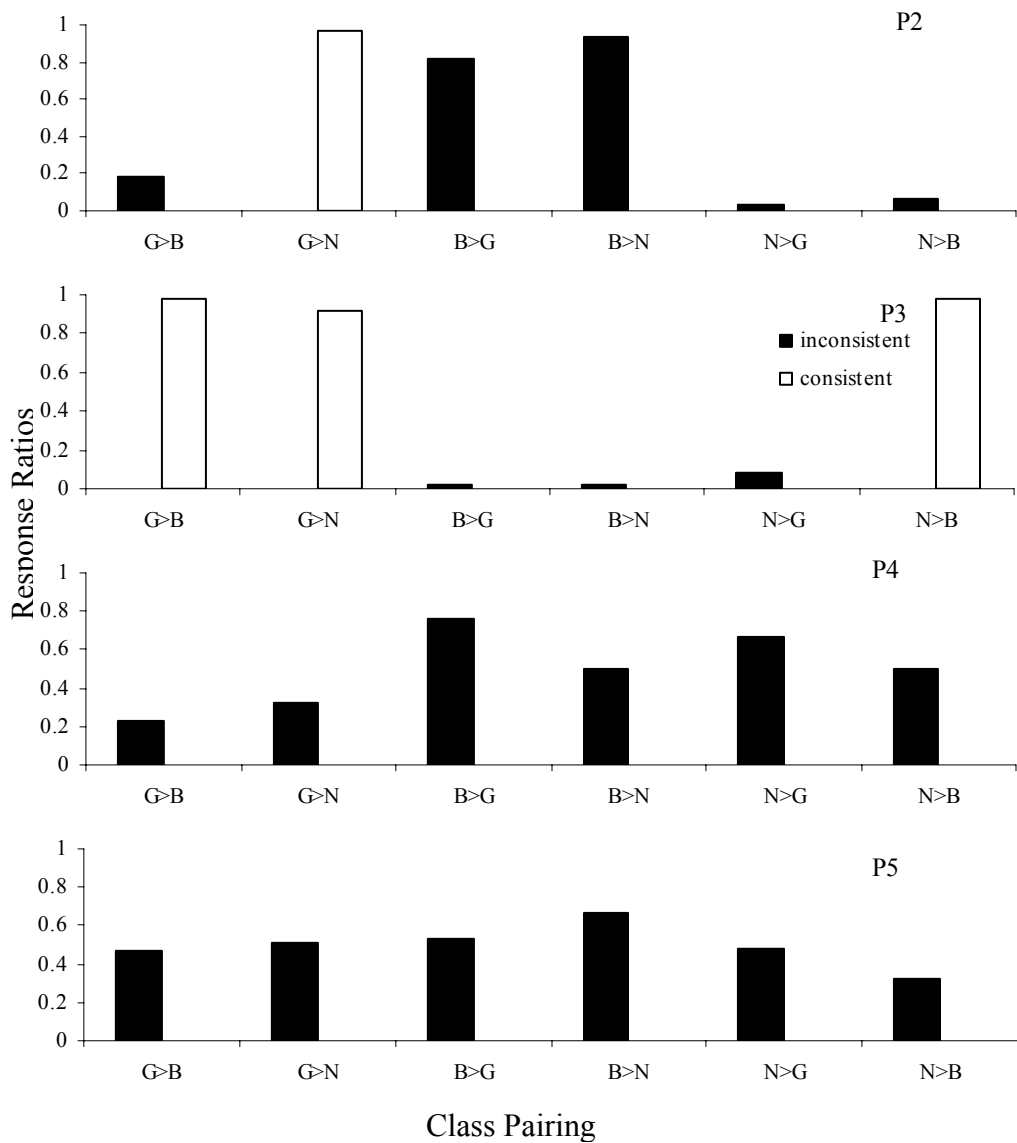


Figure 6. Class preference selection ratios of number of times selected over total number of times presented. G>B = selecting class 1 over class 2, G>N = selecting class 1 over class 3, B>G = class 2 over class 1, B>N = class 2 over class 3, N>G = class 3 over class 1, N>B = class 3 over class 2. Results consistent with theoretical expectations appear in white, and those inconsistent with expectations appear in black.

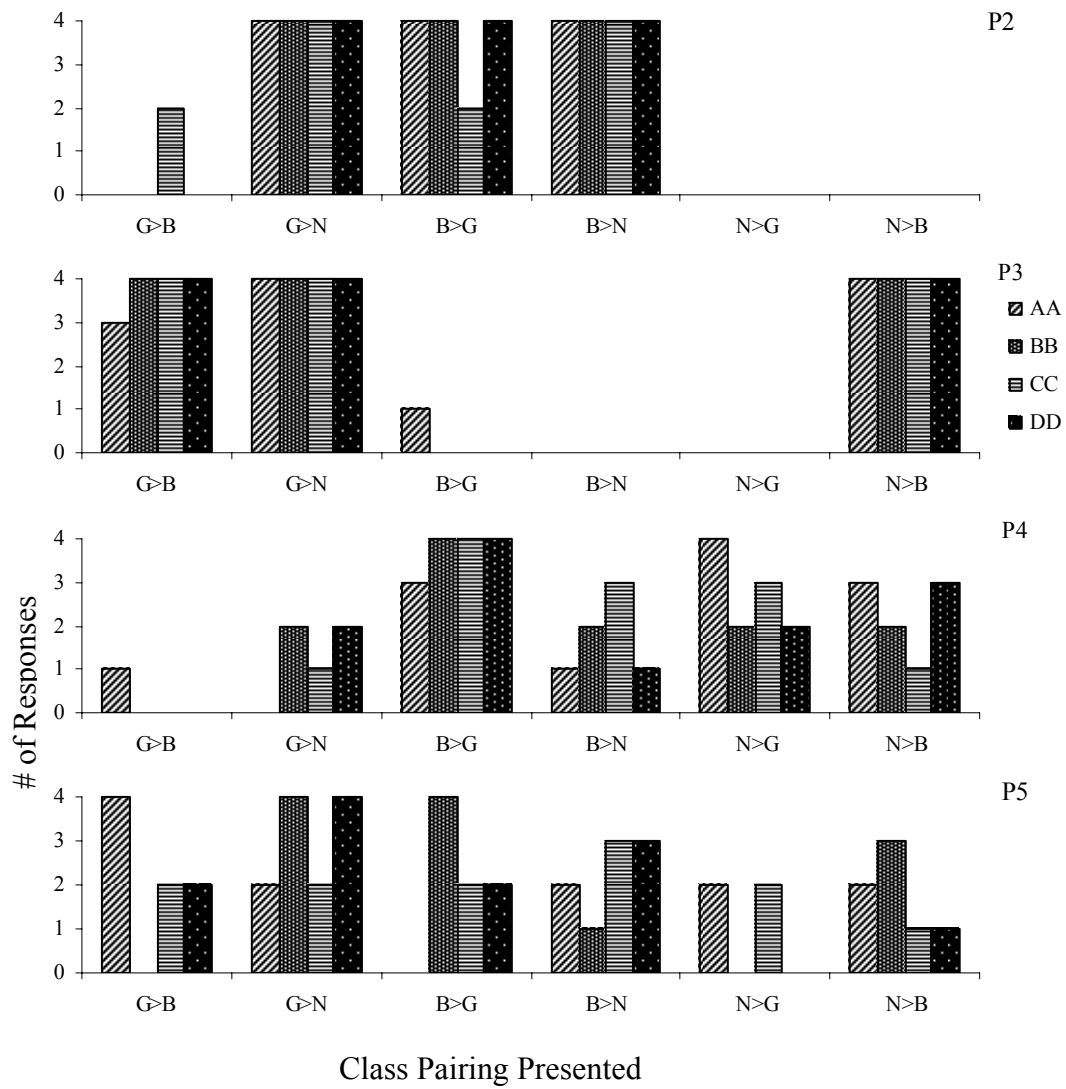


Figure 7. Class preference selection rates between stimulus set consistent pairs. Each trial type was presented four times each.

right) or grouped responses based on location (i.e., responding to consistently to the left stimulus for a period of time, then responding to the right stimulus). Due to these findings, a second experiment was initiated to replicate this study with a change in the last phase to a transfer test that was consistent with the type of task used to train the function.

EXPERIMENT II

The stimulus equivalence literature often emphasizes the role of context in transfer of function. While some researchers have shown contextual control over transfer of function, there is still speculation over what features qualify as context (e.g., Dougher et al., 2002; Dougher & Markham, 1994). The unexpected results of the previous study led to the question: what is the role of the transfer test in relation to the function training? Does the similarity or dissimilarity of the task used to test for transfer provide a type of contextual control important to this phenomenon?

Method

Participants

Six verbally competent volunteers from the University of North Texas participated in return for a monetary reward based on performance. Their ages ranged from 18 to 41 years of age. There were three undergraduate students, two female and one male, and three female graduate students. Ethnic distribution included one African American and five Caucasians.

Apparatus

The apparatuses used in this experiment were identical to those in Experiment I.

Procedure

Phase 1 and Phase 2 of the current experiment were identical to Experiment I. In Phase 3, participants were presented with a successive discrimination task similar to that in Phase 2. All stimuli were presented one at a time, four times each in a quasi-random order so that no stimulus was presented more than twice in a row. The experimenter instructed the participants to “Please use the touch-screen to make your responses. It is up to you to decide how best to respond. At this point in the experiment you will not receive feedback.” The experimenter also informed

participants that this portion of the experiment could be a bit frustrating or confusing, but they were to use their best judgment in how to respond. Each stimulus was presented for ten seconds, with a three-second interval in between each stimulus presentation to reduce response “carry-over” from a previous stimulus. After completion of Phase 3, participants were given the stimulus cards and sheets of paper with the same instructions and questions asked of them in Experiment I (i.e., to organize the cards, how they decided to respond, and what stimuli they might like).

Results

In the first phase of the experiment, all of the participants met the training criterion but one participant (Participant 7) failed to meet the test accuracy criterion. This participant continued through the rest of the experiment as a control to compare performance in the final phase of the experiment without acquisition of the derived relations (i.e., if stimulus equivalence relations are required for transfer of function to occur, then this participant’s performance should be different than the other participants). Participant 8 did not show up for the second session to complete phase two and three, and therefore there are no test data to discuss. Stimulus equivalence test scores showed that Participant 7 had a test average of 54% correct, which did not meet criterion, while test scores of Participants 6 and 9 through 11 averaged 99% correct. Their scores ranged from 97% to 100% (see Figure 8). Accuracies for derived relations by relation type were 100% accuracy for baseline and symmetry relations for Participants 6, 9, 10, and 11. Participant 6 also had 100% for equivalence relations, but performances of Participant 9 and 10 ranged between 94% and 98% correct. The control, Participant 7, had 85% correct for baseline relations, 81% for symmetry relations, and 24% for equivalence relations (see Figure 9). The response latencies again show similar patterns to the accuracies, with three participants

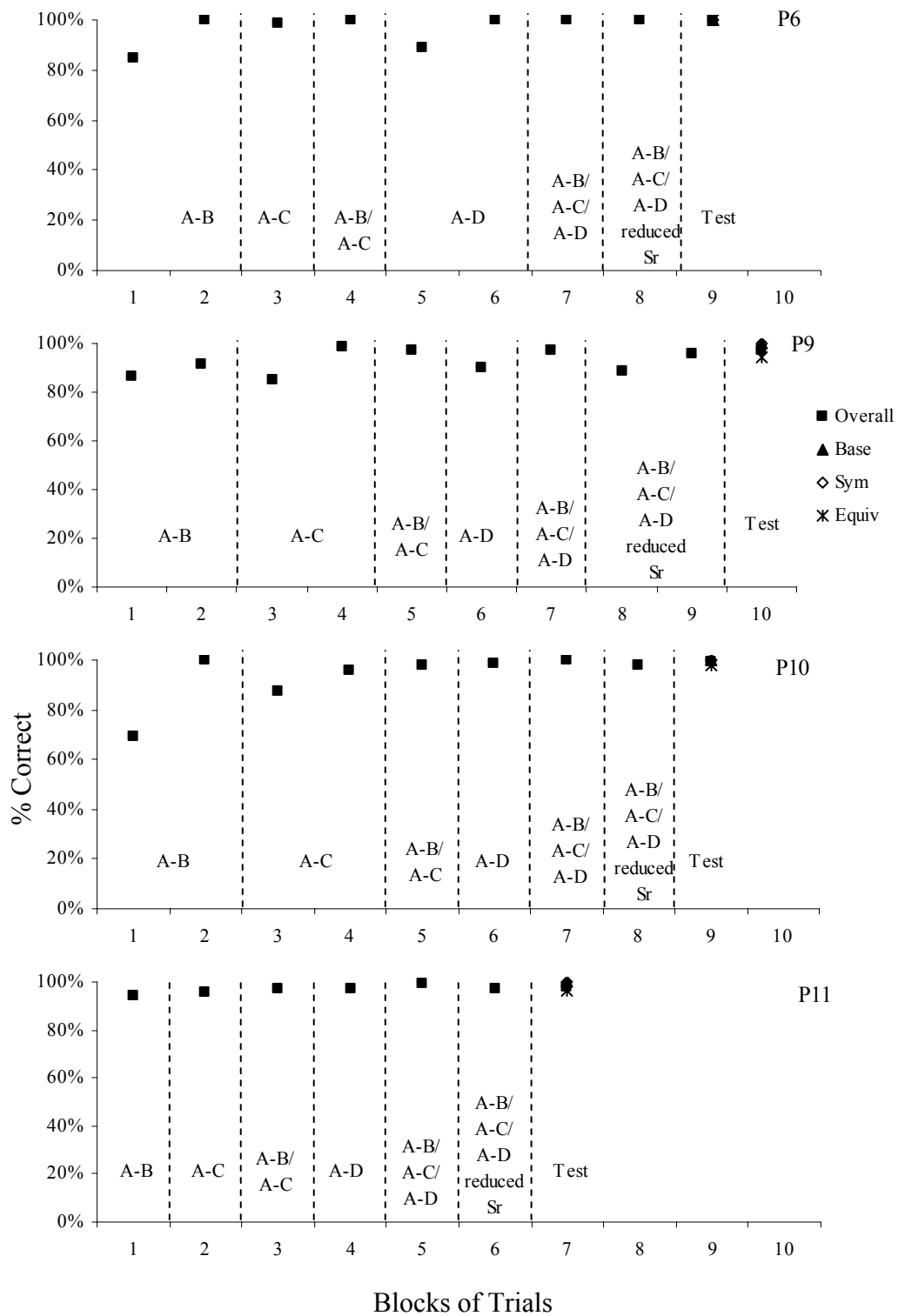


Figure 8. Participant overall percent correct across blocks of trials.

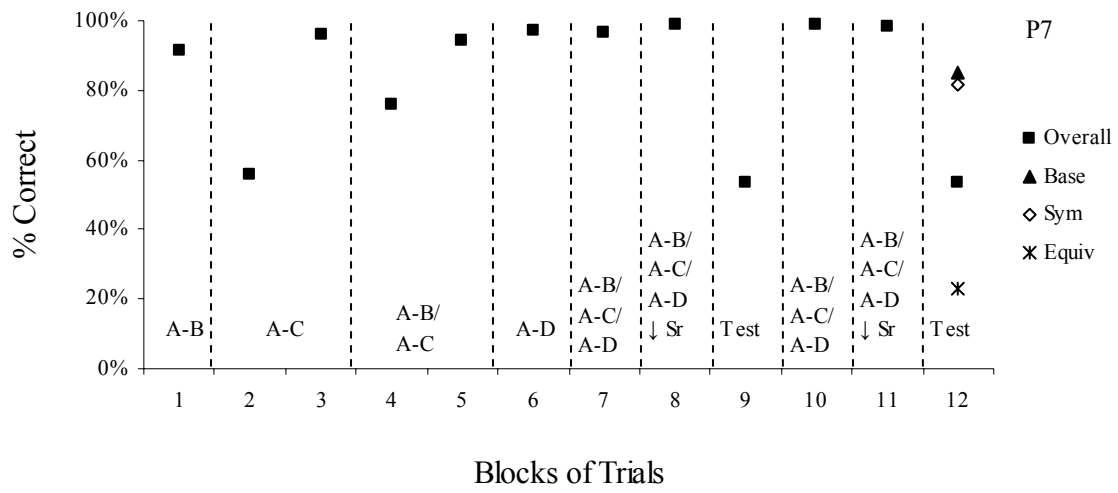


Figure 9. Participant 7's accuracy data for the conditional discrimination training and testing.

responding with shortest latencies for relations trained in baseline. Longer latencies were seen on symmetry trials, and the longest latencies were seen on equivalence trials. One participant had the same average latency for baseline and symmetry relations, which was shorter than response latencies to equivalence relations. The control participant also had a response latency pattern showing fastest response times during baseline, then symmetry, and then equivalence.

Accuracies varied across classes, with three participants scoring 100% correct in class 3, and two participants scoring 100% in class 2 and class 1. Response latencies varied across class type in an inconsistent manner, although latencies remained within a narrow range (between .09 and .49 sec). For the control participant the class accuracies ranged from 53% to 56% correct, and the response latencies varied inconsistently similar to the experimental participants' class response latencies.

The successive discrimination task produced differential responding rapidly in three of the experimental participants as well as in the control participant (see Figure 10). Because Participant 9 did not learn baseline relations rapidly, the schedule was reduced in the third run to encourage increased responding to B_1 . The reinforcement schedule reduction was a repeat of the slow schedule thinning experienced by all participants in the first run through the task (i.e., VR1, VR2, VR3, VR6, VR9, VR20). Participant 9 went through five runs of the successive discrimination task but failed to meet criterion, while Participants 7, 10, and 11 required three runs to meet criterion and Participant 6 required four runs to meet criterion. Although Participant 9's responding did start to differentiate towards the end of the fifth task run, the criterion of high steady responding to B_1 and low to zero responding to B_2 was not yet met. This participant was moved ahead in the experiment without meeting this criterion with the intention of being utilized

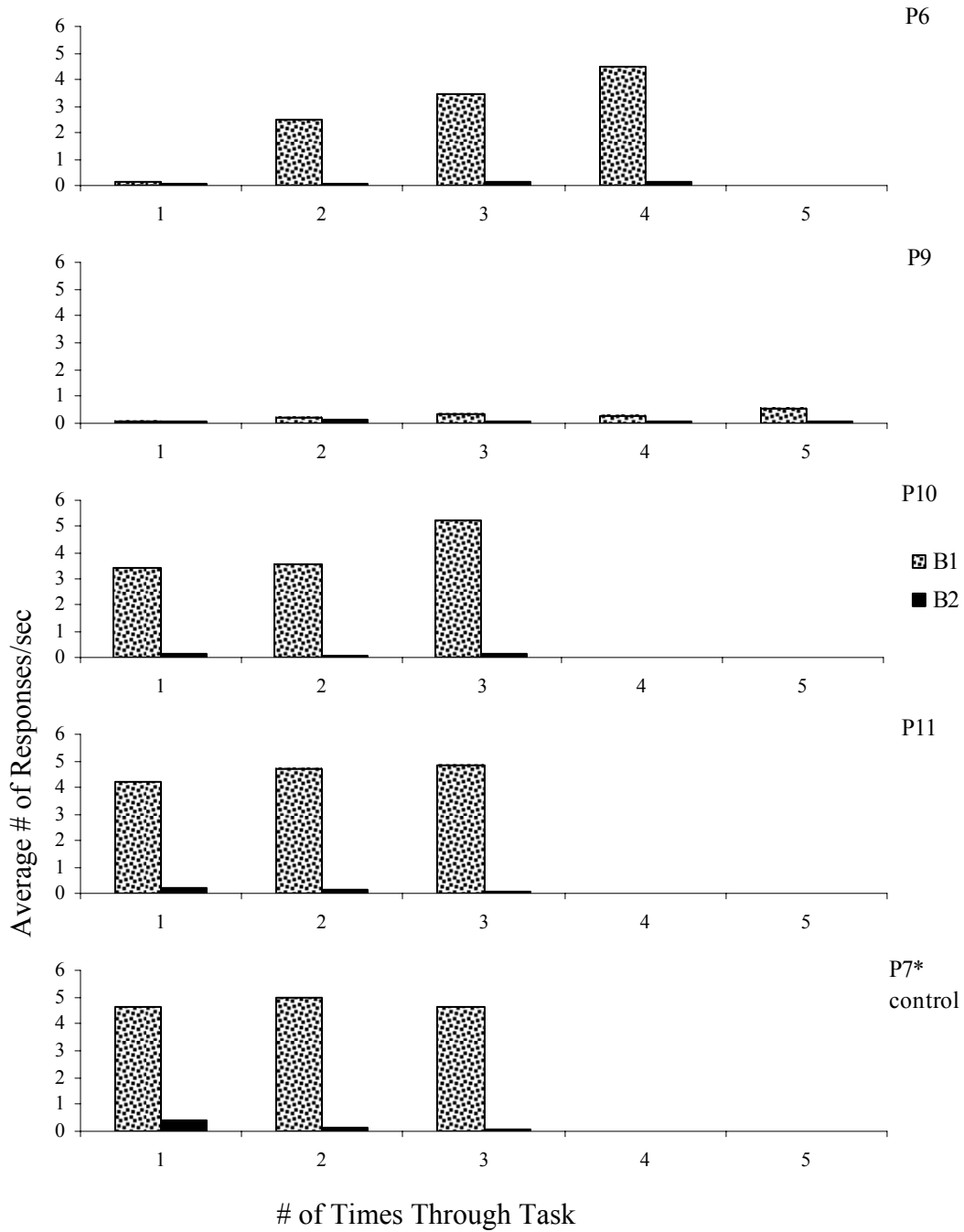


Figure 10. Average response rate ratios for the successive discrimination task.

as a control for the last phase when a person did not successfully condition, but ended up demonstrating differential responding in Phases 2 and 3.

On average, the experimental participants responded to the B₁ stimulus 38.5 times more than to the B₂ stimulus in the last 60 trials, ranging from 10 to 55 times more than B₂. Without the participant who failed to meet the criterion, the average response to B₁ over B₂ goes up to 48 times. In the last 60 trials, the experimental participants responded to the B₂ stimulus an average of 1.65 times (ranging from 0.83 to 2.27 times) and to the B₁ stimulus an average of 69.38 times (ranging from 8.6 to 97.1 times). The control participant responded to the B₂ stimulus in the last 60 trials an average of 1.83 times and to the B₁ stimulus an average of 97.4 times. Experimental participants responded on average in the last 60 trials 0.09 times per second to B₂ and 3.39 times per second to B₁. The control participant responded on average in the last 60 trials 0.10 times per second to B₂ and 4.81 times per second to B₁.

The second successive discrimination task tested for transfer of “good”, “bad”, and “neutral” functions by examining response rates to each stimulus in the three classes. The three participants who met criterion for Phase 2 responded with the highest rates to the good class (class 1), second highest rates to the bad class (class 2), and lowest rates to the neutral class (class 3). Participants 6 and 10 responded to only one bad class member and one neutral class member. Participant 11 responded to two bad class members once and two neutral class members once. Otherwise, these above-mentioned participants demonstrated high, steady responding to the good class (see Figure 11). Participant 9, who did not meet criterion in Phase 2, demonstrating highest response rates to good (failing only to respond to two A₁ presentations), lower response rates to neutral (responding to 14 class presentations), and then lowest rates to bad (responding to four

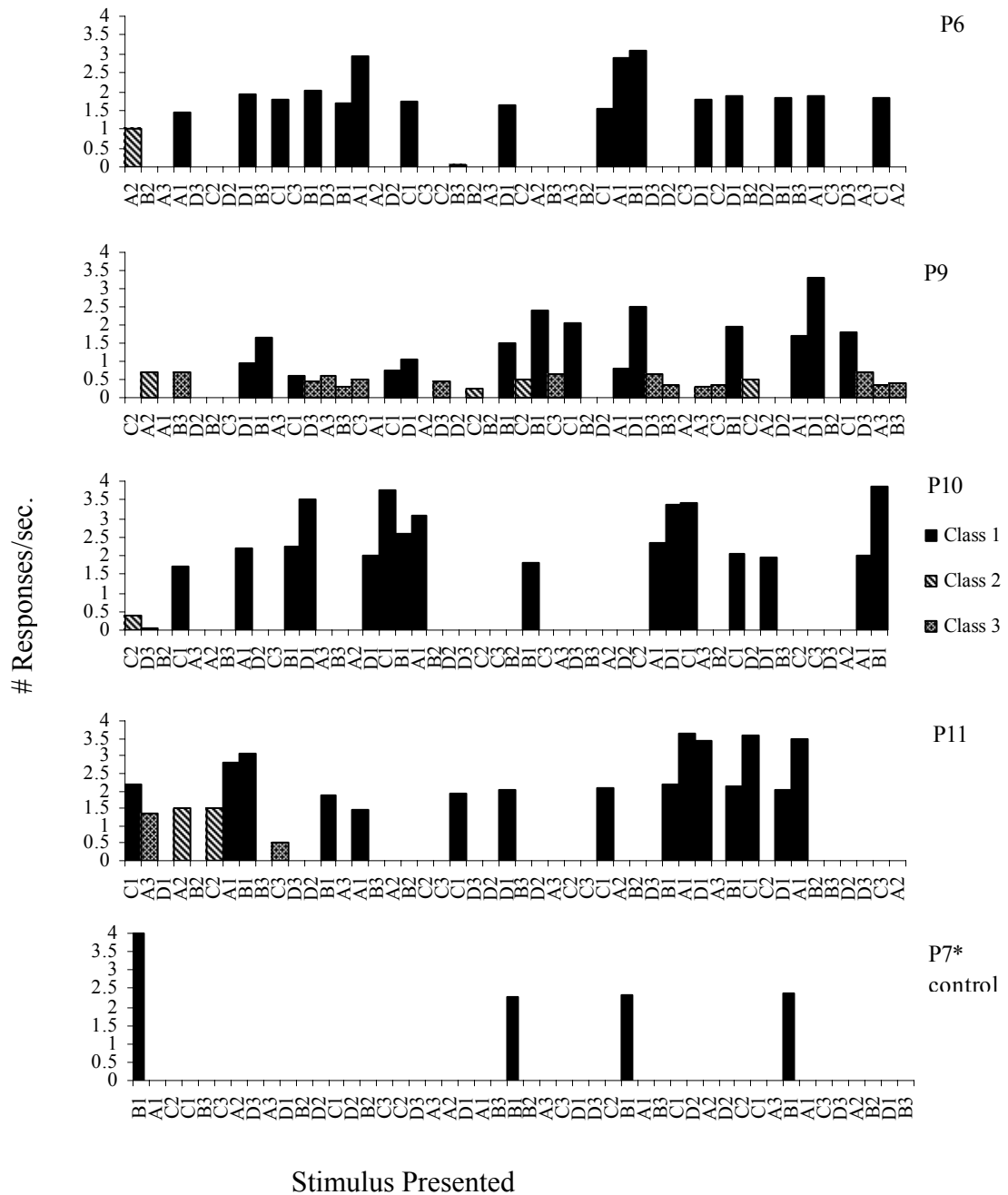


Figure 11. Response rate ratios for the second successive discrimination task that served as a test for transfer of function.

class presentations, although not to B₂). The control participant demonstrated high responding, but only responded to the B₁ stimulus presentations.

Discussion

All of the four experimental participants who demonstrated acquisition of stimulus equivalence relations also demonstrated transfer of function. The three participants who met the successive discrimination criterion for function training had high response rates to class 1 members, or the “good” stimulus class, with little responding to other class members. The one participant who did not meet criterion in the successive discrimination function training, but whose behavior did start to differentiate towards the end of the fifth run through the task, showed a more evenly distributed response pattern. This participant showed high responding to the good class, then medium responding to neutral, and then low responding to bad, as was expected.

The card sort task at the conclusion of the experiment also revealed that the participants were able to organize the stimuli based on the class membership they had initially learned in the conditional discrimination task in Phase 1. They also reported that they placed class 1 onto the sheet with a smiley face on top because those were the members related to B₁ which awarded money, placed class 2 on the sheet with a frowning face on top because those were members related to B₂ which took away money, and class 3 on the blank sheet because none of the class members were associated with gain or loss of money. The control participant, who did not demonstrate acquisition of derived relations, responded only to the stimuli associated with direct experience of earning money for responding.

GENERAL DISCUSSION

Although the discriminative function established by the successive discrimination task did not appear to transfer to choices made to other members of the equivalence class in Experiment I, transfer of function was seen reliably in Experiment II. In Experiment I, participants were unable to report coherence in their performance across the phases, and when they did report reasons for their actions, those reasons were inconsistent with their performance. For participants in Experiment II, the progression of the experiment seemed easy and obvious. Participants in Experiment II reported that the relations they learned in Phase 1 guided their responses in Phase 3. Participants in Experiment I, however, reported that they had no idea what was expected of them in Phase 3. The transfer test (Phase 3) in Experiment II showed high preference for class 1 stimuli and low preference for, or avoidance of, class 2 stimuli. Results from Experiment II are consistent with stimulus equivalence literature. While there are reports of differential responding to two discriminative functions based on contextual control, there is a paucity of reports of failed transfer of function.

Training procedures do not account for differences seen in the transfer of function between Experiment I and Experiment II. Each participant received the same training up until the transfer test in Phase 3, where the two experiments differed. Participants in the two experiments were similar in the number of blocks required to reach criterion in conditional discrimination training and the number of exposures in Phase 2 to reach criterion in discriminative function training. The one participant who received additional exposure to discrimination training (Phase 2) showed weaker transfer of function. This was seen in that subject's dispersed pattern of responding in which there were responses to each class rather than consistent choices of class 1 stimuli and avoidance of class 2 and class 3 stimuli as demonstrated by other participants.

Although there were more graduate students in the second experiment, the graduate student in the first experiment responded similarly to undergraduate participants who failed to show transfer of function.

The difference in performance between participants in Experiment I and II in Phase 3 suggests that the similarity or dissimilarity of the task to the situation in which a function is learned plays an important role in the transfer of function phenomenon. Task similarity may provide a context that signifies that functional relations learned still apply, whereas dissimilar tasks provide a different context in which functional relations are uncertain. Similarity of tasks may allow for learning efficiency seen when transfer occurs with no direct training. Dissimilar tasks in which transfer of function would be beneficial may necessitate additional cues. While most of the previous research has examined contextual control via the presence of additional stimuli (e.g., nonsense symbols) or differences in presentation (e.g., different colored backgrounds), it has been noted that this is not the only way the procedures provide contextual control. For example, Dougher and Markham (1994) suggested that in the absence of contextual stimuli to function as cues, an event such as a previous response in a task may acquire a contextual function. Perhaps it is in this sense that the similarity or lack thereof to the task in which the function was first learned took on a contextual function, especially in the absence of a manipulated contextual stimulus. Dougher et al. (2002) suggest that this type of contextual control over transfer (transformation) of function plays an important role in the development and maintenance of behavioral repertoires and it prevents classes from merging into one giant class.

Recent literature emphasizes the importance of context in stimulus equivalence and transfer of function in the acquisition of derived relations and transfer of function. However, without an operational definition of context, it is difficult to definitively support or refute the role

of context in the acquisition of derived relations and transfer of function. Researchers appear generally to agree that something needs to differentiate class membership and functional responding; else, every stimulus event becomes related to everything (Dougher et al., 2002; Dougher & Markham, 1994; Hayes & Hayes, 1992; Sidman, 1986).

Of interest here is the amount of training necessary for transfer of function to occur. Stimulus equivalence theory states that transfer of function occurs without direct training, as perhaps a type of generalized responding to class members. However, based on the results of the above two experiments, as well as result of similar research, transfer of function may require more training than originally thought. Researchers have found that transfer of function is not always an automatic occurrence (e.g., Dougher et al, 2002; Hayes et al., 1991; Gatch & Osborne, 1989; Wulfert & Hayes, 1988). To facilitate the transfer of function, researchers deliver additional training in the original task rather than directly training the function to transfer. It appears that the function can transfer without training, but the person may first require additional experience in a particular task before a function is able to transfer.

The current experiments, unlike others, included a “neutral” class in which no function was programmed by the experimenter for any of its members. Other researchers have examined transfer of consequential functions in stimulus equivalence classes, but often exclude the class member that did not receive direct training from the transfer tests (e.g., Greenway et al., 1996; Hayes et al., 1991). Augustson and Dougher (1997) trained two stimulus equivalence classes, with the use of a third class that was never specifically trained but only used as incorrect comparisons in the comparison array. Dougher (1998) reviewed a number of stimulus equivalence studies examining transfer of function, and in each one there is no examination of possible responding to a neutral class. Only members of the class in which there is a directly

trained function are tested for transfer. In a natural environment, people are often presented with more than one response option. It may be important to know how people respond in the absence of an explicit history that dictates responding. When looking at generalization that is not based on formal similarity, perhaps we should broaden our scope of interest to understand how people learn to respond in novel situations.

The performance of participants in the two experiments differed in the neutral class as well as the good and bad classes. The results of Experiment II showed participants who demonstrated transfer of function also avoided responding to the neutral class (class 3). Participant 9 showed us that people may continue to respond at a lower frequency in situations where differential responding has not yet been established. Participant 7 showed us that, in the absence of derived relations, a person may only respond to what has been directly experienced. In Experiment I the different context of the transfer test produced results in which the neutral class was not always avoided, and sometimes even preferred over the good class. This suggests that individuals who demonstrate the emergence of derived relations, but are placed in a situation that does not evoke transfer of function, will not restrict responding to stimuli in which they have had direct contact.

Limitations to these studies include participant characteristics and a procedural weakness. The difference in academic status of participants across Experiment I and II, although it did not seem to have an effect, may still play a part in performance differences. While the graduate students who participated had knowledge of psychology, including behavioral terms such as schedule of reinforcement, each was naïve with respect to stimulus equivalence research. Another limitation is the exclusion of B₃ in the successive discrimination task in Phase 2. Stimulus class 3 was meant to serve as a control in that neither reinforcement nor punishment

was delivered as a consequence for responding to B₃. It would have strengthened the results to control for exposure to B₃ in Phase 2 in which participants were exposed to but received no delivered consequence for responding to B₃. It also would have strengthened the results to ascertain that the participants in Experiment I still had the stimulus equivalence classes intact at the end of the experiment.

The results reported here may be due to other training or participant characteristics overlooked by the experimenter, but the use of the same procedures in the first two phases of the two experiments makes this unlikely. The current results would have been stronger if the participants in Experiment I had received training in the preference task used in Phase 3 to examine if such experience then resulted in transfer. The subsequent emergence of transfer could signify that the established task similarity allowed transfer of function to occur. Results of Greenway et al. (1996) support this expectation, but they suggested separating the function from the context under which the derived relations are tested and trained to examine transfer across contexts. It may also be beneficial to clarify the role of order in which tasks were trained in these experiments (i.e., conditional discrimination task followed by successive discrimination task). Perhaps the order in which the tasks were presented provided another type of contextual cue from which to respond in the transfer tests.

Researchers differ in their theoretical approaches to investigating the components of stimulus equivalence, some preferring to focus on reinforcement contingencies (e.g., Sidman, 2000) and others on derived relational responding and multiple exemplars (e.g., Hayes & Wilson, 1996). In both cases, we need to define the components of the phenomenon more clearly. A better definition of context is needed. The role of training components (e.g., use of explicit instructions versus no instructions) needs to be explicated experimentally rather than

remain in the domain of lab lore. A greater understanding is needed of the processes involved in the phenomena described by stimulus equivalence theory, the procedures necessary to acquire such relations and functions, and the conditions that facilitate or inhibit those outcomes. As stated above, such processes are believed to play a significant role in problematic behaviors of individuals, which increases the value such knowledge would provide. By strengthening our understanding of verbal behavior and how it contributes to other behaviors of individuals, we can provide greater opportunities for clinical interventions as well as more effective and efficient interventions.

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