OCCASION SETTING-LIKE BEHAVIOR IN A TWO-RESPONSE FEATURE-POSITIVE DISCRIMINATION OCCURS WITH SIMULTANEOUS, BUT NOT SERIAL PRESENTATIONS

by

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TABLE OF CONTENTS

LIST OF FIGURES

1. Introduction

Exposure to stimuli in the environment may result in a change in behavior. How behavior is changed differs depending on the manner (e.g., timing) in which the stimuli are presented, as well as differences in the physical properties of the stimuli themselves. In discrimination learning, the subject is trained to alter the probability of a response (e.g., lever pressing) in the presence (e.g., a light) versus the absence (e.g., no light) of a stimulus, or in the presence of one stimulus but not another stimulus (e.g., noise). In other words, the subject will eventually learn to behave differently in the presence of a stimulus than in its absence. In an operant discrimination, the probability of a response is altered through operant conditioning, based on the contingencies of reinforcement that are associated with the response in the presence of the discriminative stimulus. If reinforcement reliably follows lever pressing in the presence of the light but not noise, then the presence of the light should increase the probability of lever pressing, relative to the noise. It is as if the discriminative stimulus signals whether a reinforcing outcome will follow a response. In a Pavlovian discrimination, an unconditioned stimulus (US, e.g., food) is presented following a conditioned stimulus (CS, e.g., a light) but not presented in its absence or in the presence of another stimulus (e.g., a noise). After many trials, the CS comes to elicit a conditioned response (CR, e.g., approach to the food site or to the signal). In addition to encountering stimuli in isolation, stimuli may also be encountered with some overlap or compounded with identical onset and termination.

An operant feature-positive discrimination involves the reinforcement of a response during the presentation of a compound of two stimuli, but nonreinforcement when one stimulus is presented individually (XA+, A-). The compound includes a target stimulus (A) and a feature stimulus (X). In this procedure, the feature indicates that reinforcement is available and therefore is a positive feature. An alternative feature-negative procedure has the feature signal nonreinforcement and the target signal reinforcement (XA-, A+). Feature-positive discriminations can happen in nature with a biologically important outcome, such as mating behavior in peacocks. Peacocks are a lekking species, meaning that they accumulate together and perform courtship displays, such as vocal, or visual displays. Females are then lured to this location through these displays and have the opportunity to choose a mate. When a male peacock is in his lek (X), and a female is present (A), then courtship behaviors are more likely to lead to mating than when a female is encountered (A) outside of the male's lek. Feature-positive learning is also typical in humans. For example, it could be the case that when a teenager's parent is home (X) and the car is in the driveway (A), they are able to ask to borrow the car and this is frequently reinforced. However, if the parent is not home but the car is in the driveway, the desirable outcome does not occur. Under some conditions, ambiguous reinforcement in the presence of A would result in excitatory learning about X. The male peacock may engage in courtship behaviors when they are located at a lekking site (in the absence of females) and the teenager could learn to ask to borrow the car only when the parents are present (ignoring the presence of the car in the driveway). Under other conditions, humans and other animals can discriminate A when it follows X compared to when A is encountered alone. It is as if X sets the occasion for, or modulates, responding to A. Hereafter, X is represented by the term "feature" in the feature-positive discrimination procedure when there is evidence for direct control of the response by X. Alternatively, the term "occasion setter" is used for X when the response to A is predicted to be modulated by X. The conditions that promote direct vs. modulatory control of behavior by X are discussed next.

Modulatory control over responding to A when X is present results in different behavioral predictions than direct control by X. Direct control by X in a feature-positive discrimination (XA+/A-) would be expected to be similar to control by a single cue in a simple discriminative task (X+/-). Fraser and Holland (2019) distinguished occasion setting from direct control by observing the differences in response form during XA trials compared to trials of A alone, in resistance to extinction of modulation by X, and in transfer of modulation from X to other stimuli. Firstly, when Pavlovian occasion setting occurs, the form of the conditioned response (CR) observed during trials with XA is the result of learning about the binary relationship between A and the US, which is modulated by X. In other words, pairings of A (not X) and the US determine the observed CR. The second way to distinguish direct control by the feature from occasion setting are the effects of extinction of X. Extinction of X would greatly reduce direct control by X, but not modulation of A. Lastly, when X is presented with other discriminative stimuli (e.g., C, a clicker), then direct control by a feature should summate or compete (e.g., with incompatible responses) with control by C, along with some generalization decrement. In occasion setting however, the feature should modulate responding to the original target, and should transfer its modulatory properties to other targets trained in a feature-positive discrimination, and to some degree, to discriminative stimuli that have been extinguished. The distinction between occasion setting and direct control by the feature is important for the prediction of behavior, as well as for treatments that might target abnormal behavior. For example, treatment of a phobia or compulsion by extinguishing a conditioned stimulus would be effective in reducing responding, but this same treatment would not be effective if an occasion setter modulated the response to the conditioned stimulus. Though many similarities exist between Pavlovian and operant occasion setting, tests of response form and extinction of X can be demonstrated most effectively by discussing them separately.

1.1 Feature-positive Discriminations in Pavlovian Conditioning

Whether occasion setting or conditioning to the feature occurs can depend on how the stimuli are temporally arranged. Ross and Holland (1981) utilized the response form elicited by different stimuli in rats to investigate the effect of the temporal order of the feature and target. Previous research (Holland, 1977, 1980) reported different behaviors in rats depending on the modality of the stimulus paired with food. Following pairings of a tone (an auditory CS) with food, a startle, head jerk, and some magazine behaviors were observed during the tone. After light (a visual CS) and food pairings, however, rearing and magazine behaviors were observed. Ross and Holland (1981) trained different groups of rats with a light (X) and tone (A) presented either simultaneously (i.e., XA+, co-onset and termination) or serially with the light preceding the tone (onset to onset), (X→A). On these feature-positive trials, the rats received reinforcement in the Simultaneous group when XA+ was presented, and in the serial group at the termination of the tone (A). However, on target alone trials, no reinforcement was delivered. When A was presented simultaneously with X, the rats engaged in the behavior (rearing) that was typical of the feature cue. When the same stimuli were presented serially, rats engaged in behaviors typical of the target (head jerking) during A, but only when preceded by X. Overall, rats displayed different patterns of behavior depending on the temporal arrangement of the feature and target. Specifically, stimulus control with simultaneous presentations was direct, with behavior typical of the modality of the feature (X). Whereas, serial presentations led to occasion setting, where X set the occasion for engaging in behaviors typical to the modality of A. The simultaneous feature-positive discrimination resulted in learning about the feature-US relationship, whereas, the serial feature-positive discrimination resulted in learning of the target-US association in the presence of the feature.

In one interesting case, occasion setting was found with simultaneous feature-positive pairings. Holland (1989) manipulated the salience of the target to determine whether occasion setting could be learned if A was more salient relative to X. In Experiment 1, two groups of rats received a simultaneous feature-positive discrimination, (XA+, A-). In one group, X was a flashing houselight and A was an 88-dB noise. In the other group, A was a 78-dB noise. To determine what stimuli were controlling responding, a test consisting of presentations of X and both versions of A (88-dB and 78-dB noises) was given prior to and following extinction of X. After extinction of X, disruption in responding to XA would indicate that X directly controlled responding and occasion setting did not occur. Alternatively, if responding to XA is maintained following extinction, X modulated responding to A and occasion setting occurred. Results revealed that when A was moderately salient relative to X, that X alone directly controlled responding. However, when A was more salient, the feature modulated the response to A, indicating occasion setting. Therefore, the feature can modulate responding to the target in a simultaneous feature-positive task when the target is more salient relative to the feature. Under most conditions, though, simultaneous pairings result in learning about the feature and US or reinforcer. Similar results have been found with operant behavior in feature-positive discriminations.

1.2 Feature-positive Discriminations in Operant Conditioning

In an operant feature-positive discrimination, the delivery of reinforcement is contingent on a certain response (e.g., lever press) in the presence of XA+, but no reinforcement is available in the presence of A alone. With respect to occasion setting, stimulus control is made more complex by the relationship between the target and response-reinforcer contingency. In fact, some have suggested that the target, a discriminative stimulus, is an occasion setter, as it modulates the relationship of the response to the reinforcer (Bonardi, 1998). However, occasion setting typically refers to modulation of one stimulus by another. In an operant feature-positive discrimination, the feature stimulus modulates the relationship between the target stimulus and the response-reinforcer contingency. Similar to Pavlovian occasion setting, the feature should not control the response directly, or control responding as a result of pairings of the feature with the outcome.

Holland (1991) trained rats in an operant feature-positive discrimination with either simultaneous or serial feature-target pairings. Experiment 1 included extinction of the feature on lever pressing during feature-target, target alone, and feature alone trials, as well as the effect of extinction on transfer to another stimulus. The feature-positive discriminations involved a light feature (X), a tone target (A), and a clicker transfer stimulus (C). In serial presentations, the light preceded the tone with a 5-s interval, and in simultaneous presentations, both stimuli were presented at the same time. Target A was never reinforced when presented alone. During feature-positive training, there was no reliable difference between the simultaneous and serial groups. The feature (X) was then extinguished during four 60-minute sessions, consisting of 40 nonreinforced 5-s presentations of X. Following extinction of X, responses to XA and XC were disrupted in the serial group. In the serial group, on XC transfer trials, X no longer enhanced responding to C relative to C alone, but XA continued to support more responses than A alone. These results indicate that extinction of X had a larger effect on transfer of responding to a separate target cue (C) than to the original target cue (A). Testing following extinction of X revealed that the temporal arrangement of X and A altered what was learned by rats in an operant feature-positive discrimination.

Pavlovian unconditioned responses in feature-positive discriminations allow the observation of involuntary behaviors in the presence of specific stimuli. In a Pavlovian occasion setting task, such as Ross and Holland’s (1981), the response cannot be trained, but rather, is the product of evolution (e.g., rear to a light CS and head jerk to an auditory CS). Researchers are limited to the number of response forms endowed by the evolutionary history of the animal. In operant conditioning, such as Holland (1991), researchers can establish new response forms. Response form is under the control of a reward contingent on making that response in the presence of a stimulus (though still constrained, but to a lesser extent, by evolution). The rat may be trained to lever press or chain pull in the presence of a particular stimulus. Exploiting the flexibility of training different response forms was investigated using operant occasion setting tasks by Holland (1995). Rats received training with two serial feature-positive discriminations, where each controlled a different response (X→A[R1+], A[R1-] and Y→B[R2+], B[R2-]). A transfer test was then given, followed by extinction and a second transfer test. Nonreinforced test trials of XB and YA during Test 1 revealed that R1, and not R2, occurred reliably during Y→A trials, whereas the reverse was true for X→B. The features set the occasion for a specific response to each target, rather than resulting in a general facilitation or control of the response directly. After extinction of X, during Test 2, performance was not affected on X→A or Y→B trials. Transfer tests of XB and YA revealed similar effects with A and B, not X and Y, determining response form. The features modulated the target-reinforcer associations instead of controlling responses directly.

1.3 Current Experiments

In operant occasion setting, previous research using extinction of the feature and different response topographies has demonstrated that the feature and target can have independent effects on responding, where the occasion setter controls if the organism should respond, and the target controls when to respond and what response to emit. If these stimuli are truly independent, then the target and occasion setter could theoretically control different response forms (e.g., left lever and right lever press). On the one hand, one could think of the presence and absence of a response as different response forms (the animal is doing something when it is not engaged in the target response). On the other hand, this seems like a drastically different procedure from traditional occasion setting, where discriminating a left lever from a right lever response on XA and A trials, respectively, is different from discriminating whether to respond or inhibit responding based on the presence of X. Therefore, there seems to be a qualitative difference between these discriminations.

Preceding the current studies, a pilot experiment was conducted in our lab using rats. Reinforcement followed responding to one lever (left vs. right lever press) on feature-positive trials and followed a different response on trials of the same target presented alone (XA [R1+], A [R2+]). In Group Serial, (FP, X→A[R1+]), feature-positive trials were presented serially and included a 5-s presentation of the feature (jeweled light) followed by a 5-s empty interval and then a 5-s presentation of the target (clicker). The correct response was reinforced while the clicker was present. The Simultaneous group (FP, X:A[R1+]) experienced the feature and target presented at the same time for a duration of 5-s and the correct response was reinforced throughout. Discrimination training was followed by two test sessions and extinction of the feature to determine what stimuli controlled responding.

Unlike Holland (1991), the rats given serial training in our task did not initially acquire the discrimination. Various manipulations were attempted to facilitate acquisition in this group. Among them, the response requirement was increased from a fixed ratio 1 (FR1), to an FR2 and then an FR3 but no improvement was observed. When the 5-s interval in between the feature and the target was eliminated, discrimination accuracy improved. Even with improvement in the Serial group, the Simultaneous group's responding was still significantly more accurate. Based on acquisition, it can be concluded that with a delay, the discrimination was too difficult for the Serial group. Without a delay, performance in the Simultaneous group was still better than the Serial Group. At test, the number of responses and discrimination of the correct lever during tests of X alone were equally affected by extinction of X in both groups, but not during XA trials. It was quite unexpected that the Simultaneous group demonstrated the same pattern of behavior as the Serial group. This could indicate occasion setting in the simultaneous group, or configural learning. When stimuli are presented simultaneously, rather than serially, it is more likely that occasion-setting like behavior can be interpreted as configural learning. This is because during serial presentations the representation of X decays before the representation of A, while when presented simultaneously, the representation of X and A occur at the same time. Further studies are needed to evaluate the finding of possible occasion setting in the Simultaneous group, and to facilitate discrimination learning in the Serial group while retaining the 5-s gap between the feature and target.

The current studies involved two experiments conducted to determine if the temporal arrangement of stimuli affects how a target stimulus alone (A [R1+]) comes to control one response (i.e., left lever press) while the feature and target control another response (XA [R2+], i.e. right lever press). In both experiments, the feature stimulus was a jeweled light, and the target stimulus was a tone. In Experiment 1, among the more significant changes from the pilot study, the feature (jeweled light) was made more salient by turning the houselight off throughout the entirety of the experiment. It was expected that occasion setting would occur when the feature and target were presented serially, but direct control by the feature would occur when the feature-target compound was presented simultaneously

For Experiment 2, a group was added, Serial-15, with a 15-s interval between the feature and target. The original groups, Group Serial and Simultaneous were also included. The training procedures were also modified to be more similar to testing. This was done to minimize any decrement in performance due to changes other than extinction of X.

The goal of these studies was to facilitate learning in the Serial group and to determine if occasion setting would occur in the Serial group once the feature-positive discrimination has been learned. Occasion setting should occur when the feature-target is presented serially, but direct control by the feature should occur when the feature-target is presented simultaneously. The current research expands on previous studies of occasion setting by including multiple responses and reinforcement on both target alone and feature-target trials.

2. Experiment 1

Experiment 1 replicates and extends the previous pilot study with rats. To prevent indirect reinforcement of incorrect responses, the correction procedure used in Phases 2 and 3 was modified. Previously, a trial only repeated if a correct response was not made. The rat could make several incorrect responses before making a correct response with no penalty. The modified correction procedure used in Experiment 1 terminates a trial immediately with an incorrect response, and then the entire trial repeats. Modifying the correction procedure in this way eliminates reinforcement for switching from one lever to the other within a trial.

Another change involved altering the salience of X. If rats only attended to A, then the discrimination is unsolvable. Attention to A is likely to occur given its temporal proximity to a reinforced response, especially in the Serial group when A is encountered alone on target only and feature-target trials. To encourage attention to X in the Serial group in Experiment 1, the salience of the feature (X) was increased. Since the feature was a jeweled light in this series of experiments, turning off the houselight throughout all phases of the task should increase the salience of X, which could potentially help the rats in the Serial group better learn the discrimination, and in turn, we could better determine whether occasion setting is occurring in that group or not. It was hypothesized that manipulating the correction procedure and increasing the salience of X would encourage the Serial group to learn the feature-positive discrimination. Further, if the serial rats learned the task, it was also hypothesized that the feature (X) in the Serial group would be setting the occasion for rats to respond to the target (A). In the Simultaneous group, however, the opposite was expected to occur, where X should directly control responding.

2.1 Subjects

Subjects were 16 experimentally naïve (8 male, 8 female) Long-Evans rats (*Rattus norvegicus*) obtained from Envigo Laboratories (Indianapolis, IN). All subjects were pair-housed in a vivarium that was maintained on a 12-hour dark/light cycle with the 12-hour light portion occurring between 7 am and 7 pm. All experimental procedures occurred during the light portion of the cycle. Subjects were maintained at 81-85% of their free-feeding weights by limiting their access to food. Water was available at all times in their home cages.

2.2 Apparatus

All phases of the experimental procedure occurred in eight identical operant chambers each 30 x 25 x 30 cm (l x w x h) that are held in sound-attenuating chambers. The food magazine was located on one wall of the operant chamber. Levers were located on either side of the magazine. The reinforcer was a 50% sucrose chocolate pellet. When a pellet was delivered, it was available until retrieved (detected via an infrared detector at the feeding niche). A jeweled light mounted above the box and located opposite of the magazine was used as the feature stimulus, and a clicker (periodic white noise) was used as the target stimulus. In Phase 2, a white noise was used as a training stimulus.

2.3 Procedure

2.3.1 Magazine Training (Phase 1)

In magazine training, there were three sessions which lasted for 50 minutes and included pellet deliveries every 20-s following retrieval of the previous reinforcer. After 10 reinforcer deliveries, reinforcement delivery was spaced to every 180-s for 10 more deliveries of reinforcement. During the last 10 reinforcement deliveries, the lever was presented before the pellet was available and then remained presented for 3-min or until a lever press occurred. Lever presses were reinforced on a continuous reinforcement schedule. The presentation of the left and right lever alternated across trials.

2.3.2 Discrimination Training (Phase 2)

Lever pressing was brought under discriminative control by only reinforcing lever pressing during a white noise, N. The session was broken down into 1-min intervals. The left or right lever was presented at the start of each minute, but responses were only reinforced during the second half of each interval in which the noise was presented. The presented lever alternated across trials. This Phase consisted of 8 sessions, where each session was 50 minutes. The S^D duration was reduced over sessions (c.f., Holland, 1995). The S^D was presented for 30-s (Days 4-5), 15-s (Days 6-7), 10-s (Days 8-9), and 5-s (Days 10-11).

2.3.3 Feature-positive Discrimination Training (Phase 3)

This phase consisted of 50-min sessions that included 24 feature-positive (FP) and 24 discriminative-stimulus (S^D) only trials. Initially, on serial FP trials (X→A+), the jeweled light (X) was presented for 15-s followed by a 5-s empty interval (→) and then the clicker (A, 8-hz, 80-db) was presented for 15-s. On simultaneous FP trials (X:A+), the jeweled light (X) and clicker (A) were presented together for 15-s. On S^D only trials (A+), the clicker was presented for 15-s. Responses (lever pressing) were reinforced during the presentation of the clicker on both trial types. Assignment of correct lever (left or right) for each trial type was counterbalanced across subjects. Whenever an incorrect response was detected, the trial terminated, and the subject could repeat the trial up to nine times. Each session was approximately 50 minutes or 48 trials, whichever occurred first. The ITI between trials was a fixed 75-s. After two sessions of 15-s stimuli (Days 1 - 2), stimulus duration was reduced to 10-s for four sessions (Days 3 - 6), and then to 5-s for ten sessions (Days 7 - 16). When the stimuli durations were 15 and 10-s, reinforcement was delivered on a fixed ratio 1 (FR1) schedule. However, when the stimulus duration decreased to 5-s, the first five sessions were on an FR2 schedule (Days 7 - 11), while the remaining sessions were on a variable ratio 2 (VR2) schedule (Days 12 - 26). Three additional manipulations were made. Beginning on Day 14, the trial types were randomized in blocks of four (XA, XA, A, A) to create more possible trial sequences. Additionally, on Day 17, a lever press punishment contingency was implemented, where any lever press during the pre-CS period resulted in an additional 30-s before the beginning of the next trial. This no lever press period was initially 10-s (Day 17) but was increased to 20-s (Day 18), and then 30-s for the remainder of this phase (Days 19 - 26). This manipulation was implemented to discourage ITI pressing prior to testing. Lastly, on Day 21, the ITI was modified to be variable instead of fixed, to increase the unpredictability of the start of the trial. The variable ITI was 75-s +/- 20% (60, 75, or 90-s).

2.3.4 Testing

This phase consisted of two sessions of testing separated by eight sessions of extinction of X. Test 1 included five-trial blocks consisting of randomized presentations of three nonreinforced test trials of X, A, and XA intermixed with two reinforced trials of N (from Phase 2) within a block. There were also two reinforced 5-s N trials between each block. The blocks repeated 8 times. The reinforced lever alternated each time N was presented. Following Test 1, eight sessions of extinction were presented. In each 40-min extinction session, all rats received 32 nonreinforced presentations of X for 5-s along with 8 reinforced trials of N. Trials were presented in blocks with 8 trials of X and 2 trials of N. Trials of N were included to maintain a level of responding during extinction. Following extinction, Test 2, which was identical to Test 1, was administered.

2.4 Analysis Plan

The independent variable was how the stimuli were presented, either serial feature-positive (X→A+) or simultaneous (X:A+) presentations. There were also trials where the discriminative stimulus was presented alone (A+). In Phase 2, two dependent measures were used. Discrimination ratio (DS/DS+PreDS period) was used to determine how well they were discriminating, while percent correct (correct/total trials multiplied by 100) tells us that they are making a response and completing the trials. In Phase 3, the same two measures were used, but calculated differently. Discrimination ratio in Phase 3 was calculated by dividing the number of correct responses by the total responses. This measure allowed us to look at how accurate their responses were. A discrimination ratio equal to .5 indicates that they are not learning the discrimination and are pressing the levers equally. Greater than .5 means that they are pressing the correct lever more than the incorrect lever. Alternatively, less than .5 means that they are pressing the incorrect lever more than the correct lever. Percent correct was calculated the same way as in Phase 2 (correct/total responses x 100) and allowed us to look at their first response (either correct or incorrect) within each trial. During testing, mean number of correct and incorrect responses, as well as discrimination ratio (correct/total responses) were used as measures in the test phase. During Phases 2 and 3, a mixed analysis of variance (ANOVA) was conducted on each measure with Trial Type (FP trials and S^D only trials) and session as the repeated measures, and Group (Serial and Simultaneous) as the between-subjects factor. For analysis of the testing data, a mixed ANOVA was conducted on the number of responses with Trial Type (FP trials, S^D only trials, and feature alone trials) as the repeated measure and Group (Serial and Simultaneous) as the between-subjects factor. A priori planned comparisons (with a Bonferroni correction) were conducted when prior data was used to select on a few comparisons. Additionally, a *t*-test was conducted on the discrimination ratio against .5 in all phases.

3. Results

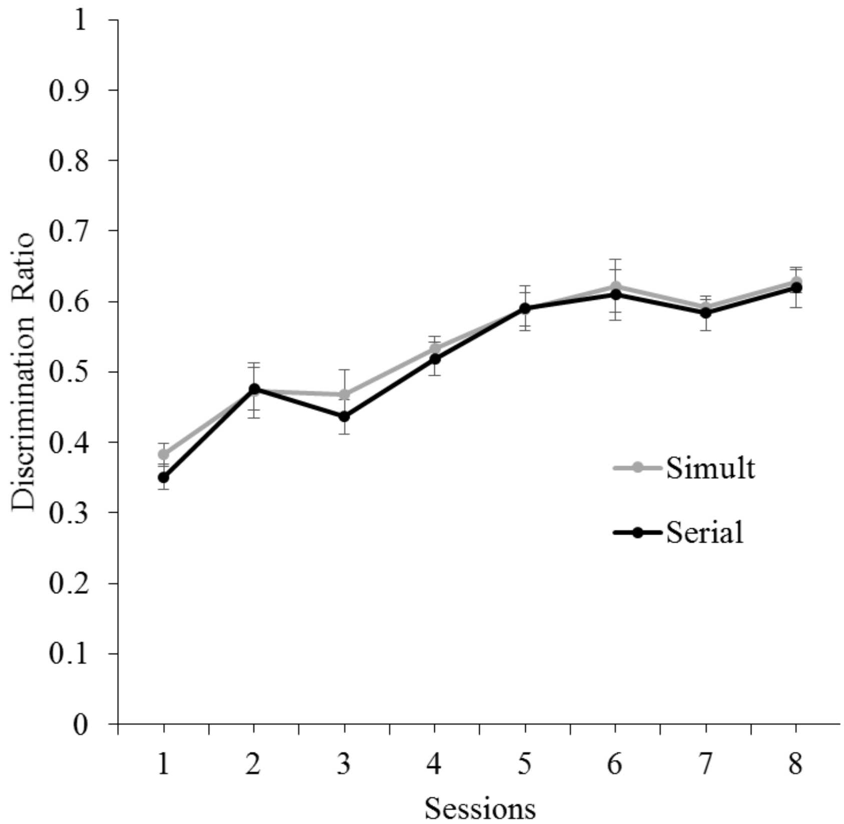
3.1 Magazine Training (Phase 1)

During Phase 1 of the experiment, rats underwent magazine and lever press training. The mastery criterion was 40 lever presses. Rats 2 and 5 required additional 50-minute sessions to meet criterion on Day 3.

3.2 Discrimination Training (Phase 2)

During discrimination training, there were 8 sessions, in which rats received an FR1 schedule for four days, an FR2 schedule for two days, and a VR2 schedule for two days. Sessions started with a stimulus presentation duration of 30-s for two days, followed by 15, 10 and 5-s, with each duration occurring for two sessions. Figure 1 reveals that the discrimination ratio improved across sessions for both groups. A repeated-measure ANOVA with Group (Serial and Simultaneous) being the between-subject factor and Sessions (7-8) being the repeated measure was conducted on the discrimination ratio for the last two sessions. There was no main effect of Group, $F < 1$, but there was a significant main effect of Session, $F(1, 14) = 9.81$, $p < .007$, with the discrimination ratio being the highest during the final session (see Figure 1). The Group by Session interaction was nonsignificant, $F < 1$. Additionally, a single-sample *t*-test was conducted against chance (.5) revealing that during sessions 7, $t(15) = 6.63$, $p < .001$, and 8, $t(15) = 7.89$, $p < .001$, the discrimination ratio was significantly above chance.

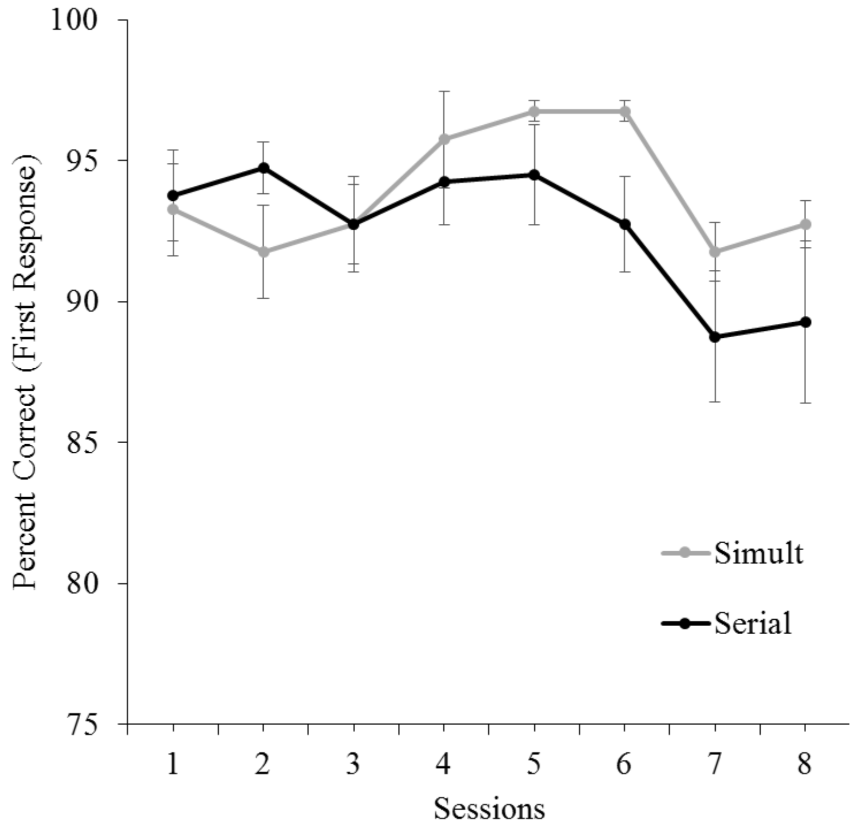
Figure 1



Note. Discrimination ratio across sessions in Phase 2 of Experiment 1. Error bars represent the standard error of the mean.

A repeated measures ANOVA was also conducted on the percent correct during the final two sessions of the phase. There were no reliable differences between Groups, $F(1, 14) = 1.77$, $p = .20$. Additionally, performance stabilized in the final two sessions and there was no significant main effect of Session, $F < 1$, with the interaction also being nonsignificant $F < 1$ (see Figure 2).

Figure 2



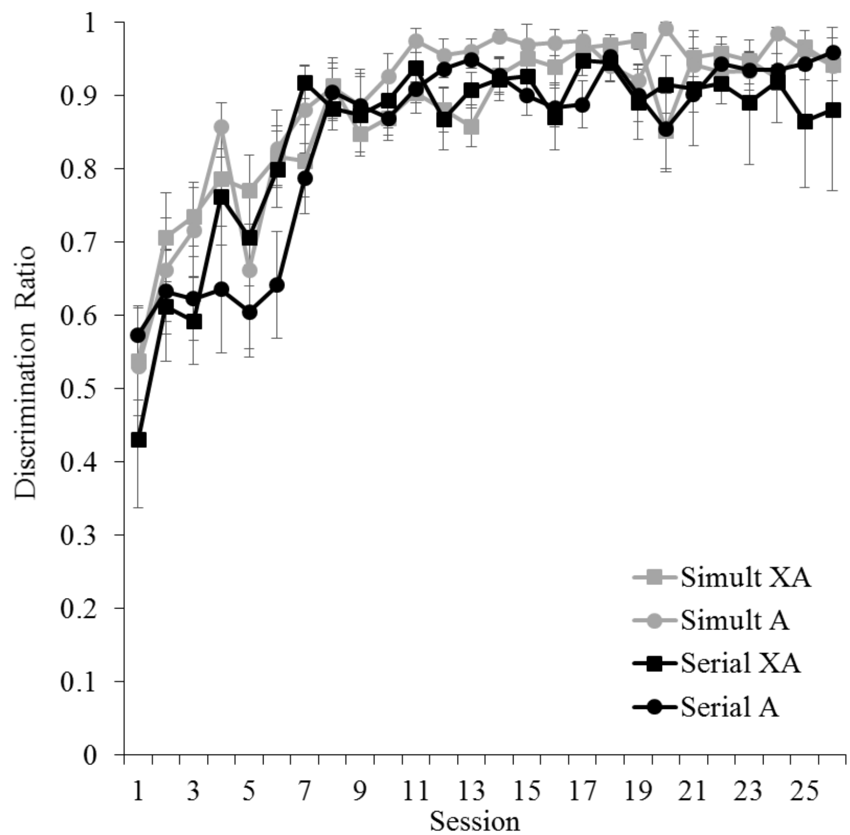
Note. Percent correct of first responses across sessions in Phase 2 of Experiment 1. Error bars represent the standard error of the mean.

3.3 Feature-positive Discrimination Training (Phase 3)

Phase 3 included FR1, FR2, and VR2 schedules of reinforcement, and the stimulus being presented anywhere from 5-15 seconds. In the last six sessions, the manipulations were stable, therefore, a repeated measures ANOVA with Trial Type (XA, A) and Sessions (21-26) as the repeated measures, and Group (Serial and Simultaneous) as the between-subjects factor was conducted on the discrimination ratio. Results revealed that there was no reliable difference in discrimination ratio between Groups, $F < 1$. The discrimination ratio also stabilized in the last six sessions, with there being no main effect of Session, $F < 1$. There were also no differences in discrimination ratio between trial types, $F < 1$. All interactions were nonsignificant, $Fs \geq .20$, $ps \geq .33$.

A single-sample *t*-test was conducted on the average of the final six sessions in each group against chance (.5). The analysis revealed that the average discrimination ratio in the final six sessions in the Serial group was significantly above chance, $t(7) = 12.02$, $p < .001$. A separate *t*-test revealed that the discrimination ratios in the final six sessions average for the Simultaneous group was also significantly above chance, $t(7) = 44.65$, $p < .001$ (see Figure 3).

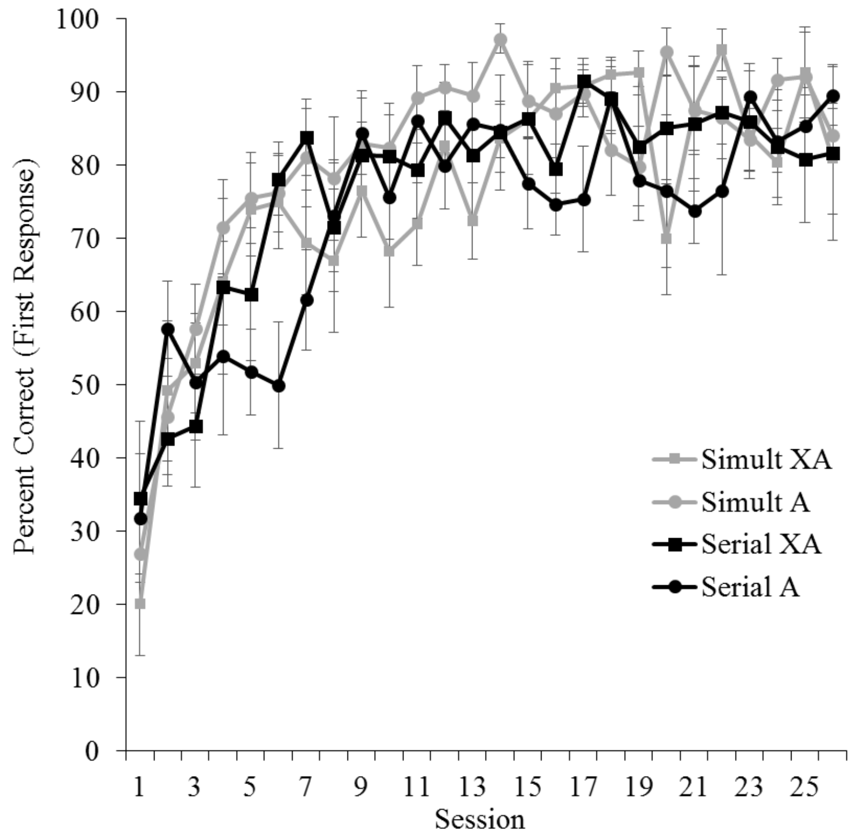
Figure 3



Note. Discrimination Ratio across sessions in Phase 3 of Experiment 1. Error bars represent the standard error of the mean.

A second repeated measures ANOVA was also conducted with percent correct of the final six sessions. Results revealed no main effect of Group, $F < 1$, no main effect of Session, $F < 1$, or Trial Type, $F < 1$. There was a significant Sessions by Group interaction, $F(5, 70) = 2.41$, $p = .05$. A Tukey's Honestly Significant Differences (HSD) post-hoc test revealed that there were no differences in percentage correct between groups across all sessions, $ps \geq .35$ (see Figure 4).

Figure 4

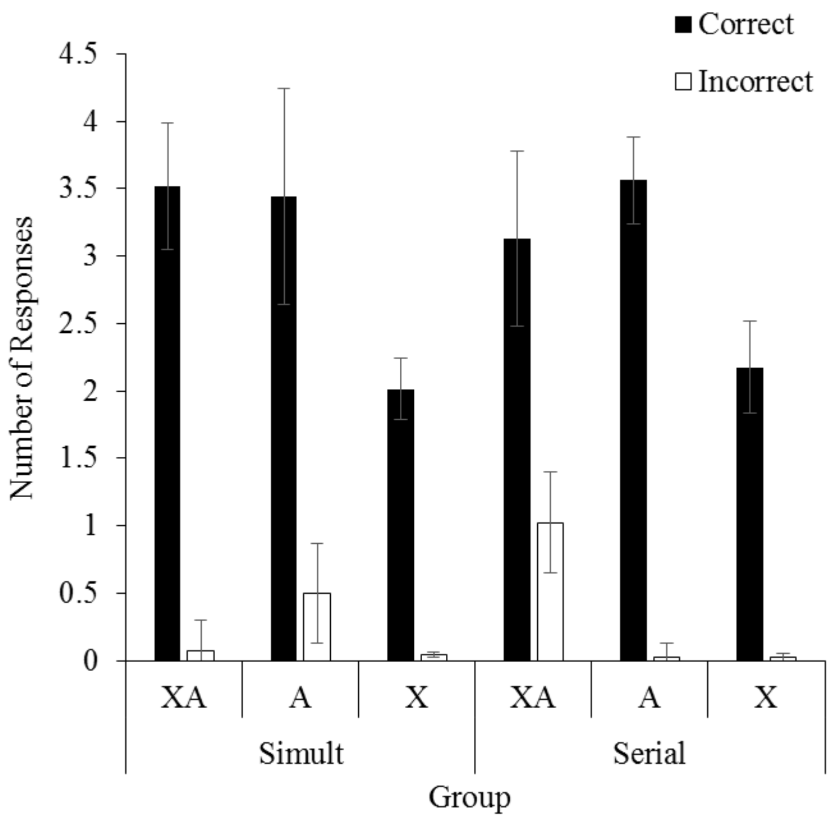


Note. Percent correct of first responses across sessions in Phase 3 of Experiment 2. Error bars represent the standard error of the mean.

3.4 Testing

For Test 1 data, a repeated measures ANOVA with Trial Type (XA, A, X) and Response Type (correct, incorrect) being the repeated measures, and Group (Serial, Simultaneous) being the between-subject factors, was conducted on the mean number of responses. There was no main effect of Group, $F(1,14) = .06$, $p = .81$, but there was a significant main effect of Response Type, $F(1,14) = 110.47$, $p < .001$, with there being more correct responses than incorrect. There was also a significant main effect of Trial Type, $F(2, 28) = 10.44$, $p < .001$. All interactions were nonsignificant, Fs $\geq .13$, ps $\geq .26$. Planned comparisons explored the main effect of Trial Type and revealed a significant difference in number of responses between X and both XA and A trials, Fs ≤ 27.94, ps $\leq .005$, with X having less responses than XA and A trials, but no difference between them, $F < 1$ (see Figure 5)

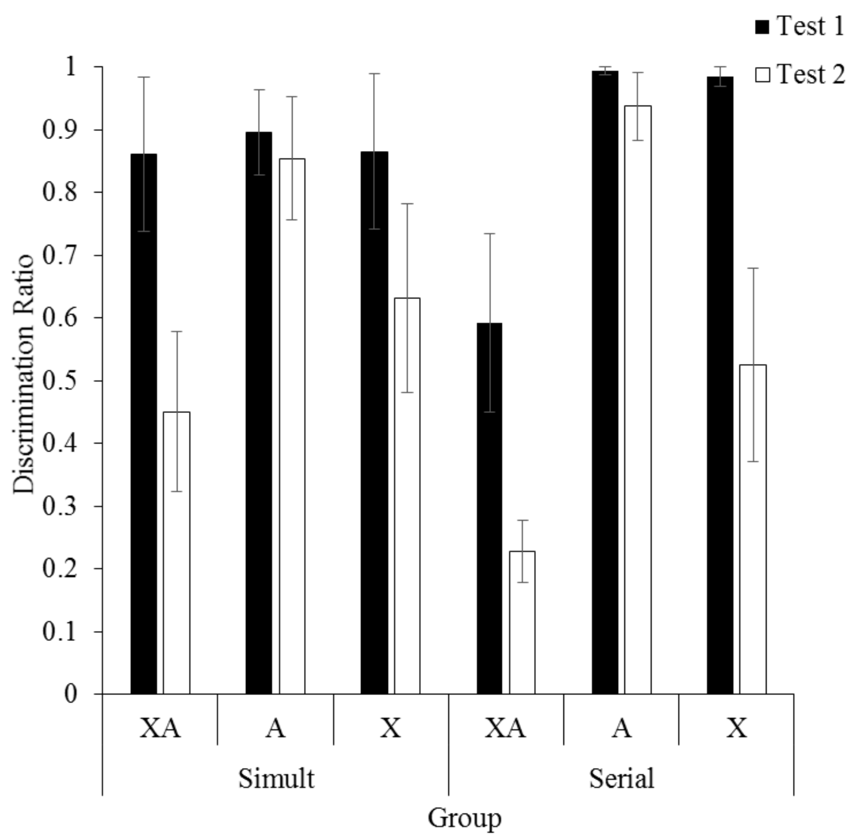
Figure 5



Note. Number of responses in Test 1 of Experiment 1. Error bars represent the standard error of the mean.

A single-sample *t*-test was performed on the discrimination ratio during Test 1 and conducted against chance (.5), revealing that the discrimination ratio in the Serial group during XA trials was not significantly different from chance, $t(7) = .65$, $p = .54$. However, discrimination ratio during trial types A and X were significantly above chance, *p*s < .001. In the Simultaneous group, all trial types were significantly above chance, *p*s ≤ .02, indicating that they were discriminating between the two responses during all trial types. Following extinction of X, the discrimination ratio conducted against chance revealed that in the Serial group, during XA trials, discrimination ratio performance was significantly below chance $t(7) = -5.46$, $p < .001$, indicating that rats were pressing the wrong lever more than the correct lever (see Figure 6). During A trials, discrimination ratio was significantly above chance, $t(7) = 8.09$, $p < .001$, and finally, X alone trials were not significantly different from chance, $t < 1$. In the Simultaneous group, following extinction, trial types XA and X were no longer significantly different from chance, $ts \geq -.39$, $ps \geq .41$, but A trial types remained significantly above chance, $t(7) = 3.62$, $p < .009$.

Figure 6

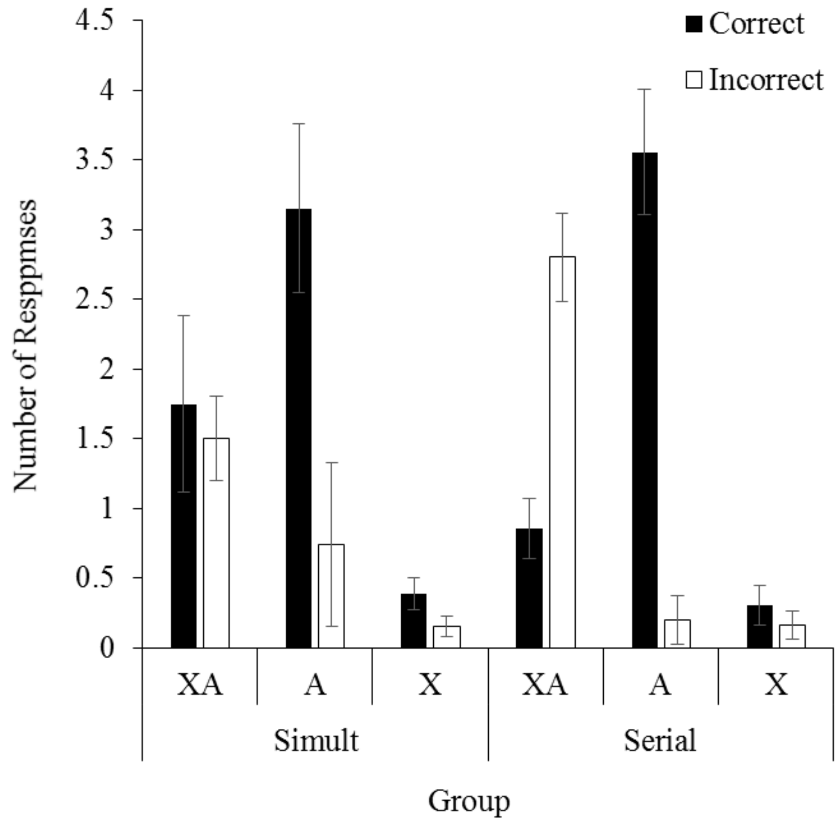


Note. Discrimination ratio in Test 1 vs Test 2 of Experiment 1. Error bars represent the standard error of the mean.

For the Test 2 response data, the same analysis was conducted and revealed no main effect of Group, $F < 1$, but there was a significant main effect of Response Type, $F(1,14) =$

17.16, $p < .001$, with there being more correct responses than incorrect responses (see Figure 7). There was also a significant main effect of Trial Type, $F(2, 28) = 82.43$, $p \leq .001$. There was a significant two-way interaction between Response and Trial Type, $F(2, 28) = 14.65$, $p < .001$. All other interactions were nonsignificant, ps $\geq .10$. Planned comparisons explored the main effect of Trial Type and revealed a significant difference in responding between X trials and both XA and A trials, Fs ≤ 111.67, ps $\leq .001$, with there being more responding to XA and A, than to X. There were no differences in number of responses between XA and A, $F(1, 14) = 2.24$, $p =$ .16 Planned comparisons were also conducted to explore the Response by Trial Type interaction. There were no differences between correct and incorrect responding during XA and X trial types, Fs ≥ 2.19, ps $\geq .10$. For A trials, however, there were more correct responses than incorrect responses, $F(1, 14) = 23.83$, $p < .001$.

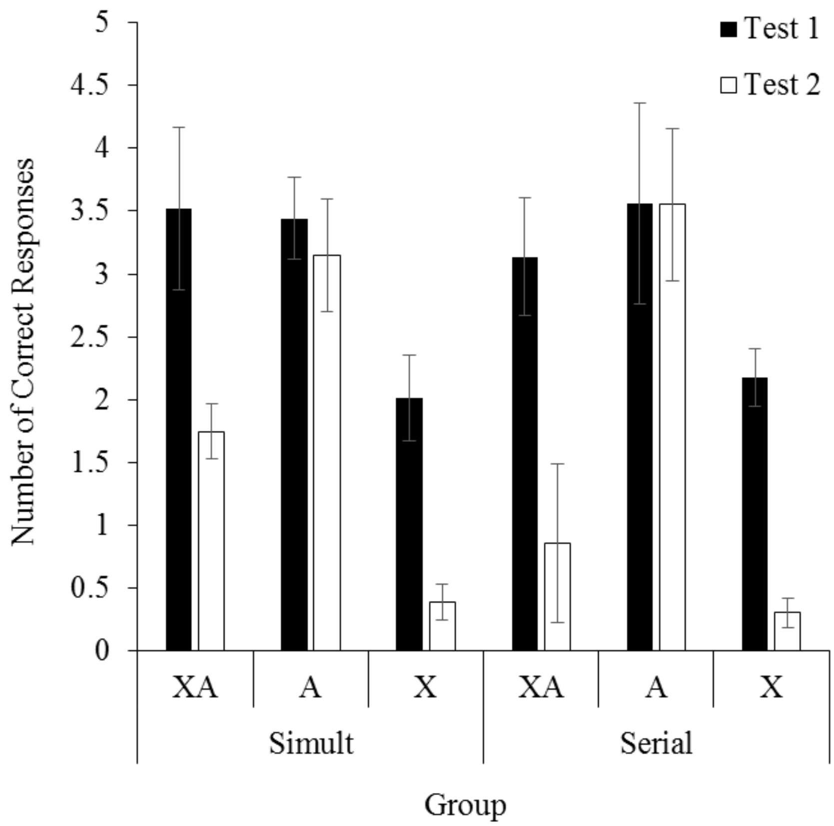
Figure 7



Note. Number of responses in Test 2 of Experiment 1. Error bars represent the standard error of the mean.

A separate ANOVA conducted on the mean number of correct responses at Test 1 and Test 2 revealed no main effect of Group, $F < 1$, but there was a significant main effect of Extinction, $F(1, 14) = 30.75$, $p < .001$, with there being less responses during Test 2. There was also a significant main effect of Trial Type, $F(2, 28) = 17.17$, $p < .001$. Finally, there was a significant 2-way interaction between Extinction and Trial Type, $F(2, 28) = 8.23$, $p < .001$. All other interactions were nonsignificant, Fs $\geq .11$, ps $\geq .47$. Planned comparisons explored the main effect of Trial Type and revealed that there was a significant difference in amount of correct responding between X and both XA and A trial types, Fs ≤ 35.36, ps $\leq .001$, with A and XA having more responses than X. There was no significant difference in responding between XA and A trial types, $F(1, 14) = 6.56$, $p = .02$. Separate planned comparisons explored the interaction of Extinction and Trial Type and revealed a significant effect of extinction in XA and X trials, *F*s ≤ 54.06, *p*s $\leq .001$, however, extinction did effect correct responses during A trials between Test 1 and Test 2, $F < 1$ (see Figure 8).

Figure 8



Note. Number of correct responses in Test 1 vs Test 2 of Experiment 1. Error bars represent the standard error of the mean.

4. Discussion

Results revealed that the Serial group was able to learn the discrimination, as the ratio was significantly above chance in the final trials of Phase 3. But, following training, the discrimination ratio declined during XA test trials, and was no longer significantly above chance. Many of the conditions were different from training to testing. For example, N trials were reintroduced in testing, and had only been previously experienced in Phase 2, not during Phase 3. Additionally, the ITI during the last six sessions of training was variable, where in testing the ITI was fixed. Other differences between training and testing include that during training, rats were exposed to reinforced trials of XA and A, but most trials were nonreinforced during testing. Looking at the number of responses revealed that response levels during XA trials were less affected by transitioning to the testing phase, compared to the discrimination ratio during XA trials. Following extinction, discrimination ratio was even lower during XA trials in the Serial group. It was significantly below chance. When the discrimination ratio is significantly below .5, this indicates that they are pressing the incorrect lever more, meaning that something about the feature-positive task is making the Serial group learn the discrimination differently. During Test 1, the discrimination ratio in the Serial group during A and X trials was significantly above chance and they seemed to have learned when to respond to the correct lever in the presence of these stimuli, but results suggest that they learned to respond to the incorrect lever in the presence of the feature-target compound. This could indicate that A was interfering with X, because following extinction of X, the feature-no reinforcer association was learned, therefore leaving A to control the behavior. Since the incorrect response to XA is the correct response during A trials, it results in a discrimination ratio that is at, or significantly below chance, indicating a preference for the lever that is correct during A trials. This indicates that rats in the Serial group learned about X and A separately, because once X was extinguished, A remained to control responding, and the correct response during A trials is the incorrect response during XA trials.

In Experiment 2, testing was made more similar to transfer, with the addition of N trials, XA and A probe trials, and a fixed ITI during the last few sessions of testing. It was expected that the discrimination ratio would be maintained with these manipulations. In the current study, what looked to be direct control occurred in the Serial group. There is a possibility that X is overshadowing A. Increasing the interval between the feature and the target could possibly diminish potential overshadowing. This is one of the manipulations that was implemented in Experiment 2.

5. Experiment 2

Experiment 2 examined whether manipulating testing conditions to be more similar to training would improve transfer in the Serial group. In the current experiment, there were three groups: Serial-5, Serial-15, and Simultaneous. The Serial-5 and Simultaneous groups were the same from Experiment 1, and the Serial-15 group had a 15-s interval between the feature and target. The additional serial group was added (Serial-15), further separating X and A, to reduce the salience of X. This could reduce any potential overshadowing by X, or learning about the Feature-reinforcer association. The results of the Serial group in Experiment 1 suggest direct control by the feature, because extinction of X reduced responding to XA and X trials. Past research (Swartzentruber, 1995) has demonstrated that a longer interval between the stimuli should facilitate learning about the Feature (Target- reinforcer) association.

Additional changes were made in Phase 3 to attempt to better equate the conditions of training and testing. In Experiment 1, there were several changes that occurred from the training sessions to testing. These include the presence of probe trials, the presence of N trials, and changing from a variable ITI to a fixed ITI. To minimize any impact from these changes in Experiment 2, the last ten sessions of Phase 3 included probe trials at a ratio of 1:5 to reinforced trials and N trials with a 1:5 ratio to training trials. Additionally, a punishment period was implemented during which lever pressing resulted in further delaying the start of the trial. The length of this period was also at a 1:3 ratio. Ten days after implementing the probe trials, the ITI ratio increased from 1:3 to 1:10, to be more similar to Holland (1995). Therefore, session duration increased from 50 minutes to 90 minutes. The final preparation for testing was to remove the correction procedure during the last five days of training.

It was hypothesized that occasion setting would occur in the Serial-15 group. Given the additional changes to make the training and testing conditions more similar, the Serial-5 group may demonstrate occasion setting. Similar to Experiment 1 and consistent with past research, it was expected that direct control by the feature would occur in the Simultaneous group.

5.1 Subjects

Subjects were 32 experimentally naïve (16 male, 16 female) Long-Evans rats (*Rattus norvegicus*) obtained from Envigo Laboratories (Indianapolis, IN). All other subject information is as described in Experiment 1.

5.2 Apparatus

Apparatus is as described in Experiment 1.

5.3 Procedure

5.3.1 Magazine Training (Phase 1)

In magazine training, there were three sessions that lasted for 50 minutes and included pellet deliveries every 20-s following retrieval of the previous reinforcer. After 10 reinforcer deliveries, reinforcement delivery was spaced to every 180-s for 10 more deliveries of reinforcement. During the last 10 reinforcement deliveries, the lever was presented before the pellet was available and then remained presented for 3-min or until a lever press occurred. Lever presses were reinforced on a continuous reinforcement schedule. The presented lever alternated across trials.

5.3.2 Discrimination Training (Phase 2)

Lever pressing was brought under discriminative control by only reinforcing lever pressing during a white noise (reinforcement type alternated). The session was broken down into 1-min intervals. The left or right lever was presented at the start of each minute, but responses were only reinforced during the second half of each interval in which the noise was presented. The presented lever alternated across trials. This Phase consisted of 8 sessions, where each session was 50 minutes. The S^D was presented for 30-s (Days 4-5), 15-s (Days 6-7), 10-s (Days 8-9), and 5-s (Days 10-11), where the stimulus duration was reduced over sessions (Holland, 1995).

5.3.3 Feature-Positive Discrimination Training (Phase 3)

This phase consisted initially of 50-min sessions (Days 1-16), and then 90-min sessions (Days 17-40). Sessions included feature-positive (FP) and discriminative-stimulus (S^D) only trials. The number of trials able to be completed varied based on ITI ratio and session length. Initially, on Serial-5 FP trials (X→A+), the jeweled light (X) was presented for 15-s followed by a 5-s empty interval (→) and then the clicker (A, 8-hz, 80-db) was presented for 15-s. On Serial-15 FP trials (X→A+), the jeweled light (X) was presented for 15-s followed by a 15-s empty interval (→) and then the clicker (A, 8-hz, 80-db) was presented for 15-s. On Simultaneous FP trials (X:A+), the jeweled light (X) and clicker (A) were presented together for 15-s. On S^D only trials (A+), the clicker was presented for 15-s. Responses (lever pressing) were reinforced during the presentation of the clicker on both trial types. Assignment of correct lever (left or right) for each trial type was counterbalanced across subjects. Whenever an incorrect response was detected, the trial terminated, and the subject could repeat the trial up to nine times. For the 50-min sessions, the ITI was fixed at a ratio of 1:3 for each group's total trial duration (feature + delay + target). After two sessions of 15-s stimuli, stimulus duration was reduced to 10-s for two sessions, and then to 5-s for the rest of the sessions, for a total of 40 sessions in Phase 3. An FR1 schedule was in place for the first six sessions. On the seventh day, an FR2 was implemented for 20 sessions, and the ITI schedule was also made variable (+/- 20% of the fixed ITI for each group). An ITI punishment period was added where pressing the lever would result in the period extending, delaying the start of the next trial. On the tenth session of the FR2 schedule, the session length increased to 90-min, or the maximum number of trials to be completed, whichever came first. For the 90-min sessions, the ITI ratio increased to 1:10 to better follow the procedure of Holland (1995). Probe trials were also implemented at the same time as the ITI increase at a 1:5 ratio. A VR2 was in place for the last 14 sessions. In the last ten sessions of Phase 3, noise (N) trials were also added at a 1:5 ratio. The correction procedure was also eliminated in the last five sessions. The last three sessions were changed to a fixed ITI of 110-s. All of these changes were intended to minimize the disruption from training to testing.

5.3.4 Testing

This phase consisted of two sessions of testing and eight sessions to extinguish X. Test 1 included five-trial blocks consisting of randomized presentations of three nonreinforced test trials of X, A, and XA intermixed with two reinforced trials of N within a block. There were also two reinforced N trials between each block. The blocks repeated 8 times. The reinforced lever alternated when N was presented. Following testing, eight sessions of extinction were presented. In each 40-min extinction session, all rats received 32 nonreinforced presentations of X along with 8 reinforced trials of N in blocks with 8 trials of X and 2 trials of N. N was reinforced to maintain a level of responding from the subjects. Following extinction, Test 2, which is identical to Test 1, was administered.

5.4 Analysis Plan

The analysis plan for Experiment 2 is as described in Experiment 1, except there is an additional group – Serial-15, which is an additional level of the independent variable.

6. Results

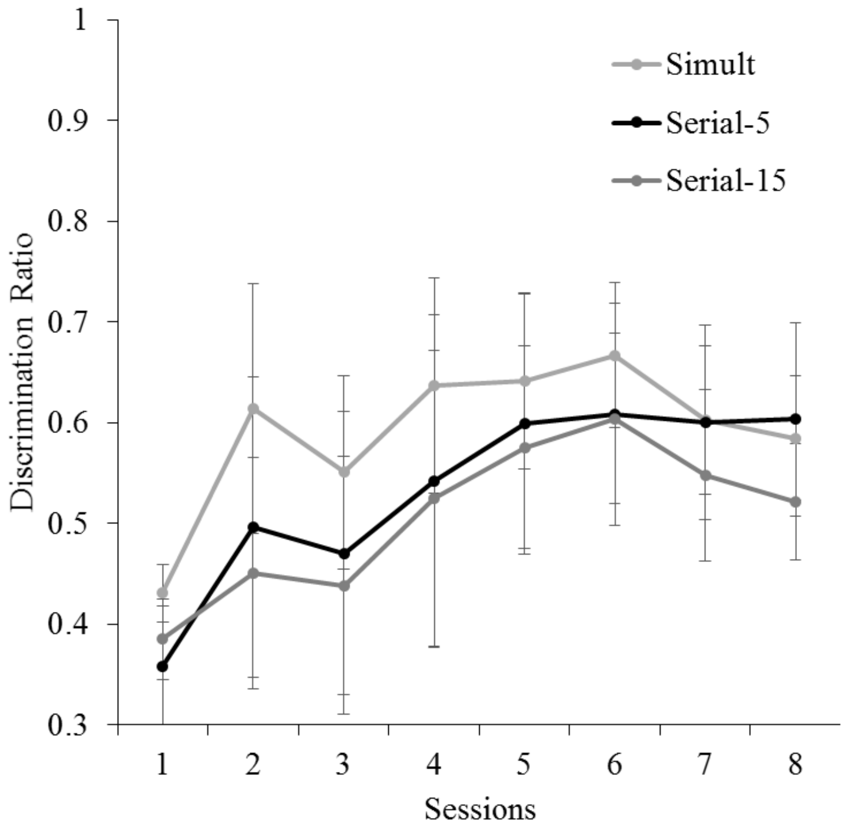
6.1 Magazine Training (Phase 1)

In Day 2 of the experiment, rats underwent magazine and lever press training. Mastery to criterion was 50 lever presses. All rats mastered the criterion and moved on.

6.2 Discrimination Training (Phase 2)

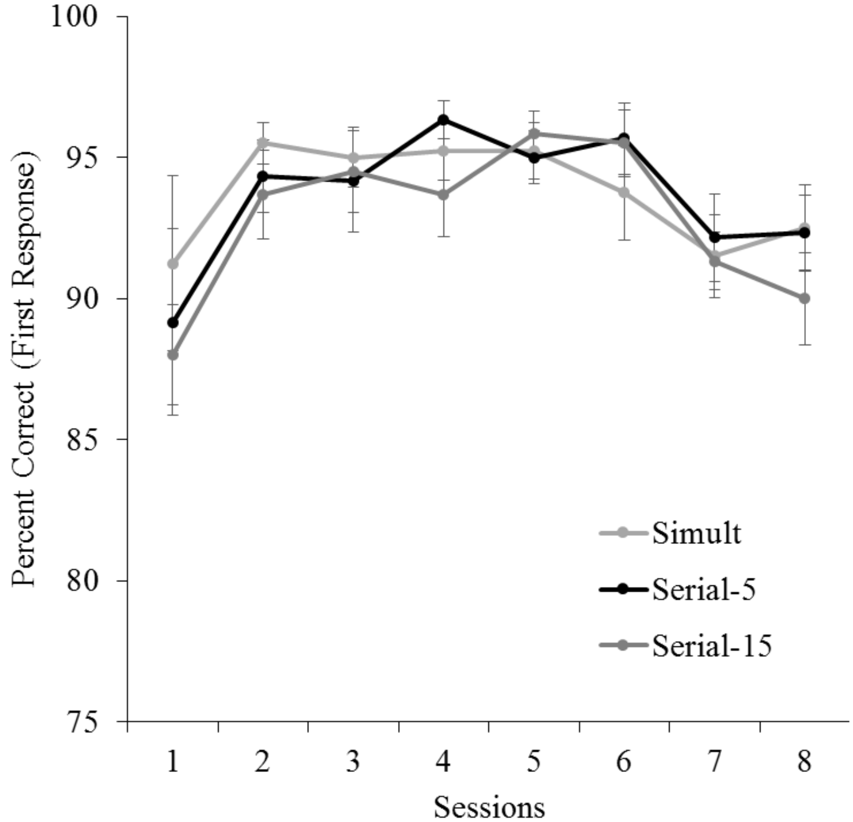
During Discrimination Training, there were 8 sessions, where rats received an FR1 schedule for four days, an FR2 schedule for two days, and a VR2 schedule for two days. Sessions started with a stimulus presentation duration of 30-s for two days, followed by 15, 10 and 5-s, with each duration occurring for two sessions. A repeated-measures analysis of variance (ANOVA) with Group (Serial-5, Serial-15, Simultaneous) being the between-subject factor and Sessions (7-8) being the repeated-measure factor was conducted on the discrimination ratio for the final two sessions. There was no main effect of Group, $F(2, 29) = 2.48$, $p = .10$, or of Session, $F(1, 29) = 1.97$, $p = .17$. The interaction was also nonsignificant, $F < 1$ (see Figure 9). A repeated-measures ANOVA was also conducted on the percent correct for the final sessions of the phase. There was no main effect of Group or Session, Fs < 1.The interaction was also nonsignificant, $F < 1$ (see Figure 10).

Figure 9



Note. Discrimination ratio across sessions in Phase 2 of Experiment 2. Error bars represent the standard error of the mean.

Figure 10



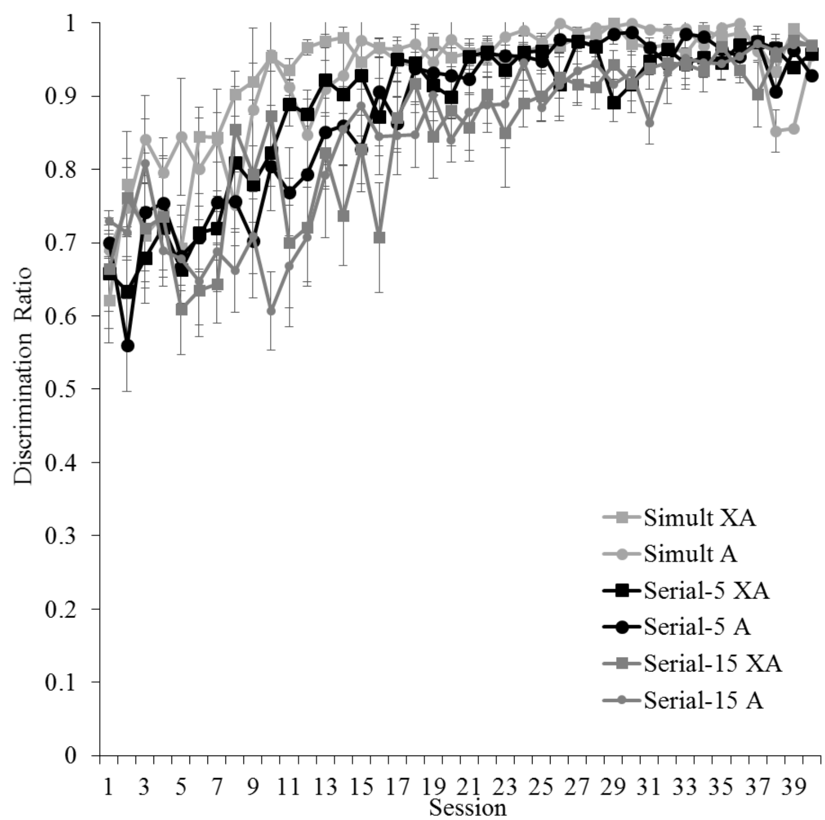
Note. Percent correct of first responses across sessions in Phase 2 of Experiment 2. Error bars represent the standard error of the mean.

6.3 Feature-positive Discrimination Training (Phase 3)

In Phase 3 training, a repeated-measures ANOVA with the last three Sessions (38-40) and Trial Type (XA, A) as the repeated measures and Group (Serial-5, Serial-15, Simultaneous) as the between-subjects factor was conducted on the discrimination ratio. There was no main effect of Group, $F(2, 29) = 1.09$, $p = .35$, Session, $F(2, 58) = 1.44$, $p = .25$, or Trial Type, $F(1, 29) = 1.89$, $p = .18$, with discrimination ratio being similar between XA and A trial types and all groups. All interactions were also nonsignificant, $F\text{s} \geq .58$, $p\text{s} \geq .33$.

A single-samples *t*-test was conducted on the discrimination ratio and compared to chance (.5), which revealed that the discrimination ratio during all sessions and groups was significantly above chance, *p*s < .001 (see Figure 11).

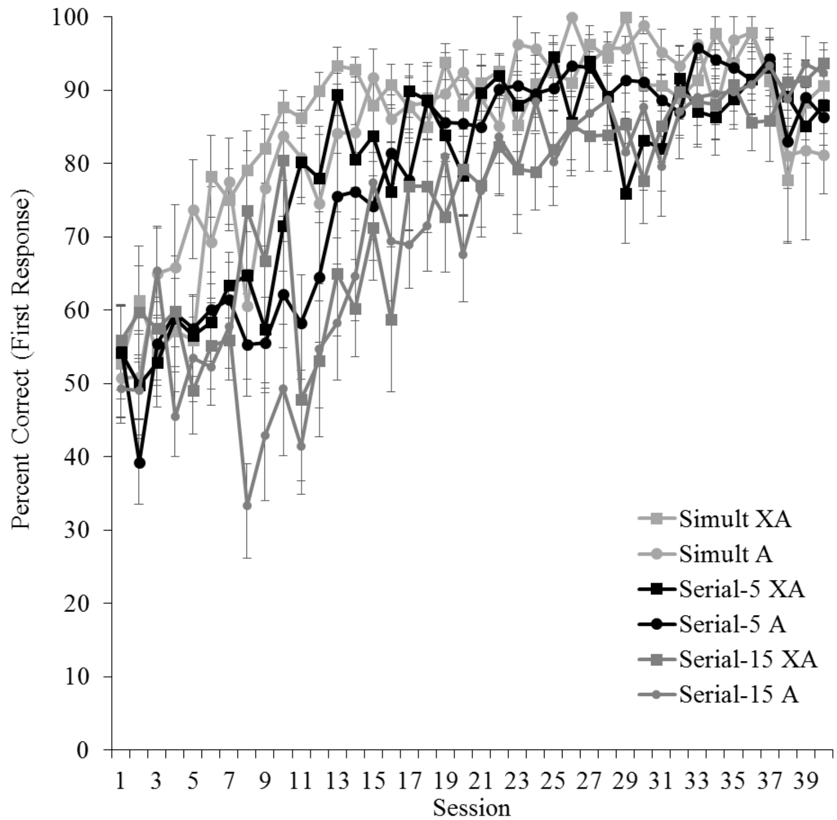
Figure 11



Note. Discrimination ratio across sessions in Phase 3 of Experiment 2. Error bars represent the standard error of the mean.

A second repeated measures ANOVA with the same factors as above was conducted on the percent correct of the final three sessions of Phase 3. There was no effect of Group, $F(2, 29) = 1.53$, $p = .23$, Session, $F(2, 58) = 1.09$, $p = .34$, or Trial Type, $F < 1$. All interactions were also nonsignificant, Fs $\geq .15$, ps $\geq .47$ (see Figure 12).

Figure 12



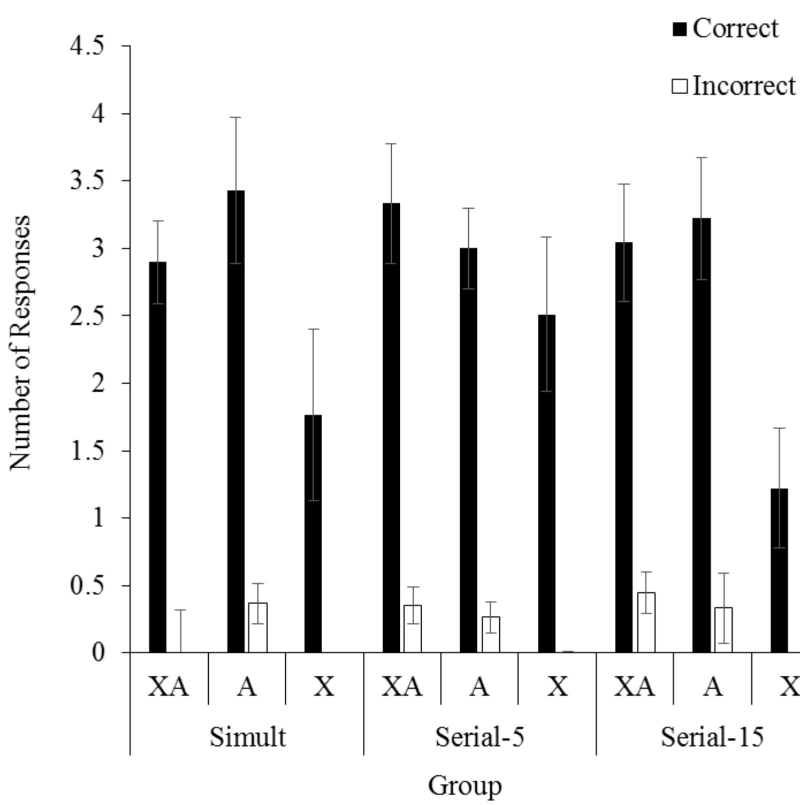
Note. Percent correct of first responses across sessions in Phase 3 of Experiment 2. Error bars represent the standard error of the mean.

6.4 Testing

For Test 1, a repeated-measures ANOVA was conducted on number of responses, with the repeated measures being Trial Type (XA, A, X) and Response Type (Correct, Incorrect), and Group (Simultaneous, Serial-5, Serial-15) being the between-subjects factor. There was no main effect of Group, $F < 1$. There was a significant main effect of Trial Type, $F(2, 58) = 146.41$, $p < .001$, and Response Type, $F(1, 29) = 12.60$, $p < .001$, with there being more correct than incorrect responses (see Figure 13). Finally, the Trial Type by Response Type interaction was significant, $F(2, 58) = 13.25$, $p < .001$. All other interactions were nonsignificant, $F\text{s} \geq .35$, $p\text{s} \geq$

.42. Planned comparisons explored the main effect of Trial Type and revealed a significant difference in total number of responses between X and both XA and A trial types, *F*s ≤ 13.08, *p*s ≤ .001, with XA and A having more responses, and there being no difference between them, *F* < 1. Planned comparisons also explored the Trial Type by Response interaction. There was no difference between number of correct responses between XA and A trials, *F* < 1. There was, however, a difference between X, and XA and A, *F*s ≤ 8.13, *p*s ≤ .006, with there being more correct responses to XA and A, than X trials. There was no difference between incorrect responses between XA and A trials, *F* < 1, but there were differences in incorrect responses between X, and XA and A trials, *F*s ≤ 6.75, *p*s ≤ .01.

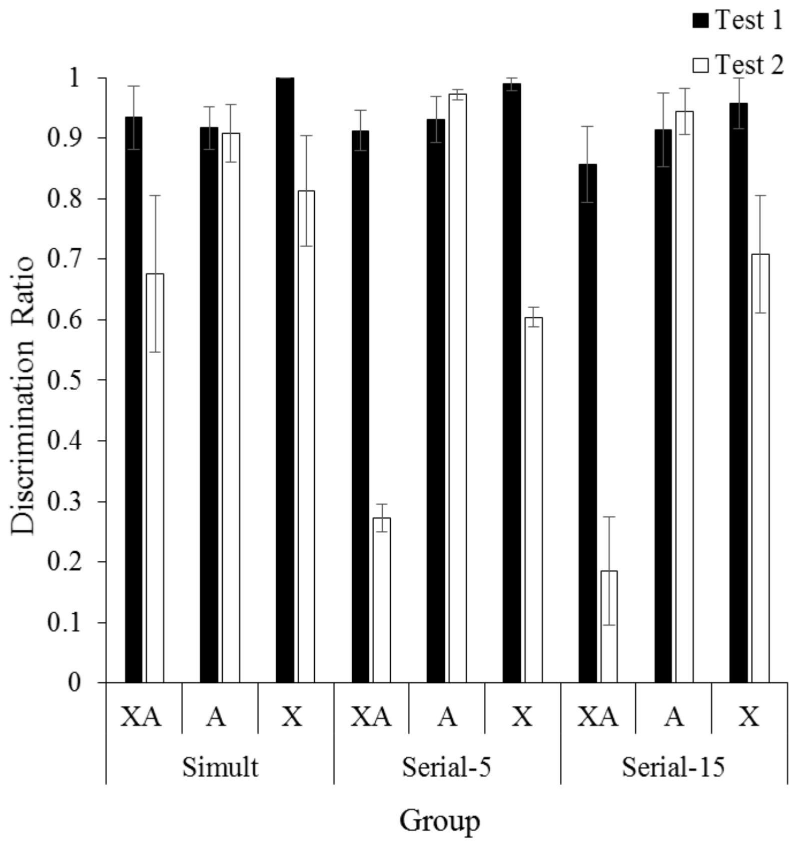
Figure 13



Note. Number of responses in Test 1 of Experiment 2.

A single-samples *t*-test was conducted on the discrimination ratio against chance (.5) in Test 1. For all groups, the discrimination ratios were all significantly above chance, *p*s ≤ .001, with the rats pressing the correct lever significantly more than the incorrect lever (see Figure 14).

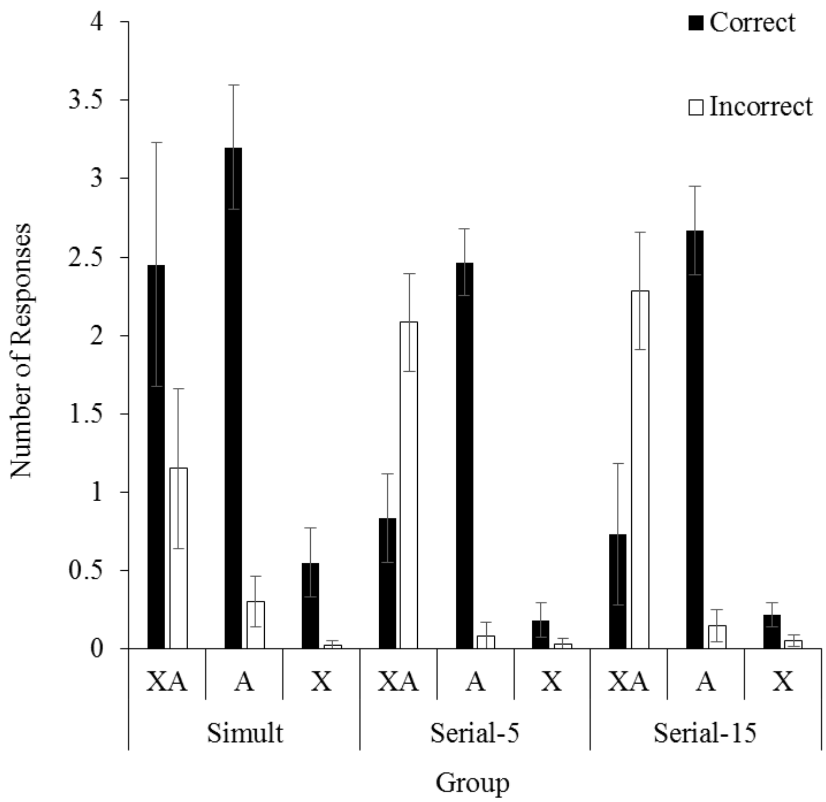
Figure 14



Note. Discrimination ratio in Test 1 vs Test 2 of Experiment 2.

For Test 2, a repeated-measures ANOVA was conducted on the number of responses, with the repeated measure being Trial Type (XA, A, X) and Response Type (Correct, Incorrect), and Group (Simultaneous, Serial-5 Serial-15) being the between-subjects factor. There was no main effect of Group, $F(2, 29) = 1.97$, $p = .16$. There was a significant main effect of Response Type, $F(1, 29) = 22.76$, $p < .001$, with there being more correct responses than incorrect (see Figure 15). There was also a significant main effect of Trial Type, $F(2, 58) = 91.83$, $p < .001$, along with the Trial Type by Response Type interaction, $F(2, 58) = 35.07$, $p < .001$, and the interaction between Response and Group, $F(2, 29) = 4.84$, $p = .02$. The Trial Type by Group interaction was nonsignificant, $F < 1$. However, the Response Type by Trial Type by Group interaction was marginally significant, $F(4, 58)$ 2.36, $p = .06$. Planned comparison tests explored the main effect of Trial Type revealed that the number of responses differed between X trials, and XA and A trials, Fs ≤ 251.4, ps $\leq .001$, with there being less responding during X trials. There was no reliable difference in responding between XA and A trials, $F < 1$. Additional planned comparisons explored the Trial Type by Response Type interaction. There was no difference Within XA trials, there was no difference between correct and incorrect responses, $F(1, 29) = 1.35$, $p = .25$. However, there was a difference between correct and incorrect responses within A and X trials, Fs ≤ 164.41, ps $< .001$, with there being more correct responses than incorrect responses. Planned comparisons were conducted to explore the interaction between Group and Response. Within the Serial-5 and Serial-15 groups, there was no difference between response types, Fs ≥ 2.01, ps $\geq .12$, with both groups having a similar number of correct and incorrect responses across trial types. In the Simultaneous group there was a difference between response types, $F(1, 29) = 23.24$, $p < .001$, with there being more correct responses than incorrect responses.

Figure 15



Note. Number of responses in Test 2 of Experiment 2.

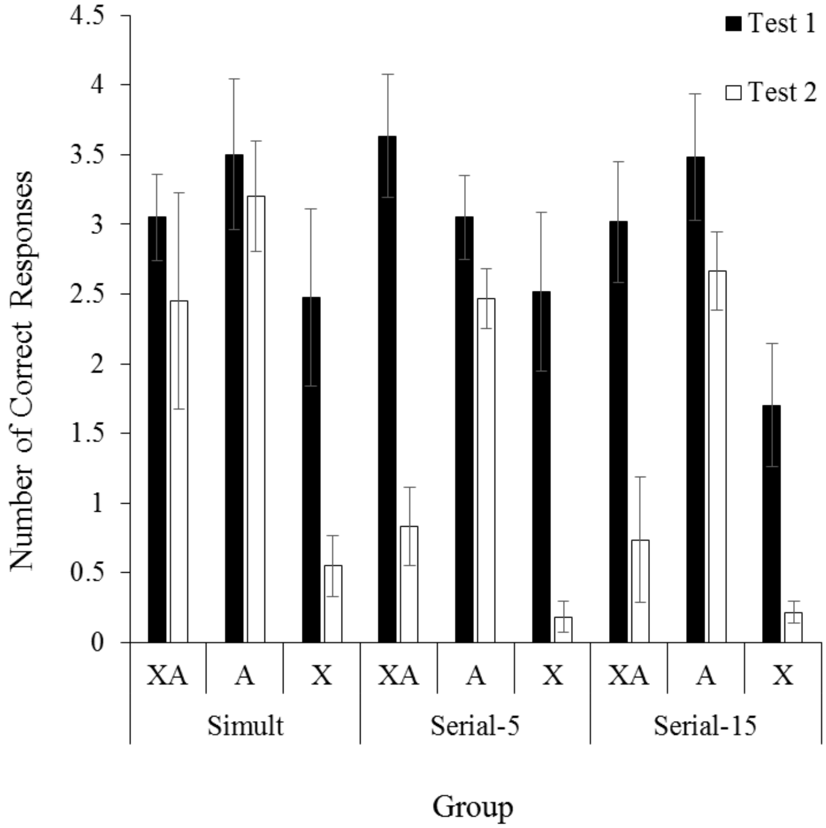
Single-samples *t*-tests were conducted on the discrimination ratio for XA, A, and X trials against chance (.5) during Test 2. In the Simultaneous group, the discrimination ratio during XA trials was not different from chance, $t(7) = 1.36$, $p = .22$, indicating no response preference following extinction of X. During A and X trials, however, the discrimination ratio was significantly above chance, *p*s ≤ .01 (see Figure 14). In both the Serial-5 and Serial-15 groups, the discrimination ratios during XA trials were significantly below chance, *p*s ≤ .005, indicating that following extinction of X, rats presented with the serial feature-target compound pressed the incorrect lever more than the correct lever (i.e., the correct lever for trials of A alone). During A trials in both Serial groups, the discrimination ratio was significantly above chance, *p*s ≤ .001.

Finally, during X trials in Group Serial-5, the discrimination ratio was not significantly different from chance, $t(11) = 1.82$, $p = .10$. In the Serial-15 group, the discrimination ratio during X trials was marginally different from chance, $t(11) = 2.16$, $p = .05$.

When comparing Test 1 vs. Test 2 and looking at mean number of correct responses, a repeated measures ANOVA was conducted with Extinction (Test 1 vs. Test 2) and Trial Type (XA, A, X) as repeated measures, and the between-subject factor being Group (Simultaneous, Serial-5, Serial-15). There was no main effect of Group, $F(2, 29) = 1.69$, $p = .20$. There was a main effect of Trial Type, $F(2, 58) = 27.80$, $p < .001$, and a significant main effect of Extinction, $F(1, 29) = 68.13$, $p < .001$, with there being less responses overall in Test 2. The Trial Type by Extinction interaction was also significant, $F(2, 58) = 6.91$, $p < .001$. All other interactions were nonsignificant, $F\text{s} \geq .64$, $p\text{s} \geq .12$. Planned comparison tests were conducted to explore the main effect of Trial Type and revealed a difference in the number of correct responses between all trial types, $F\text{s} \leq 52.90$, $p\text{s} \leq .01$, with there being the most correct responses to A, then XA, followed by X. Planned comparisons also explored the interaction between Trial Type and Extinction. Within trial types XA and X, there was a significant effect of Extinction, $F\text{s} \leq 34.04$, $p\text{s} \leq .001$, but there was not an effect of Extinction in A trials, $F(1, 29) = 6.24$, $p = .02$. Based on previous research, we conducted planned comparisons to unpack the effect of Extinction (Test 1 vs. Test 2) on each group and trial type. Results revealed that within the Simultaneous group, extinction had a significant effect on the amount of correct responding during X trials, $F(1, 29) = 8.80$, $p < .005$, with there being a decrease in correct responses during Test 2. There was no extinction effect during XA and A trials, $F\text{s} \geq .45$, $ps \geq .35$. In both Serial groups, extinction had a significant effect on the number of correct responses during XA and X trials, $F\text{s} \leq 32.67$, $p\text{s} \leq$

.008, with the number of correct responses decreasing. However, there was no effect of extinction during A trials in either group, $Fs \geq 2.57$, $ps \geq .03$ (see Figure 16).

Figure 16



Note. Number of correct responses in Test 1 vs Test 2 of Experiment

7. Discussion

Following feature-positive discrimination training, testing involving nonreinforced presentations of XA, A and X trials, followed by extinction of X revealed that when looking at number of correct responses, the feature was not setting the occasion for responding to the target in the Serial-5 or Serial-15 groups. However, since there was no difference between Test 1 and Test 2 during XA trials in the Simultaneous group, but there was a difference during X trials, there is a possibility that occasion setting is occurring in this group. The results could also indicate that the Simultaneous group learned about XA as a unique configural cue, however, this is unlikely, as X and A are from different stimulus modalities. These results are opposite of what was expected based on prior research using one operant response, where typically, serial presentations of the feature-target compound result in the feature setting the occasion for responding to the target, and simultaneous presentations of the feature-target compound result in direct control by the feature. Discriminating between two responses, instead of just determining whether to make a response or not, changes what is typically found with these temporal arrangements.

Additionally, manipulating the training conditions to be more similar to testing seems to have facilitated transfer in both Serial groups, but particularly in the Serial-5 group, where the changes in the training trials were the only change from Experiment 1 to Experiment 2. Similar to Experiment 1, both the Serial-5 and Serial-15 group's discrimination ratios decreased following extinction of X to significantly below chance. As previously mentioned, a ratio below .5 indicates that the rat is pressing the lever that is correct during A trials when XA is presented.

Previous research (Holland, 1989) has shown that when A is more salient relative to X, occasion setting is more likely to occur. Alternatively, decreasing the salience of A relative to X results in direct control by X. The increased interval in the Serial-15 group did seem to slow the acquisition of the results, with the Serial-15 group performing below both the Serial-5, and Simultaneous groups numerically, when looking at both discrimination ratio and percent correct. This is likely due to A being more ambiguous in the Serial-15 group, due to X being further removed from where a correct response is reinforced. However, when looking at testing, there did not seem to be a difference between the Serial groups, regardless of the interval length.

8. General Discussion

In the pilot studies, it was of interest whether the feature-target compound could control one response, while the target alone controlled a separate response. It was hypothesized that when presented with a serial feature-positive discrimination, the feature would set the occasion for responding to the target, whereas it was expected that simultaneous feature-positive discriminations would result in the feature directly controlling responding. The Serial group included a 5-s delay between the feature and target initially, but the delay was removed to facilitate learning. Results from the pilot study revealed what looked to be occasion setting in both the Serial and Simultaneous groups. The goal of the current studies was to replicate the finding of possible occasion setting in the Simultaneous group, and facilitate learning in the Serial group to extend our results to a group with a 5-s gap between the feature and target. In Experiment 1, it was hypothesized that manipulating the correction procedure and increasing the salience of X would facilitate learning in the Serial group. For Experiment 2, it was expected that adding a 15-s interval between the feature and target in a separate Serial group would encourage occasion setting, and making training conditions more similar to testing would result in better transfer of learning from training to the testing phase in all groups. The results of Experiment 1 revealed that the Serial group was able to learn the discrimination, with the discrimination ratio of both trial types XA and A being significantly above chance in the last few trials of feature-positive discrimination training, but that dropped to chance in Test 1. This suggests that the extent that the feature-positive discrimination was acquired during training did not transfer to test. There were many differences between training and testing which may have been responsible for the performance decrement. Training trials included XA+ and A+ trials, but testing trials were composed of XA-, A-, X-, and N+ trials. Not only were N trials reintroduced into testing from Phase 2, but the majority of trials during the test session were nonreinforced. The correction procedure in place during training was eliminated in testing, and the ITI changed from variable in training to fixed in testing. These differences may have led to generalization decrement.

Correct responses were less affected by transitioning to the testing phase. This highlights the differences between the two measures, where discrimination ratio can tell us how accurate the rats are responding and allows us to test against a constant (.5). The number of correct responses can be low, but might still be higher than the number of incorrect responses. On the other hand, there can be a higher number of incorrect responses, which seems to be the case during XA trials in the Serial group. Even though the raw number of responses is what is typically measured when looking at extinction, having discrimination ratio as an additional measurement allowed us to see that although they might be responding a lot, extinction of the feature diminished the discrimination ratio to the point of reversing the preference instead for the incorrect lever. Results from acquisition in Experiment 1 indicated that the rats in the Serial group learned where to press in training during A alone and XA trials. During Test 1, they pressed both levers on XA trials. After extinction, at Test 2, they pressed the incorrect lever significantly more than the correct lever. This indicates that after X was extinguished, A exerted control over responding on XA trials, resulting in rats pressing the lever that was correct for A trials, but incorrect for XA trials. Since extinction of the feature resulted in reduced responding to XA and X trials in the Serial group, direct control by the feature was occurring. Direct control is typically a result of simultaneous feature-target presentations in a feature-positive discrimination with one response, but not in the Serial group. Therefore, our hypothesis was partially supported, as the feature appeared to be directly controlling responding in the

Simultaneous group, but also in the Serial group, thus regardless of the temporal arrangement of the feature and target. It was hypothesized that a stimulus could act as both a target stimulus and a discriminative stimulus. In Experiment 1, rats were able to learn A as a discriminative stimulus, but A did not act as a target, since extinguishing the feature resulted in a reduction of the number of correct responses to XA and X trials.

The goal of Experiment 2 was to improve transfer of acquisition to the test trials by making the training and testing conditions more similar. A Serial 15-s group was added to explore the possibility of overshadowing by X. It was hypothesized that the Serial-5 group, which was the original Serial group in Experiment 1, would continue to show what looked to be direct control by X, whereas it was expected that occasion setting would be more likely to occur in the Serial-15 group, since X would be less proximal to the point in time when correct responses were reinforced, resulting in increased salience of A relative to X. Results revealed that both Serial groups continued to appear to be controlled by the feature, but the feature modulated responding to the target in the Simultaneous group. Occasion setting, which is a form of hierarchical learning, occurs when the feature stimulus modulates the association between the target and the reinforcer. Occasion setting from a simultaneously presented feature-target compound has only been found one other time, in a Pavlovian feature-positive discrimination (Holland, 1989) by increasing the salience of the target. These data are also consistent with an alternative explanation, that the feature-target compound could have been learned as a configural stimulus. Configural learning is more likely when stimuli are simultaneously presented, as the organism experienced the representation of the stimuli at the same time. However, when presented serially, an interval in between X and A can result in the representation of X decaying before the representation of A, resulting in a lower likelihood of the stimuli being learned as a unique configural cue. In configural learning, the combination of the feature and target are learned about as a unitary representation, instead of elemental learning of the value of each individual stimulus (Pearce, 1989). Extinguishing the feature typically results in diminished responding to X, but not XA trials if occasion setting is occurring. However, this is also the case for configural learning, where extinguishing X would not have an effect on XA, because XA is a unique configural cue. However, as previously mentioned, configural learning is less likely due to the feature and target being from different stimulus modalities. Future studies involving a second feature-positive discrimination (i.e. YB) could involve a transfer task to help differentiate between hierarchical and configural learning. It would be expected that a configural cue would transfer to the degree that the novel configuration is similar to the original configural cue. Occasion setting powers should transfer to a target trained in another feature-positive discrimination, but not a separately trained cue without a history of reinforcement (Holland, 1991). However, configurations in the sense they are generally talked, are unlikely as both stimuli in our study are of different modalities.

In Experiment 2, rats were able to learn a feature-positive discrimination with two responses, where the feature-target compound controls one response and the target alone controls a separate response. There was a linear relationship between the groups during Phase 3, where the Simultaneous group had the highest discrimination ratio, followed by the Serial-5 group, then the Serial-15 group, however this difference between groups was not significant. In testing, it seems that once any interval is introduced between the feature and the target, the associations are learned about similarly. Responding in rats presented with a serial presentation of a feature-target compound resulted in direct control by X in both experiments and groups. However, in the Simultaneous group, evidence of both direct control by X (Experiment 1) and occasion setting

(Experiment 2) were found. It’s possible that the pattern of responses was different between experiments in the Simultaneous group because of the changes in training conditions in Experiment 2. In Experiment 1, the ITI was fixed at 75-s for both groups, resulting in a 1:15 stimulus to ITI ratio in the Simultaneous group, and a 1:5 ratio in the Serial group. In Experiment 2, the experiment begun with an ITI that was at a 1:3 ratio, and then was increased to a 1:10 ratio for the remainder of training. Therefore, in the Simultaneous group, the ITI ratio was reduced from Experiment 1 to 2, while in the Serial group, the ratio increased. Additionally, there were more training sessions in Experiment 2, and they were of a longer duration. It’s possible that these changes in conditions between experiments were the cause of the different patterns of behavior observed in the Simultaneous group. The results of these experiments were not typical of what has been found using one response in a feature-positive discrimination.

Most events in everyday life involve emitting multiple responses. For example, when leaving work, in the presence of a feature (i.e. the day) and a target (i.e. the time), one might decide that on Fridays, at four, taking one route from work is the best decision given the cues and how they relate to traffic. However, if leaving work on a different day, at the same time, an alternative route may be the best decision. Studying how the various arrangement of stimuli influence responding in tasks with more than one response can aid in our understanding of discrimination learning in human and non-human animals.

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ABSTRACT

OCCASION SETTING-LIKE BEHAVIOR IN A TWO-RESPONSE FEATURE-POSITIVE DISCRIMINATION OCCURS WITH SIMULTANEOUS, BUT NOT SERIAL PRESENTATIONS

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In typical feature-positive discriminations, responding is reinforced during the target stimulus on trials with the feature stimulus (XA+), but not during target alone trials (A-). In the current studies, one response (e.g., left lever press) was reinforced during feature-target trials (XA+) and a different response (e.g., right lever press) was reinforced during target alone trials (A+). In Experiment 1, rats received either serial (X→ A+), or simultaneous (X:A+) presentations of the feature-target compound. Both groups also received A alone trials (A+). Experiment 2 included an additional Serial group, with an extended interval between the stimuli. Following training in both experiments, responding to presentations of X-, XA-, and A- was examined before and after extinction of X. Experiment 1 results suggest that direct control by X occurred in both groups. Experiment 2 results suggest that in both Serial groups, X controlled responding, but in the Simultaneous group, occasion setting-like behavior occurred.