THE EFFECTS OF OUTCOME VALUE AND PRETRAINING ON THE DIFFERENTIAL

OUTCOMES EFFECT IN A VISUAL DISCRIMINATION TASK WITH RATS

by

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Bachelor of Science, 2020
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Submitted to the Graduate Faculty of the
College of Science and Engineering
Texas Christian University
in partial fulfillment of the requirements
for the degree of

Master of Science

May 2024

THE EFFECTS OF OUTCOME VALUE AND PRETRAINING ON THE DIFFERENTIAL
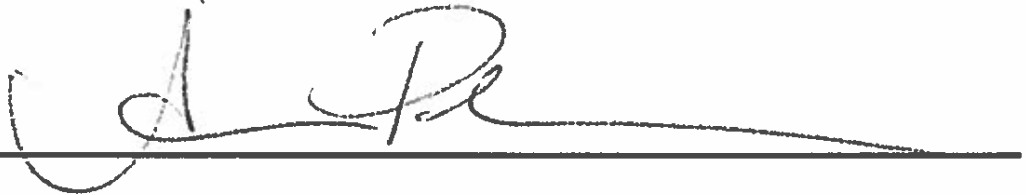OUTCOMES EFFECT IN A VISUAL DISCRIMINATION TASK WITH RATS

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For the College of Science and Engineering

ACKNOWLEDGEMENTS

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I. Introduction

In nature, animals may need to learn to make different responses to different stimuli (e.g., climb some trees to obtain ripe fruit but forage near the base of others). To examine such discriminations in the laboratory, animals are reinforced for making one kind of response (e.g., a right lever press) in the presence of one discriminative stimulus (S^D, e.g., a tone), whereas a different response (e.g., a left lever press) is reinforced in the presence of a different S^D (e.g., a clicker). Discrimination procedures can deliver a common outcome (CO) to reinforce both responses (e.g., tone → right lever press → pellet; clicker → left lever press → pellet) or a different outcome following each response (e.g., tone → right lever press → pellet; clicker → left lever press → sucrose). Differential outcomes (DO) procedures have been found to facilitate discrimination learning compared to nondifferential outcome (NDO) procedures (e.g., CO or mixed-outcome [MO] procedures), an effect known as the differential outcomes effect (DOE).

The DOE was first demonstrated by Trapold (1970) who trained rats on an auditory discrimination. Rats in the DO group were reinforced with one outcome (e.g., food) for a correct response (e.g., left lever press) to one stimulus (e.g., a tone), but reinforced with a different outcome (e.g., a sucrose solution) for a correct response (e.g., right lever press) to another stimulus (e.g., a clicker). Trapold (1970) found that rats that received DO training acquired the discrimination at a faster rate compared to control groups that received the same outcome (sucrose-only or pellet-only) for both responses (i.e., CO controls). Trapold's (1970) explanation for his results was based on the two-process theory of instrumental behavior, which stipulates that two associative learning processes are occurring when an operant response is reinforced: stimulus-response (S-R) learning and stimulus-outcome (S-O)

learning. S-R learning is strengthened gradually throughout conditioning, is outcome-independent, and is the mechanism responsible for what is also referred to as habit learning. In contrast, learning about S-O associations occurs more rapidly early in training and is outcome-dependent (Urcuioli, 2005). According to Trapold (1970), as a result of Pavlovian S-O pairings (e.g., light → food), conditioned expectancies for the outcome are formed, and, when a DO procedure is used (e.g., tone → left lever press → food; clicker → right lever press → sucrose), the two stimuli acquire differential conditioned expectancies (e.g., tone → $food_{e1}$; clicker → $sucrose_{e2}$), which facilitate the acquisition of the correct response. In contrast, when NDOs are used, both stimuli involved in the discrimination share the same conditioned expectancy (e.g., tone → $food_{e1}$; clicker → $food_{e1}$). As a result, the only cue that can be used to solve the discrimination is the discriminative stimulus (Trapold, 1970). The nature of the expectancy will be discussed in a subsequent section.

Since Trapold's (1970) foundational experiment, research using DO procedures has demonstrated the robustness of the DOE and established its clinical relevance. Differential outcomes effects have been observed in a variety of species including rats (Trapold, 1970), rhesus monkeys (Flemming et al., 2011), pigeons (Friedrich & Zentall, 2011; Urcuioli, 1991), dogs (Overmier et al., 1971), horses (Miyashita et al., 2000), and humans (Hochhalter et al., 2000; Litt & Schreibman, 1981). Further, DO procedures have been found to facilitate learning in various experimental paradigms, including working memory tasks (e.g., Brodigan & Peterson, 1976; DeLong & Wasserman, 1981), feature-positive discriminations (Nakajima & Kobayashi, 2000), matching to sample (MTS) tasks (e.g., April et al., 2011), relational matching to sample (RMTS) tasks (e.g., Flemming et al, 2011), matching to position (MTP), and delayed matching to position (DMTP) tasks (e.g., Ramirez et al., 2005; Ramos &

Savage, 2003; Savage & Pearsons, 1997). The DOE has even been found when the outcomes differed in ways other than taste or texture (e.g., Carlson & Weilkiewicz, 1976; Friedrich & Zentall, 2011; Kelly & Grant, 2001; Mok & Overmier, 2007; Morfin et al., 2018; Urcuioli, 1991). The ability of DO procedures to facilitate the learning of difficult discriminations makes the procedure particularly useful for clinical populations that have difficulty discriminating between stimuli or with working memory deficits, such as individuals with autism or dementia (e.g., Hochhalter et al., 2000; Litt & Schreibman, 1981).

Differential Outcomes

The DOE has been found using a variety of different outcome types. In addition to qualitatively different rewards (e.g., sucrose and pellets) used as differential outcomes, researchers have used outcomes that differ in terms of other hedonic properties, such as different magnitudes or probabilities of the same reward (Carlson & Wielkiewicz, 1976; Urcuioli, 1990). The DOE has also been found with variations in the outcomes experienced by control groups. Carlson and Wielkiewicz (1976) trained rats on an auditory discrimination like that of Trapold (1970) except the outcomes differed in terms of magnitude of reinforcement (large vs. small reward) and three control groups were included: one MO control group and two CO control groups. Rats in the DO condition acquired the discrimination at a faster rate than all three control groups, which did not differ from each other (Carlson & Weilkiewicz, 1976). Since Trapold (1970) and Carlson and Weilkiewicz (1976), the vast majority of DO research has used a single MO control group as opposed to two CO control groups (see Urcuioli, 2005 for a review).

The DOE has also been found with outcomes differing in only non-hedonic properties (i.e., sensory outcomes), such as different locations for rewarded foods (Friedrich & Zentall,

2011), and a blue or yellow light after correct responses (e.g., Kelly & Grant, 2001; Mok &

Overmier, 2007; Morfin et al., 2018). Friedrich and Zentall (2011) examined whether the

DOE would occur when the outcomes were spatially differential (i.e., the location in which

the outcome was delivered) but hedonically nondifferential. Pigeons were trained on a

matching to sample (MTS) task in which correct responses to one sample (e.g., a red key)

were reinforced on one side of the operant box (e.g., the left side) and correct responses to

the other sample (e.g., a green key) were reinforced with food on the other side of the operant

box (e.g., the right side). A control group received MO training. Following training with no

delay between sample and choice stimuli, all pigeons were tested with varying delays (0, 2,

4, and 8-s). They found that pigeons in the DO condition reached the training criterion (90%

overall accuracy for two consecutive sessions) in an average of 5.2 sessions, whereas pigeons

in the MO group took an average of 12 sessions. This difference, however, was not

statistically significant. Despite this, consistent with findings from previous DO literature

(see Urcuioli, 2005 for a review), differences between the two groups emerged when the

delays were imposed during the testing phase. Pigeons in the DO condition were less affected

by increases in delay than the MO condition and had higher overall accuracy compared to

pigeons in the MO group. These results suggest that differential conditioned expectancies

about *where* food is obtained can facilitate performance (Friedrich & Zentall, 2011). Overall,

the ability of the DOE to withstand variations in outcomes extends the type of expectancies

that may be involved in discrimination learning and demonstrates the robustness of the DOE.

Variations of the Differential Outcomes *Procedure* and its Application

Although the DOE is robust, simple discriminations often result in ceiling effects, and

thus hide any differences between groups (Urcuioli, 2005). The magnitude of the effect is

larger in difficult tasks, such as when a delay is inserted between the stimulus offset and the opportunity to make a response or if the discrimination is between two stimuli of the same modality (e.g., Trapold, 1970; Carlson & Weilkiewicz, 1976). Brodigan and Peterson (1976) trained pigeons on a two-choice conditional discrimination using either DO or MO and found that the DOE emerged only after a delay (3-s) was inserted between the offset of the cue and onset of choice stimuli. The DOE persisted across delays up to 15-s (Brodigan & Peterson, 1976).

Much of the recent research examining the DOE has used some variation of the MTS task, which involves presenting a sample stimulus which is followed by the presentation of two stimuli (i.e., the choice phase). Although the standard MTS can be used, some variation is often implemented to make the task more difficult, such as imposing delay between the sample and choice phases (delayed matching to sample, DMTS; Brodigan & Peterson, 1976). Another way to increase the difficulty of the MTS is by making the match symbolic (i.e., bearing no perceptual similarity but linked by the contingency; Urcuioli & DeMarse, 1994), or based on relationship (RMTS, i.e., whether the sample and choice stimuli are the same or different; April et al., 2011). In another, even more difficult variation of the RMTS procedure, animals are asked to identify *relations between relations*, such that the sample is the relationship between a pair of sample stimuli that are either the "same" (e.g., AA) or "different" (e.g., AB). In the choice phase, two novel pairs of stimuli are presented (e.g., CC vs. DE). Reinforcement is delivered if the subject chooses the pair of stimuli that share the same relationship as the pair of stimuli shown in the sample phase (e.g., Flemming et al., 2011). In each version, the DOE has been found (e.g., April et al., 2011, Brodigan & Peterson, 1976, Flemming et al., 2011).

Another version of an MTS task that is typically used with rats and common in the DO literature is matching to position (MTP) and delayed matching to position (DMTP) task. In MTP tasks, rats are presented with one of two levers located on either the left or right side of one wall of the chamber in the sample phase. Following a lever press, the sample lever retracts and a nose-poke response into the feeding niche causes both levers to be inserted into the chamber (i.e., the choice phase). The rat must press the lever that was presented in the sample phase to earn reinforcement. The DMTP procedure is the same as the MTP procedure, except a delay is inserted between the sample phase and the choice phase. Regardless of the kind of MTS task that is used, animals are typically first trained on the matching rule before any delays are added (e.g., Ramirez et al., 2005; Ramos & Savage, 2003; Savage & Parsons, 1997).

The flexibility of DO procedures to facilitate learning difficult discriminations makes it particularly useful for populations that have deficits in discrimination learning or working memory, such as individuals with autism or dementia, respectively. Litt and Schreibman (1981) found that a DO procedure facilitated learning to label spoken objects compared to a NDO procedure in children with autism. Differential outcomes have also been found to facilitate acquisition of a DMTS task in individuals with dementia. Hochhalter et al. (2000) presented participants either suffering from alcohol dementia or no dementia controls with a DMTS task that required participants to discriminate between various faces across varying delays (2, 5, 10, and 25-s). All participants received both DO and NDO treatments, with the order of the condition counterbalanced. Although there were no differences between treatment conditions across delays for the control group, the DOE was evident in participants with dementia, with higher accuracy when DOs were used compared to their performance

with the NDO treatment. Further, the performance of participants with alcohol dementia did not differ from that of control participants when DOs were used but, were significantly less accurate than controls when NDOs were used (Hochhalter et al., 2000).

Like human clinical populations, DO procedures have also been found to attenuate age-related memory deficits in non-human animals. Savage et al. (1999) compared acquisition in young (3 months) and aged (24 months) rats that received either DO or MO in a DMTP task. Rats were first trained on a typical MTP task (i.e., with no delay) in which correct responses to each lever resulted in both sucrose and pellets (i.e., MO). Once rats reached an acquisition criterion (90% correct on three consecutive sessions), DMTP training began and delays of 2, 4, and 8-s separated the end of the sample phase and the ability for the rat to nose-poke to initiate the choice phase. Beginning in DMTP training, half of the rats in each group received DO and the other half continued to receive MO as was the case in pretraining. Overall, rats that received DO training acquired the DMTP task faster than those that received MO training in the DMTP phase. Although aged rats in both DO and MO groups were slower to learn the DMTP than young rats, DO facilitated learning relative to each age group's corresponding MO group (i.e., Young DO > Young MO; Aged DO > Aged MO) across all delays (Savage et al., 1999).

Variations of the Differential Outcomes *Effect*

Aside from simply facilitating acquisition, DOs have been found to result in facilitated transfer of discrimination learning to novel stimuli or above-chance accuracy in discrimination tasks in which acquisition would not otherwise be expected. This is likely because the outcome expectancy provides a cue that is less tied to the S^D properties, which thus provides a cue that is more generalizable to novel stimuli. For example, if an animal is

using a relational strategy (i.e., discriminating based on the relationship as opposed to the physical or item-specific properties of the stimuli) to solve a RMTS task, they should demonstrate above-chance accuracy when presented with novel stimuli that were not encountered in training (i.e., transfer). In contrast, above-chance accuracy on trained items but at-chance accuracy on novel stimuli would suggest the use of an item-specific strategy (e.g., peck the red circle when the sample was the red circle).

Schmidtke et al. (2010) trained pigeons on a two-item same/different (S/D) RMTS discrimination task to examine whether the DO procedure would facilitate acquisition of the task and the emergence of S/D concept-like behavior. On each trial, pigeons were presented with a picture on a computer screen. A response to the image resulted in a picture appearing below the sample image and a white rectangle to the right. If the two images were the same, a response to the choice image resulted in reinforcement. However, if the sample and choice images were different, a response to the white rectangle resulted in reinforcement. For pigeons in the DO group, correct "same" responses were reinforced with one outcome (e.g., 5-s access to grain and sound 1) and correct "different" responses were reinforced with a different outcome (e.g.,1-s access to grain and sound 2). CO control groups received the same outcome for both "same" and "different" responses. The set size was gradually increased from 8 items to 16 items, then to 32, 64, 128, 256, 512, and lastly, to 1,024 pictures. Previous research has found that pigeons do not demonstrate such concept learning when trained on RMTS tasks with small set sizes (e.g., eight items). If differential outcomes facilitated acquisition of the RMTS task, then the DO groups should demonstrate above-chance accuracy in fewer sessions and show better transfer to novel stimuli relative to the CO controls. The results revealed that, although DO did not facilitate acquisition, it did facilitate

better transfer relative to control animals at the 32-item set size, indicating an earlier emergence of relational learning within the DO group (Schmidtke et al., 2010).

Like pigeons, monkeys also show evidence of a relational rule with large set sizes following extensive S/D RMTS training (Katz et al., 2002). However, unlike humans and chimpanzees, monkeys do not show acquisition of the *relations between relations* variation of the RMTS tasks. Flemming et al. (2011) trained three groups of rhesus monkeys on an RMTS task with varying DO treatments to see whether a DO procedure might result in learning. In the differential-reward-only (DR) group, correct "same" responses resulted in one outcome (e.g., 4 pellets), whereas correct "different" responses resulted in a different outcome (e.g., 1 pellet). Incorrect "same" (i.e., choosing different when the sample pair shared the same relationship) and incorrect "different" (i.e., choosing same when the sample pair shared a different relationship) responses both resulted in the same outcome (e.g., a 5-s intertrial interval [ITI]). Monkeys in the differential punishment (DP) group received a similar treatment as the DR group except reversed: incorrect "same" responses resulted in one type of punishment (e.g., a 45-s ITI) and incorrect "different" responses resulted in a different punishment (e.g., a 10-s ITI). All correct responses resulted in the same outcome (e.g., one pellet), regardless of the type of relationship. Lastly, in the differential both (DB) group, differential outcomes were delivered for each correct response (like that of group DR) and differential punishments for each incorrect response (like that of group DP). Differential reward *and* differential punishment (i.e., group DB) facilitated acquisition and resulted in significantly higher accuracies than the other two conditions. Interestingly, when the DB treatment was removed in a subsequent phase, monkeys' performance on the task fell to chance. However, when the DB treatment was reinstated, the initial results were replicated.

In other words, monkeys that received both differential reward and differential punishment returned to above-chance performance levels. Flemming et al. (2011) suggested that the conditioned expectancies that formed as a result of the DB treatment provided monkeys with a label-of-sorts that could be used to distinguish between same and different relationships, and, when the label was removed, monkeys could no longer match the relations.

Theories of DOE

The facilitation of discrimination learning when using differential outcomes could be the result of outcome or response expectancies mediating response probability (Overmier & Lawry, 1979; Peterson & Trapold, 1980), acquired distinctiveness between the cues being discriminated (Lawrence, 1949; cf. Peterson & Trapold, 1982), or some combination.

Trapold (1970) used an associative two-process theory approach to explain the DOE, which involved instrumental S-R associations and Pavlovian S-O associations. More specifically, because each stimulus is paired with a unique outcome for animals receiving DO, two unique S-O associations are being learned (i.e., S1 → O1; S2 → O2), which Trapold (1970) refers to as conditioned expectancies. According to expectancy mediation theory, following DO training, the presentation of each stimulus comes to elicit the unique expectancy associated with it, which can then serve as an additional discriminative cue. For example, the presence of a tone (S1) might elicit the conditioned expectancy for food (E1) which in turn acts as a cue to make a response (R1, e.g., a right lever press). Whereas the presentation of a clicker (S2) elicits an expectancy for sucrose (E2) which cues the animal to make a different response (R2, e.g., a left lever press). In contrast, the conditioned expectancies to S1 and S2 in the CO or MO control groups are the same in the presence of both stimuli. As a result, the expectancy of the outcome provides no additional information

about which response is correct (and may interfere with acquisition). The subject must rely solely on the properties of the stimuli to solve the discrimination (Trapold 1970; Trapold & Overmier, 1972; Urcuioli, 2005).

Evidence that unique conditioned expectancies form because of DO training can be seen in the characteristics of the response elicited by the discriminative stimuli. Brodigan and Peterson (1976) used lit keys as discriminative stimuli, and food and water as differential outcomes with pigeons. During training, the response topography to each discriminative stimulus reflected its associated outcome (e.g., open-beaked pecks to stimuli associated with food vs. closed-beaked pecks to stimuli associated with water). Such differential responding has also been found with qualitatively similar outcomes. For example, when outcomes differ in terms of probability of reinforcement, pigeons have been found to be slower to respond to stimuli associated with a low probability of reinforcement compared to the sample associated with a high probability of reinforcement (Urcuioli, 1990). Similarly, pigeons respond more to a sample stimulus associated with food than to a sample stimulus associated with a hopper light (i.e., no food; Urcuioli & DeMarse, 1994).

Although differential responding in the presence of sample stimuli could be interpreted as evidence that the sample stimuli elicit an expectation of the outcome, it could be the case that the kinesthetic differences in the response topographies, rather than unique conditioned expectancies, are acting as the additional discriminative stimuli. Urcuioli and DeMarse (1994) examined whether differential sample responding acted as a cue for which comparison stimulus to respond to in an MTS task. To do so, they trained pigeons on an MTS task in which responding to one comparison stimulus (C1) in the presence of one sample stimulus (S1) resulted in the delivery of food and a response to a different

comparison stimulus (C2) in the presence of a different stimulus (S2) resulted in the presentation of the hopper light (i.e., no food). Differential sample responding should develop to the comparison stimuli as a result of S1 being associated with food (i.e., more responding to C1, R1) and S2 being associated with no food (i.e., a lower rate of responding to C2, R2, see Figure 1). Following this training, pigeons were then trained with two new stimuli (S3 and S4), such that responding to S3 was reinforced with food on a fixed interval (FI) 3-s schedule, and like S1, was expected to produce high rates of pecking. A no-peck response was trained in the presence of S4 by using a differential reinforcement of other behaviors (DRO) schedule of reinforcement. Reinforcement (i.e., food) was only delivered when pigeons did not peck the stimulus for 3-s. S3 and S4 were never followed by the comparison stimuli. Lastly, a transfer test was conducted in which S3 and S4 replaced S1 and S2 in the MTS task that the pigeons were originally trained on. Unlike in the initial MTS training, all correct responses in the transfer test resulted in food (i.e., a common outcome).

If the correct response (i.e., R1 or R2) was cued by the response elicited by the sample in training (i.e., pecking or no pecking), then pigeons should select the comparison stimulus associated with pecking (i.e., R1) in the presence of S3 and the comparison stimulus associated with no pecking (i.e., R2) in the presence of S4 because S3 and S4 elicit the same sample responding (pecking and no pecking, respectively) as S1 and S2. In contrast, if the outcome expectancy drives performance, then pigeons should demonstrate chance-levels of accuracy at transfer because S3 and S4 are both associated with the same outcome (i.e., food). Consistent with a role for differential sample responding, Urcuioli and DeMarse (1994) found that pigeons pecked the comparison stimulus that matched the sample response (e.g., S3 → R1+ / S4 → R2+) more often than chance-levels during training. Their results

suggest that differential sample responding can act as a discriminative stimulus (Urcuioli & DeMarse, 1994).

Despite evidence that differential sample responding can serve as discriminative stimuli that support the DOE, there are also instances in which the DOE is found in the absence of such overt behavioral cues. To examine the relative contributions of differential sample responding and differential outcomes on discriminative performance, Zentall and Sherburne (1994) conducted an experiment in which they manipulated both differential sample responding *and* differential outcomes. For one group (group DRDO), 10 responses (i.e., an FR-10) were required in the presence of one sample stimulus (e.g., a red key, S1), whereas a DRO-6-s was required for the other sample stimulus (e.g., a green key, S2) and a correct response following the FR-10 sample was reinforced with food and no food following the DRO-6-s sample. For pigeons in group NRDO, the response requirement was the same for both sample stimuli (i.e., FR-10) but the outcomes differed (e.g., S1 → food, S2 → no food). The opposite was true for pigeons in group DRNO – in the presence of one sample, an FR-10 was required, whereas a DRO-6-s was required in the presence of the other and correct responses resulted in both food and no food 50% of the time for both comparison stimuli. Lastly, for pigeons in group NRNO, an FR-10 was required for both sample stimuli and correct responses resulted in both outcomes for both comparison stimuli. Following acquisition, matching performance for all groups was tested at different delays (0, 1, 2, and 4-s). Groups that received differential outcomes acquired the task faster than those that did not. In other words, differential sample responding alone was not enough to facilitate learning. Further, performance was relatively unaffected by increases in delays in all DO groups, but accuracy decreased as a function of delay for groups that received nondifferential

outcomes, including those groups with differential sample responses (i.e., group DRNO and group NRNO). Lastly, although differential sample responding facilitated performance compared to group NRNO, this facilitation was not to the same extent that was seen when differential outcomes were used. Overall, in contrast to the results found by Urcuioli and DeMarse (1994), the results Zentall and Sherburne (1994) suggest that differential sample responding is not necessary to obtain the DOE.

Differential outcomes are, at least in some conditions, more important for the DOE than differential sample responding. Expectancy mediation theory proposes that the conditioned expectancy acts as an additional cue, such that animals can now use both the sample stimulus and its unique expectancy when making a response selection. However, a simpler explanation is that the conditioned expectancy works to increase the distinctiveness of the sample stimuli with which they are paired. In other words, the sample stimuli, themselves, are perceived as more distinct (i.e., acquired distinctiveness).

If differential outcomes simply make the sample stimuli more distinct, then learning should be facilitated so long as DOs are used, regardless of whether the samples are correlated or uncorrelated with the outcome. To distinguish between outcome-mediated expectancies and acquired distinctiveness, Urcuioli (1990) trained pigeons on an MTS task in which two outcomes (different reinforcement probabilities [.2 vs. 1.0]) were associated with four different sample stimuli (vertical lines, horizontal lines, a blue key, and a yellow key [S1, S2, S3, and S4], see Figure 2). Following the presentation of one of the four samples, pigeons were presented with two comparison stimuli (a red or green key light). The red key was correct for two of the sample stimuli and the green for the other two. For one group (group correlated), the different outcomes were correlated with the correct comparison

stimulus (e.g., S1 → Red → O1, S2 → Green → O2, S3 → Red → O1, S4 → Green → O2). In contrast, in group uncorrelated, the correct comparison choice was not correlated with the different outcomes (e.g., S1 → Red → O1, S2 → Green → O2, S3 → Red → O2, S4 → Green → O1). If the expectancy acted as an additional cue, then group correlated should perform better than group uncorrelated. In contrast, if differential outcomes enhance the discriminability of the samples, then both groups should perform similarly. Urcuioli's (1990) results were consistent with the former, and birds in group correlated acquired the task at a faster rate and were less disrupted by increases in delays between sample and choice phases than the pigeons in group uncorrelated.

Overall, factors such as differential sample responding or differences in arousal that may occur as a byproduct of DO training likely play some role in the DOE, but the evidence suggests that conditioned expectancies are the most robust mechanism behind the effect. Friedrich and Zentall (2011) demonstrated that the DOE occurs even when the outcomes are hedonically nondifferential, thus ruling out different states of arousal as a cue. Zentall and Sherburne (1994) found that, unlike DO groups, differential sample responding did not attenuate performance decrements across increases in delays, suggesting that differential sample responding alone cannot account for the DOE. Lastly, the DOE is not the result of acquired distinctiveness, as evidenced by Urcuioli (1990), who found that the comparison stimuli needed to be correlated with the outcomes in a many-to-one MTS task. This evidence suggests that conditioned expectancies somehow mediate responding, thereby facilitating acquisition.

Two-memory systems theory proposes one perspective on how the conditioned expectancies that result from DO training facilitate learning. According to this theory, the

type of memory system activated (retrospective or prospective) depends on whether a DO or NDO procedure is used. Retrospective memory involves remembering what occurred in the past (e.g., which sample stimulus was previously presented), whereas prospective memory involves remembering events that will happen in the future (e.g., press the right lever for pellets). The DO procedure is thought to utilize the latter memory system (i.e., prospective) because the sample stimulus activates the outcome expectancy, which elicits the appropriate response (e.g., which response results in pellets), as opposed to the retrospective memory, which would require the animal to remember the stimulus that was presented previously (Carmona et al., 2020).

Retrospective and prospective memory systems have been found to be associated with different brain regions, with the former being associated with the hippocampus and dependent on the cholinergic system and latter with the amygdala and dependent on the glutamatergic system. This reliance on different structures is thought to be the reason behind why differential outcomes have been found to facilitate learning (e.g., DMTS) in individuals with memory deficits, such as those with Alzheimer's disease or dementia (Carmona et al., 2019). The hippocampus is the area of the brain that is most severely affected by Alzheimer's disease and individuals with Alzheimer's display deficits in declarative (explicit and conscious) retrospective memory (Villain et al., 2008). In contrast, implicit (unconscious) prospective memory is relatively unaffected by the disease. Implicit memory includes the expectancies that result from Pavlovian S-O pairings encountered during differential outcomes training, and thus discrimination learning can occur via the unimpaired prospective system (Carmona et al., 2020).

Figure 1

MTS Task from Urcuioli and Demarse (1994)


```
R1
  ╲           C1 (R1) ── Food
   ╲        ╱
    S1
      ╲
       ╲     C2 (R2) ── No Food
R2
  ╲           C1 (R1) ── No Food
   ╲        ╱
    S2
      ╲
       ╲     C2 (R2) ── Hopper Light
```
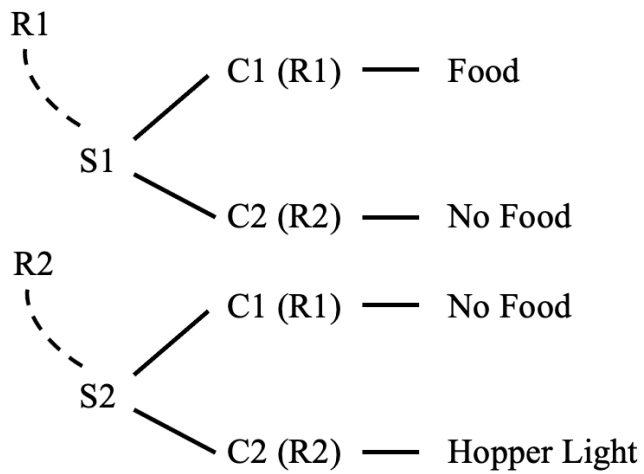
Note. S1 and S2 refer to the sample stimuli, C1 and C2 refer to the choice stimuli, and R1 and R2 refer to the differential responding (high rates of pecking vs. low rates of pecking) that result from being paired with food and a hopper light (i.e., no food). The dashed lines represent the response expectancy that is elicited by the sample stimulus.

Figure 2

Many-to-one MTS Task from Urcuioli (1990)

Group Correlated

```
                Red Key   —  O1
        S1    /
        S3    \
                Green Key —  No Food


                Red Key   —  No Food
        S2    /
        S4    \
                Green Key —  O2
```

Group Uncorrelated

```
                Red Key   —  O1
        S1    /
              \
                Green Key —  No Food


                Red Key   —  No Food
        S2    /
              \
                Green Key —  O2


                Red Key   —  O2
        S3    /
              \
                Green Key —  No Food


                Red Key   —  No Food
        S4    /
              \
                Green Key —  O1
```
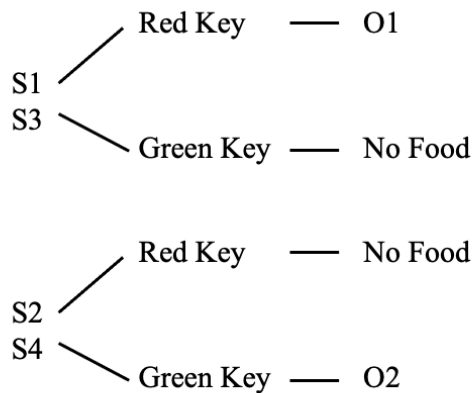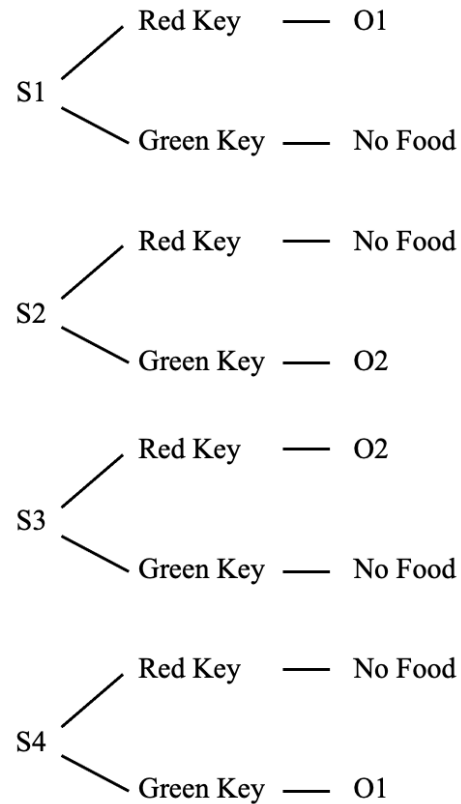
Note. S1 and S2 refer to the sample stimuli (horizontal or vertical lines), O1 and O2 differed in terms of reinforcement probability (1.0 vs. .2). For group correlated, the red key was always correlated with O1 and the green key with O2. In group uncorrelated, both key colors were associated with both outcomes.

DOE and Pretraining

According to outcome expectancy mediation theories, the DOE occurs as a result of unique S-O associations leading to conditioned expectancies (Trapold, 1970). According to Urcuioli (2005), in order for S-O associations to act as discriminative stimuli themselves, and

thus facilitate learning, they must be established prior to the S-R associations (i.e., before performance asymptote). Trapold (1970, Experiment 2) found that rats that received the appropriate S-O pairings in pretraining acquired the discrimination at a faster rate than rats that received S-O pairings that were inconsistent with those encountered during discrimination training. Ramos and Savage (2003) found evidence that while differential outcomes facilitated learning a DMTP task, they interfered with MTP acquisition prior to DMTP training relative to control animals. The authors hypothesized that learning the S-R and S-O associations simultaneously in MTP training might have been responsible for the slower acquisition relative to control animals. To test this hypothesis, Ramos and Savage (2003) conducted a second experiment in which half of the rats received typical lever press training with MO and the other half received DO beginning in lever press training. In other words, for rats in the DO pretraining group, each lever (position and response) was associated with its corresponding reinforcer prior to any formal MTP training. Rats were further divided into groups before MTP training began. Half of the rats in the pretrained DO group continued to receive DO in MTP training (group DO-DO) and the remaining half were switched to a MO group for MTP training (group DO-MO). Similarly, half of the rats pretrained with MO continued to receive mixed-outcomes in MTP training (group MO-MO) and the other half were switched to a DO condition in MTP training (group MO-DO).

The results revealed that group DO-DO out-performed all groups in both MTP training and DMTP training. Consistent with Trapold (1970, Experiment 2), removing the DO procedure during MTP training in group DO-MO resulted in poor performance relative to group DO-DO, likely because the switch prevented rats from using the expectancies acquired during pretraining. Interestingly, group MO-MO was more accurate in MTP

training than the shifted groups (DO-MO and MO-DO), suggesting that consistency across training might be an important factor. When the delays were added (i.e., DMTP training), rats that received DO in MTP training (groups DO-DO and MO-DO) were more accurate than rats that received MO in MTP training (groups DO-MO and MO-MO), and group DO-DO was more accurate than group MO-DO. These findings suggest that preestablishing proper outcome expectancies during pretraining can facilitate acquisition, whereas preestablishing improper outcome expectancies in pretraining can interfere with learning (Trapold, 1970, Experiment 2; Ramos & Savage, 2003; Urcuioli, 2005).

Both Trapold (1970, Experiment 2) and Ramos and Savage (2003, Experiment 2) preestablished outcome expectancies by including S-O pairings in pretraining. Unlike Trapold (1970, Experiment 2), the discriminative stimuli (i.e., the left and right levers) used in Ramos and Savage (2003) are confounded with the response manipulandum. Therefore, it is difficult to determine whether pretraining with differential outcomes resulted in the preestablishment of the S-O outcome expectancy, as was suggested by Ramos and Savage (2003), or if, as a result of the stimulus (the lever) being confounded with the response (the lever press), the DO pretraining resulted a stronger *response*-outcome (R-O) association. The same question can be asked in relation to a typical DO discrimination procedure because the R-O associations are differential as well. DeMarse (1997, Experiment 1) found what looked like a DOE in a one-to-many MTS task in which the sample stimuli were uncorrelated with the outcome, but the responses were correlated, a result that is inconsistent with Trapold's (1970) theory. Taken together, the differential outcomes effect could occur as a result of differential outcome expectancies eliciting differential responses (O-R) that act as discriminative stimuli.

Current Experiment

The DO procedure has been found to facilitate acquisition in tasks that might be particularly difficult for the individual (or species) to learn. The use of the DO procedure allowed for above-chance accuracy in an RMTS task in capuchin monkeys (Flemming et al., 2011). Additionally, it has been found to ameliorate the memory deficits associated with aging in rats (Mateos et al., 2016; Savage et al., 1999) as well as individuals suffering from alcohol-related dementia (Litt & Schreibman, 1981). Rats have poor visual acuity compared to humans, most likely due to their nocturnal nature resulting in fewer cones, including those sensitive to red (Jacobs et al., 2001). Consequently, visual discriminations, such as discriminating between a diffuse flashing or steady light, are more difficult than olfactory or auditory discriminations. Although matching to position tasks (e.g., Ramos & Savage, 2003) could be considered a visual discrimination, the presentation of the lever is also associated with other salient stimuli, such as the sound of the lever extending into the chamber. To my knowledge, there has not been a differential outcomes experiment using purely visual stimuli (e.g., a flashing vs. steady light).

Previous research in our lab has aimed to address this question by conducting several experiments like that of Trapold (1970), except visual stimuli were used and rats were required to nose-poke to initiate a trial. A ready-response, such as a nose-poke, has been found to facilitate the acquisition of visual discriminations in rats, possibly because it causes the animal to orient toward the stimulus (Bussey et al., 2008). After many experiments with more complex visual stimuli presented on a touchscreen-equipped monitor, we simplified the task to a visual discrimination of steady or flashing light and lever press responses. We also increased the value of reinforcement by using a chocolate-flavored pellet to try to facilitate a

differential outcomes effect. In a recent experiment, a nose-poke resulted in the presentation of either a flashing or a steady jeweled light that was followed 3-s later by the insertion of both levers into the chamber. Pressing a lever to the left of the feeding niche was reinforced during one visual stimulus (e.g., solid light), whereas presses to the right lever were reinforced during the other visual stimulus (e.g., flashing light). Rats in group DO received a different outcome for each correct response (e.g., flashing light → right lever → sucrose; steady light → left lever → chocolate pellets). In the control group, rats received one outcome (either a 30% w/w sucrose solution or chocolate-flavored pellets) for both responses. Rats were reinforced on an FR-10 schedule of reinforcement and the rats' first response committed them to that lever (i.e., the opposite lever was retracted), whether the response was correct or incorrect (cf. Trapold, 1970). No differences in acquisition were found, with both groups reaching asymptote around session 10. Because of previous findings of delays resulting in the emergence of the DOE, a 5-s delay was inserted between the termination of the jeweled light and the insertion of the levers. This change affected all groups performance equally, and, once again, all groups acquired the discrimination at the same rate. In other words, no DOE was observed.

The lack of a DOE in the experiment conducted in our lab was an unexpected finding, especially considering the robustness of the DOE and the similarity of the experimental design to Trapold's (1970) original DO experiment. An extensive literature review of more recent (1997-2022) DO research in rats revealed some common procedural departures from Trapold (1970). Most notably, no recent DO rat studies utilized the CO (i.e., sucrose- and pellet-only) control groups that Trapold (1970) and our own experiment utilized (e.g., Blundell et al., 2001; Mateos et al., 2016; Ramierez et al., 2005; Ramos & Savage, 2002;

Savage & Pearsons, 1997; Savage et al., 1999). In addition, unlike the FR-10 schedule of reinforcement and lever commitment procedure imposed in Trapold (1970) and our own experiment, most recent experiments (both discrimination and MTP) used an FR-1 reinforcement schedule throughout training (e.g., Mateos et al., 2016; McDannald et al., 2005; Ramos & Savage, 2002; Savage & Pearsons, 1997; Savage et al., 1999).

To examine whether pretraining with DO would affect acquisition of a visual discrimination, we conducted a second experiment in which rats in the DO condition received specific lever-outcome pairings beginning in lever press training. Additional modifications were included to make the experiment more like that of more recent DO procedures. An MO control group was used instead of two CO control groups. Additionally, rats were reinforced on an FR-1 schedule of reinforcement throughout the entirety of the experiment. Interestingly, the results revealed that rats in the DO condition acquired the task at a faster rate than rats in the MO condition. However, unlike typical DOEs where the control group simply acquires at a slower rate, our control group's performance did not rise above chance-levels consistently until the 19th session, compared to the DO group which performed above chance-levels beginning on session nine. Although direct comparisons cannot be made between experiments, the data is suggestive of either a very difficult procedure in which differential outcomes are required, or that the use of MOs somehow disrupted learning. The previous experiment in our lab in which all groups acquired the discrimination, suggests it is the latter. Additionally, no definitive conclusions can be made regarding the effect of differential outcomes pretraining because all groups received the same pretraining.

The present experiments aimed to further investigate the nature of differential outcome effects and whether a DO procedure can facilitate learning a visual discrimination in rats. Experiment 1 replicated the previously described experiment but directly compared whether the kind of reinforcer affects the emergence of the DOE. Chocolate-flavored pellets and a sucrose solution were used in the previous experiments conducted in our lab. Chocolate pellets were chosen because of their novelty (i.e., they differ from the chow consumed in their home cages). However, it could be possible that two sugary outcomes do not differ extensively enough for a DOE to emerge. In addition, most of the literature on DO in rats use chow-flavored pellets and a sucrose solution (e.g., Blundell et al., 2001; Mateos et al., 2016; Nakajima & Kobayashi, 2000; Ramierez et al., 2005; Ramos & Savage, 2002; Savage & Pearsons, 1997; Savage et al., 1999). Given that the DOE has been found with a variety of outcomes (i.e., magnitude of reinforcement, probability of reinforcement, food vs. light), the type of pellet used would not be expected to eliminate the DOE. However, because we have previously found chocolate-flavored pellets to be a highly preferred reinforcer, it could be possible that giving both outcomes together (i.e., MO control) somehow disrupts learning. For example, it could be the case that the expectancy for chocolate pellets overshadows the discriminative stimuli themselves for rats in the MO group in Experiment 2. There have been no comparisons of this sort in the literature. Regarding acquisition in the chow pellet control groups, perhaps the lack of novelty mentioned above may somehow (e.g., US preexposure, US habituation, and relative validity) reduce the salience of the chow outcome expectancy, enabling acquisition with mixed-outcomes based on the discriminative stimuli.

Consistent with previous research in our lab that utilized chocolate pellets, it is hypothesized that the magnitude of the DOE will be larger between the DO chocolate group

and MO chocolate group than that between the DO chow and MO chow groups due to potential disruptive effects that using MO with chocolate pellets might have on learning. In addition, if the unpredictable delivery of a high valued reinforcer (i.e., the chocolate pellets) disrupts learning, then the MO chow pellet group should acquire the discrimination at a faster rate than rats in the MO chocolate pellet condition. Experiment 2 further investigated whether pretraining with differential outcomes would result in faster acquisition relative to rats that receive DO only in discrimination training and to rats that receive MO throughout training. The findings of Experiment 2 might further add to research that suggests the involvement of R-O associations, as opposed to the typical S-O association predicted by two-process theories, in the DOE.

II. Experiment 1 Method

Subjects

Thirty-two male (16) and female (16) experimentally-naïve Long-Evans rats (*Rattus norvegicus*) approximately 8.5 months of age obtained from the Texas Christian University (TCU) breeding colony served as subjects. All subjects were pair-housed in translucent plastic tubs with a substrate of wood shavings in a vivarium maintained on a 12-hr dark/12-hr light cycle. All experimental manipulations were conducted during the light portion of the cycle. A progressive food restriction schedule was imposed two weeks prior to the beginning of the experiment, until rats were within 81-85% of their free feeding body weight. All animals were handled a minimum of three times per week for 30-s. The research was conducted in accordance with an approved Institutional Animal Care and Use Committee (IACUC) protocol.

Apparatus

All tests occurred within a standard operant chamber measuring 30 x 25 x 20 cm (l x w x h) housed within a sound and light-attenuating environmental isolation chest (Med Associates). The walls and ceiling of the chamber were composed of clear Plexiglas and the floor was constructed of stainless-steel rods measuring 0.5 cm in diameter, spaced 1.5 cm center-to-center. The chamber was equipped with a food dispenser capable of delivering sucrose solution (30% w/w or 18% w/w) and food pellets (chow or chocolate-flavored). The operant chamber included two retractable levers on either side of the magazine. The levers were used to measure the subjects' responses. A jeweled light capable of presenting a flashing and steady light was located at the top rear of the operating chamber and angled upward to produce a diffuse light source. When the jeweled light was off, there was no other source of illumination. A discrete light was located above the left lever in all boxes but remained extinguished throughout all of training. Ventilation fans in each enclosure and a white-noise generator on a shelf outside of the enclosure provided a constant 74-dB (A) background noise.

Procedure

Magazine Training

On day 1, the rats were trained to drink sucrose and retrieve pellets from the feeding niche. The type of reinforcers the subjects received varied depending on their group assignment. Half of the rats received chow-flavored pellets and an 18% w/w sucrose solution, whereas the other half received chocolate-flavored pellets and a 30% w/w sucrose solution. Different sucrose concentrations were used for each group to prevent reinforcement biases. Pilot studies in our lab have determined that a higher concentration of sucrose solution is needed to equate the reinforcer value of the chocolate-flavored pellets. These

reinforcer assignments remained for the entirety of the experiment. After a fixed-time (FT) 3-min period, sucrose and pellets were randomly delivered on a variable time (VT) 60-s schedule. When sucrose was delivered, the dipper arm elevated and waited for the subject to interrupt the infrared beam located in the feeding niche. Once interrupted, the arm lowered 15-s later. A pellet delivery operated in much the same way, but the timer for the next delivery of a pellet waited until the infrared beam was interrupted to ensure multiple pellets were not delivered. After six pellet or sucrose retrievals, the schedule of reinforcement changed to a variable interval (VI) 55-s schedule. The houselight remained off throughout the session, this was true for all phases.

Pretraining

On days 2-5, rats were trained to lever press. For half of the rats in each reinforcement condition, each lever was associated with both pellets and sucrose (groups MO chocolate-pellet [choc] and MO chow pellet [pell]). Each combination was presented with each lever an equal number of times. For the remaining rats in each reinforcement condition, a DO procedure was used to enhance the discriminability of the two levers prior to the start of conditioning (groups DO choc [$n = 8$] and DO pell [$n = 8$]). The reinforcer associated with each lever was counterbalanced for each DO group. For half of the rats, the right lever was associated with pellets and the left lever with sucrose. This was reversed for the remaining half of the DO conditions. Rats were reinforced according to their group assignments from Phase 1 onward. See Table 1 for Experiment 1 group assignments.

After a FT-90-s acclimation period, one of the two levers was inserted into the chamber. On day one, the lever inserted during a trial alternated and was followed by reinforcement according to a mixed Pavlovian-Instrumental schedule. If a response was

made, the lever retracted, and rats were given 10-s access to reinforcement. This period did

not begin until the infrared beam in the feeding niche was interrupted. This reinforcement

procedure was used for all subsequent phases. A 30-s ITI separated the end of the

reinforcement period and the start of the next cycle. If no response occurred after 10-s, one of

the outcomes was delivered. Immediately after this reinforcement period, the same lever was

reinserted for a FT-3-min period. If no response occurred during this time, the lever was

removed for a VT-3-min period, after which the cycle restarted, and one of the two levers

was randomly presented.

Once all rats completed 10 or more lever presses on each lever and a minimum of

three sessions, they were advanced to an FR-1 schedule of reinforcement. Once advanced to

an FR-1, an opportunity to press the lever was signaled by the insertion of one of the levers.

A response caused the lever to retract, and reinforcement was delivered. The lever remained

extended until a response was made. A session terminated after the completion of 60 lever

presses or 49-min, whichever came first.

Table 1

Experiment 1 Design

Group	Pretraining	Discrimination Training
DO Choc	R1 – O1	S1 – R1 – O1
	R2 – O2	S2 – R2 – O2
DO Pell	R1 – O3	S1 – R1 – O3
	R2 – O4	S2 – R2 – O4
MO Choc	R1 – O1/O2	S1 – R1 – O1/O2
	R2 – O1/O2	S2 – R2 – O1/O2
MO Pell	R1 – O3/O4	S1 – R1 – O3/O4
	R2 – O3/O4	S2 – R2 – O3/O4

Note. R1 and R2 refer to the reinforced response (i.e., the left or right lever), O1 and O2 represent either the chocolate-flavored pellet or a 30% (w/w) sucrose solution, and O3 and O4 represent the chow-flavored pellet or an 18% (w/w) sucrose solution. Pretraining included lever press training and ready-response training.

Ready-Response Training. Following lever press training, rats were required to insert their head into the feeding niche (i.e., nose-poke) to initiate a trial. Following a 60-s acclimation period, a nose-poke caused one lever to be inserted into the chamber. A response caused the lever to retract and an outcome was delivered (as in lever press training). Rats were reinforced on a FR-1 schedule of reinforcement. All lever-reinforcement assignments were the same as described in lever press pretraining. For two sessions, rats could initiate a trial immediately following the reinforcement period. On the subsequent two sessions, a VI-15-s separated the end of one trial and the ability to start a new trial with a nose-poke. A session terminated after the completion of 60 trials or 49-min, whichever came first.

Discrimination Training

A flashing or steady jeweled light located on the ceiling and oriented toward the ceiling of the chamber signaled the lever to which a response would be reinforced. Following a nose-poke, the steady or flashing light was presented for 5-s prior to the insertion of the

levers. The levers were inserted into the chamber as soon as the S^D was terminated. A response to the correct lever caused both levers to retract and reinforcement was delivered. For all groups, the left lever was the correct response in the presence of the steady light and the right lever was the correct response in the presence of the flashing light.

For half of the rats in groups DO choc and DO pell, responses to the left lever in the presence of the steady light were reinforced with sucrose, whereas, in the presence of the flashing light, a response to the right lever resulted in the delivery of a pellet. The lever-reinforcer pairings were reversed for the other half of the rats in each DO condition. For rats in the MO conditions (groups MO choc and MO chow), a response to either lever resulted in the delivery of sucrose 50% of the time and a pellet the other half of the time (i.e., each response was associated with both outcomes). The onset of the stimulus was always initiated by a nose-poke. All trials (correct and incorrect) were separated by a VT-60-s ITI (range = 40 to 80-s in steps of 10-s). A correct response to the stimulus resulted in both levers retracting followed by 10-s access to sucrose or a pellet. If no response was made in 10-s, both levers retracted, and the ITI ensued. Trials with an incorrect response or no response resulted in a correction procedure in which, following the ITI, the same trial type would repeat until the correct response is made. A session terminated after the completion of 60 (non-correction) trials or 85-min, whichever came first. Subjects received 20 sessions of discrimination training. Acquisition was evaluated based on the average percent correct across both trial types (trials with a correct response/total trials) with outcome value (high [choc and 30% sucrose] vs. low [pell and 18% sucrose]) and training (DO vs. MO) as between-subjects factors. Any bias for outcome preference was evaluated by comparing a preference ratio (number of responses to the lever associated with pellets [either chocolate or chow-flavored]

divided by total lever presses) to .50 (no preference). For rats in the mixed-outcomes groups,
response biases were assessed in a similar manner, except a lever preference ratio was used
(number of left lever presses divided by total lever presses). All rats acquired the response to
both levers. The results of discrimination training are broken down by reinforcer and lever
preference to assess for response and reinforcer biases, and then acquisition.

III. Experiment 1 Results

Reinforcer and Lever Preference

Figure 3 displays lever preference (number of lever presses on the lever associated
with pellets (chow or chocolate-flavored) divided by total lever presses [left + right lever
presses]) for the DO groups (DO choc and DO pell) and lever preference (left lever
presses/total lever presses) for the MO groups (MO choc and MO pell) across five blocks of
4 sessions. A group mean of .50 indicates no preference, a group mean greater than .50
indicates a pellet preference for the DO groups or a left lever preference for the MO groups,
and a group mean below .50 indicates a preference for sucrose for the DO groups or a
preference for the right lever for the MO groups. Both DO groups appear to have a pellet
preference on blocks 1-3 and 5, but no preference on block four. This observation was
confirmed with a series of t-tests performed against a constant (.50, i.e., no preference) for
each group at each block (1-5). Group DO choc was significantly above .50 on block 1, $t(7) =$
5.82, $p < .001$, and group DO pell differed marginally from .50, $t(7) = 2.16$, $p = .07$. Both DO
groups had a significant pellet preference on blocks 2, 3, and 5, ts$(7) > 2.74$, ps $< .03$, but
showed no preference for either reinforcer on block 4, ts$(7) < 1.10$, ps $> .31$. Group MO pell
had a significant preference for the left lever on block 2, $t(7) = 2.90$, $p = .02$, but no lever
preference in any of the other blocks, ts$(7) < 1.32$, ps $> .23$. Group MO choc showed no

significant lever preference on blocks 1-4, ts(7) < 1.08, ps > .32, but had a significant left

lever preference on block 5, t(7) = 3.23, p = .05.

Figure 3

Experiment 1 Reinforcer and Lever Preference across Blocks
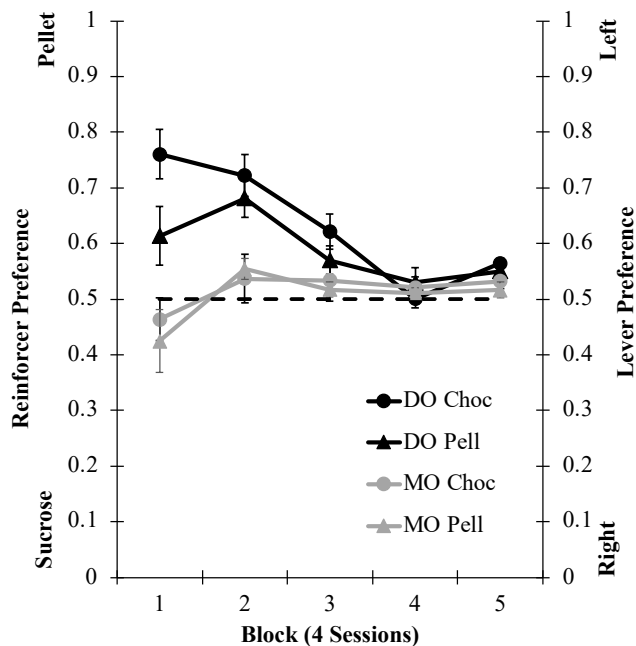
Note. A group mean of .50 indicates no preference (represented by the dashed line), a group mean greater than .50 indicates a preference for pellets (groups DO choc and DO pell) or for the left lever (groups MO choc and MO pell), and a group mean below .50 indicates a preference for the sucrose reinforcer (groups DO choc and DO pell) or for the right lever (groups MO choc and MO pell). The DO groups received differential outcomes throughout all of training and the MO groups received mixed-outcomes throughout all of training. For groups DO choc and MO choc, the outcomes were a chocolate-flavored pellet and a 30% (w/w) sucrose solution. The outcomes for groups DO pell and MO pell were a chow-flavored pellet and an 18% (w/w) sucrose solution. Error bars represent standard error of the mean (SEM).

Acquisition

Figure 4 shows proportion correct (no correction trials) across five 4-session blocks as a function of group (DO pell, DO choc, MO pell, and MO choc). A repeated measures analysis of variance (ANOVA) was performed on proportion correct with outcome value (high vs. low) and training (DO vs. MO) as between-subjects factors and block (1-5) as the repeated measure. The assumption of sphericity was not met, so a Greenhouse-Geisser correction was used for all within-subjects effects. There was a main effect of training, $F(1, 28) = 8.47$, $p = .007$, $\eta_p^2 = .23$, a main effect of block, $F(2.61, 73.13) = 103.47$, $p < .001$, $\eta_p^2 = .79$, and a significant block by training interaction, $F(2.61, 73.13) = 20.93$, $p < .001$, $\eta_p^2 = .43$. There was, however, no main effect of outcome value, $F < 1$, and no other interactions, Fs < 1.81, $ps > .19$.

To examine the block by training interaction, planned comparisons that compared each DO group with its control MO group at each block were performed on proportion correct with a Bonferroni correction (equal variances not assumed). Group DO pell and MO pell differed on block 2, $t(8.63) = 2.86$, $p = .04$, with group MO pell being more accurate than group DO pell on block 2, and differed significantly on blocks 4, $t(11.00) = 2.58$, $p = .05$, and 5, $t(7.84) = 5.45$, $p = .002$, with group DO pell having a higher accuracy on blocks 4 and 5. No other comparisons were reliable, ts < 1.65, $ps > .24$. Group DO choc and MO choc differed marginally on block 1, $t(11.38) = 2.45$, $p = .06$, with group MO choc being marginally more accurate, but differed significantly on blocks 3-5, ts > 2.79, $ps < .04$, with group DO choc having higher accuracy than group MO choc. The groups did not differ on block 2, $t(8.69) = 1.26$, $p = .48$.

To examine acquisition within each group relative to chance-level, a series of t-tests were against a constant (.50) were performed on the data at each block. Group DO pell and

DO choc were significantly below chance-level on blocks 1-2, ts(7) > 2.67, ps < .03, and significantly above chance-level on blocks 3-5, ts(7) > 2.50, ps < .05. Groups MO pell and MO choc were significantly below chance on blocks 1-2, ts(7) > 3.00, ps < .02. Group MO pell was significantly above chance-level on blocks 3-5, ts(7) > 2.35, ps < .05, whereas group MO choc was only marginally above chance-level on block 5, t(7) = 2.22, p = .06.

Figure 4

Experiment 1 Acquisition across Blocks
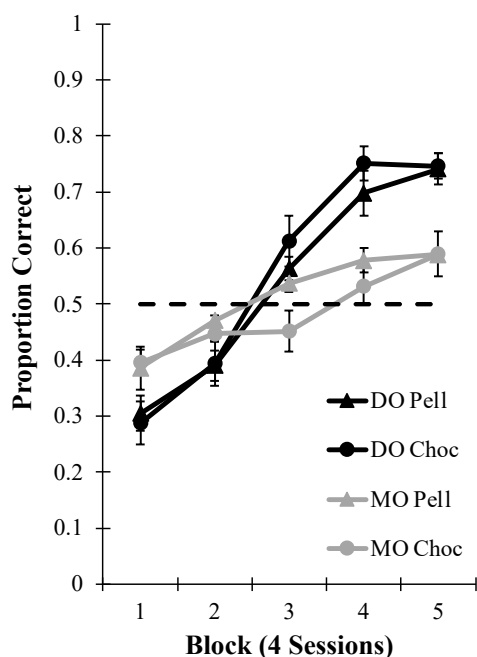
Note. The dashed line represents chance-level performance (.50). The DO groups received training with a differential outcomes procedure throughout all of training and the MO groups received training with a mixed-outcomes procedure throughout all of training. For groups DO choc and MO choc, the outcomes were a chocolate-flavored pellet and a 30% (w/w) sucrose solution. The outcomes for groups DO pell and MO pell were a chow-flavored pellet and an 18% (w/w) sucrose solution. Error bars represent SEM.

IV. Experiment 1 Discussion

Experiment 1 examined whether the value of outcomes (two high [chocolate-flavored pellets and a 30% sucrose solution] vs. two moderately valued [chow-flavored pellets and an 18% sucrose solution] reinforcers) would affect the emergence of the DOE in rats trained on a visual discrimination. The results revealed that both DO groups had a significant bias for pellets (i.e., a group mean greater than .50 [no preference]) during four out of the five blocks for group DO choc and three out of the five blocks in group DO pell (Figure 3). Although neither DO group showed a reinforcer preference in block 4, the bias for the pellet reemerged in block 5 for both groups. Overall, these results suggest that pellets are preferred over sucrose, regardless of the flavor (chocolate vs. chow) and level of familiarity (novel [chocolate] vs. familiar [chow]). Lever preference was assessed instead of reinforcer preference for rats in the MO groups since both levers were associated with both outcomes. When compared to .50 (i.e., no preference), the results revealed that group MO pell had a left lever preference in block 2 and that group MO choc had a left lever preference on block 5. Because each lever was associated with both outcomes for these groups, these biases were likely spurious (Figure 3).

Regarding acquisition, a DOE was found in both reinforcer groups. In other words, the differential outcomes procedure facilitated learning in each DO group relative to its corresponding MO control group (Figure 4). These results suggest that DO training facilitated acquisition relative to a MO control group regardless of the hedonic value of the outcomes that were used. Although there was no effect of outcome value or a block by outcome value by training interaction, the DOE emerged sooner (block 3) when high-valued reinforcers (i.e., choc pellets and a 30% sucrose solution) were used compared to when familiar/lesser-valued reinforcers were used (block 5). Further, when compared to chance-

level (.50), whereas proportion correct for group MO pell rose significantly above chance-level beginning in block 3, the MO choc group remained at chance-level on blocks 3-4, and was only marginally above chance-level in block 5. This finding suggests that unpredictable delivery of the highly valued chocolate pellet may have interfered with learning. Lastly, both MO groups were marginally more accurate than their corresponding DO groups early in training (block 1 [choc groups] and block 2 [pell groups]), but less accurate than the DO groups later in training (blocks 3-5, i.e., the DOE). Lower accuracy in the DO groups early in training resulted from a bias to press the lever associated with pellets (chocolate or chow) in blocks 1-3 of training. It could be the case that the reinforcer bias in the DO groups leads to an underestimation of the DOE, as these animals had to learn to counter their bias before they began to get more trials of the different outcomes paired with their respective S^Ds (i.e., S-O pairings).

V. Experiment 2

The aim of experiment 2 was to examine whether pretraining with DO or MO prior to MO or DO discrimination training affects the acquisition of a visual discrimination. Previous research using a MTP task found that using differential outcomes in both lever press pretraining and MTP training (DO-DO) resulted in better performance than rats that received MO in pretraining and DO in MTP training (MO-DO), rats that received MO in both phases (MO-MO), and rats that received DO pretraining followed by MO MTP training (DO-MO; Ramos & Savage, 2003). The facilitative effect in the DO-DO group could have been due to pre-establishing proper S-O (lever-outcome) associations in pretraining. However, because the levers served as both the sample stimuli and the response manipulanda in this task, it is

difficult to tease apart the contributions of the S-O associations and R-O associations that were formed in pretraining.

In Experiment 1, rats in the DO groups (DO choc and DO pell) received differential outcomes beginning in lever press pretraining and continuing throughout training (i.e., DO-DO), whereas the MO groups (group MO choc and MO pell) received mixed-outcomes throughout (i.e., MO-MO). The results of Experiment 1 revealed that, early in training, the DO groups both had a significant preference for the lever associated pellets and were marginally less accurate than their respective MO controls before the DOE emerged later in training (blocks 3-5). This finding might suggest that DO pretraining resulted in a strong bias that the animals had to overcome in order to learn the S-O associations in discrimination training. Such a finding might suggest that the results of Ramos and Savage (2003) were likely due to pre-establishing S-O associations, as opposed to R-O associations in lever press pretraining. Experiment 2 aimed to directly test this question. In addition to the groups used in Experiment 1 (MO-MO and DO-DO), Experiment 2 also included rats that received mixed-outcomes in pretraining, followed by differential outcomes in discrimination training (MO-DO), and a group that received differential outcomes pretraining followed by mixed-outcomes discrimination training (DO-MO). If, like in Ramos and Savage (2003), group DO-DO has higher accuracy than all other groups, then it might suggest a role of R-O associations in the differential outcomes effect. However, if pretraining has no effect or a negative effect (e.g., slower acquisition in the groups that receive DO pretraining), then S-O associations are indeed the driving force behind the DOE.

VI. Experiment 2 Method

Subjects

Thirty-two male (16) and female (16) experimentally-naïve Long-Evans rats (*Rattus norvegicus*) approximately 5.5 months of age obtained from the TCU breeding colony served as subjects. All subjects were pair-housed in translucent plastic tubs with a substrate of wood shavings in a vivarium maintained on a 12-hr dark/12-hr light cycle. All experimental manipulations were conducted during the light portion of the cycle. A progressive food restriction schedule was imposed two weeks prior to the beginning of the experiment, until rats were within 81-85% of their free feeding body weight. All animals were handled a minimum of three times per week for 30-s. This research was conducted in accordance with an approved IACUC protocol.

Apparatus

The apparatus was as described in Experiment 1.

Procedure

Magazine Training

Magazine training progressed in the same manner as Experiment 1, except all animals received chocolate-flavored pellets and a 30% (w/w) sucrose solution as reinforcers.

Pretraining

Lever press pretraining was as described in Experiment 1, except the experimental conditions differed. Half of the rats in the DO condition received the differential outcomes procedure beginning during lever press training (as was in Experiment 1), whereas, the other half, along with rats in the control groups ($n = 16$), received mixed outcomes pretraining (i.e., both levers result in both outcomes).

Ready-Response Training. Rats were trained to nose-poke to initiate a trial as in Experiment 1.

Discrimination Training

Discrimination training progressed exactly as it did in Experiment 1. Half of the rats ($n = 8$) that were pretrained with DO continued to receive differential outcomes training (group DO-DO), whereas the other half ($n = 8$) now received MO during discrimination training (group DO-MO). Half of the rats ($n = 8$) that received MO during pretraining now received differential outcomes training beginning in this phase (group MO-DO) and the remaining rats ($n = 8$) continued to receive MO (group MO-MO). See Table 2 for the design of Experiment 2. Subjects received 20 sessions of discrimination training. Acquisition was evaluated based on the average proportion correct across both trial types (trials with a correct response/total trials) with pretraining (DO vs. MO) and training (DO vs. MO) as between-subjects factors. Any bias for outcome preference was evaluated by comparing a preference ratio (number of responses to the lever associated with pellets [either chocolate or chow-flavored] divided by total lever presses) to .50 (no preference). For rats in the mixed-outcomes groups, response biases were assessed in a similar manner, except a lever preference ratio was used (number of left lever presses divided by total lever presses). All rats acquired the response to both levers. The results of discrimination training are broken down by reinforcer and lever preference to assess for response and reinforcer biases, and then acquisition.

Table 2

Experiment 2 Design

| Group	Pretraining	Discrimination Training
DO-DO	R1 – O1 R2 – O2	S1 – R1 – O1 S2 – R2 – O2
DO-MO	R1 – O1 R2 – O2	S1 – R1 – O1/O2 S2 – R2 – O1/O2
MO-DO	R1 – O1/O2 R2 – O1/O2	S1 – R1 – O1 S2 – R2 – O2
MO-MO	R1 – O1/O2 R2 – O1/O2	S1 – R1 – O1/O2 S2 – R2 – O1/O2

Note. R1 and R2 refer to the reinforced response (i.e., the left or right lever), O1 and O2 represent either a food pellet or a 18% (w/w) sucrose solution. Group DO-DO received differential outcomes training throughout the entirety of the experiment (i.e., in both pretraining and discrimination training). Group DO-MO received differential otucomes pretraining but received mixed-outcomes during discrimination training. Group MO-DO received mixed-outcomes during pretraining and differential outcomes during discrimination training. Group MO-MO received mixed-outcomes throughout the entirety of the experiment. For all groups, the left lever was correct in the presence of the flashing light and the right lever was correct in the presence of the steady light.

VII. Experiment 2 Results

Reinforcer and Lever Preference

Figure 5 shows the reinforcer preference (responses to the lever associated with pellets/total responses) for groups DO-DO, MO-DO, and DO-MO on the left axis, and the lever preference (left lever presses/total lever presses) for group MO-MO on the right axis. A series of *t*-tests were performed against .50 (no preference) for each group at each block. Groups that received DO pretraining (groups DO-DO and DO-MO) had a significant bias for

the chocolate-flavored pellets in block 1, ts(7) > 3.57, ps < .01, and group DO-MO was marginally higher than .50 (i.e., trending toward a chocolate pellet bias) on block 2, t(7) = 1.98, p = .09. Group DO-DO did not differ from .50 on blocks 2-5, ts(7) < 1.89, ps > .10, and group DO-MO did not differ significantly from .50 on blocks 3-5, ts(7) < .35, ps > .42. Group MO-DO did not differ from .50 on blocks 1-4, ts(7) < 1.81, ps > .11, but was significantly above .50 on block 5, t(7) = 2.33, p = .05. Overall, these results suggest that pretraining with DO results in a chocolate pellet bias early in training that disappears as training continues. Lastly, t-tests against .50 performed at each block for the MO-MO revealed that rats did not have a lever preference at any block, ts(7) < 1.62, ps > .15.

Figure 5

*Experiment 2 Reinforcer and Lever Preference across Blocks*
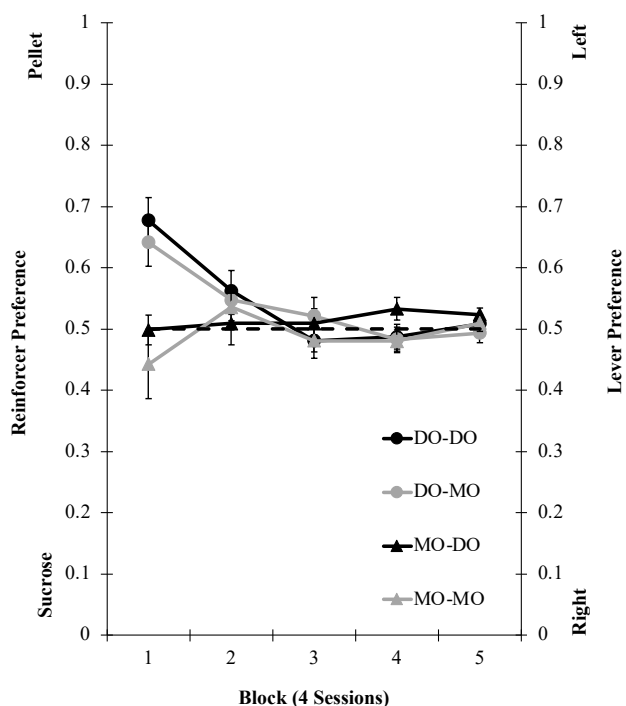
Note. A group mean of .50 indicates no preference (represented by the dashed line), a group mean greater than .50 indicates a preference for pellets (groups DO-DO and MO-DO) or for the left lever (groups MO-MO and DO-MO), and a group mean below .50 indicates a preference for the 30% (w/w) sucrose solution (groups DO-DO and MO-DO) or for the right lever (groups MO-MO and DO-MO). Group DO-DO received differential outcomes in both pretraining and discrimination training, group DO-MO received differential outcomes in pretraining, but mixed-outcomes in discrimination training, group MO-MO received mixed-outcomes in both pretraining and discrimination training, and group MO-DO received mixed-outcomes during pretraining, but differential outcomes in discrimination training. Error bars represent SEM.

Acquisition

Figure 6 shows proportion correct (no correction trials) across five 4-session blocks as a function of group (DO-DO, MO-DO, DO-MO, and MO-MO). A repeated measures ANOVA was performed on proportion correct with pretraining (DO vs. MO) and training (DO vs. MO) as the between-subjects factors and block (1-5) as the repeated measure. There was a main effect of training, $F(1, 28) = 11.78$, $p = .002$, $\eta_p^2 = .30$, with higher accuracy in groups that received DO than MO during discrimination training. There was no main effect of pretraining, $F < 1$, and no significant pretraining by training interaction, $F(1, 28) = 2.44$, $p = .13$. Using a Greenhouse-Geisser correction, there was a main effect of block, $F(2.68, 75.13) = 139.84$, $p < .001$, $\eta_p^2 = .83$, but no block by pretraining, block by training, or block by pretraining by training interactions, $ps > .11$.

Follow-up tests using a Bonferroni correction were performed on the main effect of block. The results revealed that all blocks differed significantly from one another, $ps < .002$, with proportion correct increasing incrementally across blocks. Additionally, given the finding in Experiment 1 of differences in proportion correct between DO and MO groups at specific blocks, planned comparisons with a Bonferroni correction (equal variances not assumed) were conducted for each DO training group against its control MO training group (i.e., DO-DO vs. DO-MO and MO-DO vs. MO-MO) at each block. Proportion correct for groups DO-DO and DO-MO did not differ across any of the five blocks, $ts < 2.12$, $ps > .10$. In contrast, groups MO-DO and MO-MO did not differ in blocks 1 and 2, $ts < 2.04$, $ps > .13$, but differed marginally on block 3, $t(13.53) = 2.02$, $p = .09$, and differed significantly on blocks 4 and 5, $ts > 2.92$, $ps < .02$.

To further examine acquisition within each group, a series of *t*-tests were performed comparing each group's (DO-DO, DO-MO, MO-DO, and MO-MO) performance to chance-level (.50) at each block. The results revealed that all groups differed from chance-level on blocks 1 and 3-5, $ts(7) > 2.74$, $ps < .03$, with performance being below chance-level on block 1, and above chance-level on blocks 3-5. Groups DO-DO, DO-MO, and MO-MO did not differ from chance-level on block 2, $ts(7) < .88$, $ps > .41$. Group MO-DO, however, was marginally above chance-level on block 2, $t(7) = 2.21$, $p = .06$.

Figure 6

Experiment 2 Acquisition across Blocks

Block (4 Sessions)
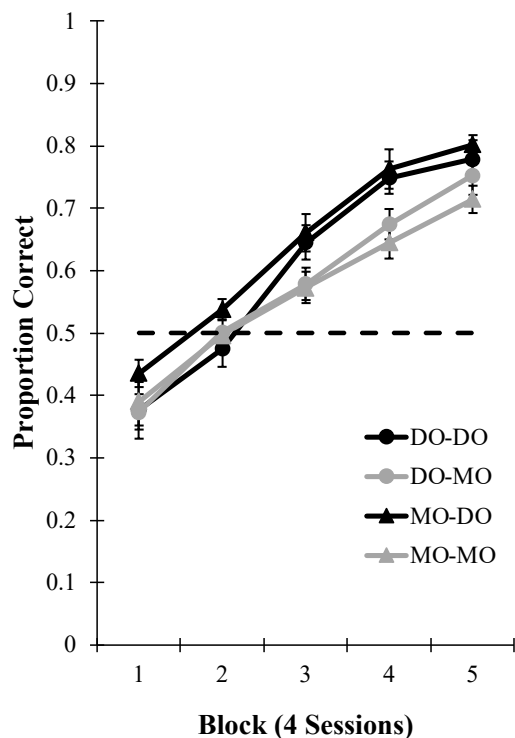
Note. The dashed line represents chance-level performance (.50). Group DO-DO received differential outcomes in both pretraining and discrimination training, group DO-MO received differential outcomes in pretraining, but mixed-outcomes in discrimination training, group MO-MO received mixed-outcomes in both pretraining and discrimination training, and group MO-DO received mixed-outcomes during pretraining, but received training with a differential outcomes procedure in discrimination training. Error bars represent SEM.

VIII. Experiment 2 Discussion

Experiment 2 examined whether pretraining with differential outcomes would result in faster acquisition relative to rats that received DO only in discrimination training and to rats that received MO throughout training. Pretraining with DO or MO prior to

discrimination training had no effect on the acquisition of the visual discrimination, suggesting that pretraining with differential outcomes did not facilitate acquisition relative to animals that did not receive differential outcomes until the start of the discrimination. Further, establishing improper lever-outcome expectancies in pretraining did not disrupt acquisition relative to animals whose expectancies were consistent throughout all of training.

In contrast, whether the rats received MO or DO in discrimination training did matter, and rats that received DO in training had higher overall accuracy relative to rats that received MO training. Despite this, there was no significant block by training interaction. In other words, there were no group differences in the rate of acquisition, and both DO and MO groups' performance increased across training blocks. Because the differential outcomes effect is typically defined as a difference in the rate of acquisition between groups, not in overall performance, a typical differential outcomes effect was not found in Experiment 2. Despite, this, the higher accuracy of the DO groups in discrimination training that the DO had some facilitative effect, consistent with other findings within the differential outcomes literature (e.g., Friedrich & Zentall, 2011, but see Urcuioli, 2005 for a review). Further, planned comparisons revealed a differential outcomes effect in groups that received MO pretraining, but not in those that received DO pretraining, suggesting that DO pretraining may have affected learning, but more animals may have been needed to reach significance. In support of this, the pretraining by training interaction was approaching significance ($p = .13$).

Lastly, although no effect of DO pretraining was found in acquisition, it did result in a significant bias for the lever associated with pellets early in training. However, as mentioned above, this bias did not result in any statistical differences in the acquisition of the visual discrimination.

IX. General Discussion

Pilot studies that used an FR-10 schedule of reinforcement, MO pretraining, and CO control groups failed to find a DOE. However, a DOE was found in subsequent pilot studies that used an FR-1 reinforcement schedule, DO pretraining (for DO groups), and an MO control group. The current experiments examined two different variables within a DOE procedure to investigate these contrasting findings. In both experiments, rats were trained that a left lever press was reinforced during one visual stimulus (e.g., a flashing light) and a right lever press was reinforced during another visual stimulus (e.g., a steady light). The differential outcomes groups received a pellet or sucrose for each correct response, whereas the mixed-outcomes groups received interspersed deliveries of both outcomes for each response.

One explanation for the opposing results of our pilot studies is that perhaps the delivery of a high-value reinforcer (i.e., a chocolate-flavored pellet) disrupts learning when its delivery is unpredictable (as it is in a MO procedure). Experiment 1 compared the DOE when using higher-valued versus lower-valued reinforcers. Half of the rats received the high value reinforcer pair (chocolate-flavored pellets and a 30% sucrose solution; groups DO choc and MO choc) and the other half received the moderate value reinforcers (chow pellets and an 18% sucrose solution; groups DO pell and MO pell). It was hypothesized that if the unpredictable delivery of the high value chocolate-flavored pellets disrupts learning, then the magnitude of the DOE should be greater compared to the DOE observed in rats that received the more familiar, lower valued chow pellets. The results revealed that group MO choc did not rise significantly above chance-level throughout all of training, although performance was marginally above chance-level in the final block. In contrast, group MO pell rose

significantly above chance-level beginning on block 3. This finding is likely why the difference between the DO and MO choc groups emerged earlier than the difference between the DO and MO pell groups. A DOE was found regardless of the outcomes used, with the DO groups acquiring the discrimination faster than their respective MO groups, suggesting that using a lower value reward did not eliminate the DOE.

Although the chow-flavored pellets used in Experiment 1 were intended to serve as a lower-value reward relative to the chocolate-flavored pellets, both the DO pell and DO choc groups had a significant bias for the lever associated with pellets early in training. Therefore, although the chow pellet was more familiar and likely less valuable than the chocolate-pellet, it was still preferred over the sucrose solution, and thus the finding of a DOE in the MO pell group could also be the result of the unpredictable delivery of a high value reinforcer. Indeed, the vast majority of the DO research has used outcomes that differ in reward quality (i.e., with one reward having a higher value), such as outcomes that differ in magnitude or probability of reinforcement (Carlson & Wielkiewicz, 1976; Urcuioli, 1990). However, evidence of the DOE using a mixed-outcomes control has been found with non-hedonically differential outcomes (e.g., different reward locations, Friedrich & Zentall, 2011), which suggests that differences in reward quality might not be the critical condition. Future experiments with outcomes that differ non-hedonically, but varying in what makes them distinct, as well as including common outcome controls may help identify the most important factors. Overall, the findings of Experiment 1 suggest that high value reinforcers disrupt learning only when their delivery is unpredictable.

The differential outcomes effect is thought to occur as a result of differential conditioned expectancies formed as a result of Pavlovian S-O associations learned early in

training. These conditioned expectancies then serve as an additional discriminative stimulus for the correct response, thus making the original two S^Ds even more discriminable. There has been some evidence that has found that establishing improper S-O expectancies prior to discrimination training interferes with acquisition (e.g., Trapold, 1970, Experiment 2). Ramos and Savage (2003) found that lever press training with mixed-outcomes prevented the emergence of a DOE in MTP training compared to rats that received differential outcomes throughout all of training. However, because the stimulus location (i.e., the left or right lever) was confounded with the response (left or right lever press) in Ramos and Savage (2003), it cannot be determined whether the facilitative effect of pretraining with DO was the result of preestablishing the proper S-O associations or due to strengthening R-O associations. In the current experiments (Experiment 2), the effects lever press pretraining with DO or MO on subsequent discrimination learning with either DO or MO procedures was examined. The results revealed that pretraining with DO or MO did not provide any facilitative or disruptive effects in the first trial accuracy of correct responding during discrimination training. This finding supports the notion that the DOE depends on conditioned expectancies that form as a result of S-O associations, rather than R-O associations. In fact, the results of Experiment 2 suggest that the R-O associations formed as a result of DO pretraining may have resulted in a bias for the chocolate pellets early in training. However, this bias did not have any statistically significant impact on acquisition.

The results of Experiment 2 revealed that rats that received DO in discrimination training had higher overall accuracy than rats that received MO in training. Unlike Experiment 1, however, Experiment 2, did not find any differences in rate of learning across the groups, so a *typical* DOE was not found. However, much of the DO literature reports

finding a DOE in the absence of acquisition effects (e.g., higher performance in DO groups when a delay is imposed, e.g., Friedrich & Zentall, 2011, but see Urcuioli, 2005 for a review). Further, the MO groups (MO-MO and DO-MO) appeared to have better overall performance in Experiment 2 than those in Experiment 1, which might account for the lack of an interaction. In fact, on block 2 of training, the MO-MO group differed marginally from chance-level when all other groups did not rise above chance-level until the following training block. Rat age might be one factor contributing to this better overall performance, as the rats in Experiment were approximately 8.5 months of age at the start of the experiment, and rats in Experiment 2 were approximately 5.5 months of age. Previous research has found the DOE to be magnified in aged rats relative to young rats (e.g., Mateos et al., 2016). Lastly, although pretraining with differential outcomes did not affect acquisition, it did result in a significant bias for the lever associated with pellets early in training. Such a bias could possibly underestimate the DOE, as the bias must be overcome in order to learn about the S-O associations. In support of this, planned comparisons revealed a DOE in the groups that received MO pretraining, but not in the groups that received DO pretraining. Further, the pretraining by training interaction was approaching significance, suggesting that more subjects may have been needed. A replication of Experiment 2 is needed to determine whether the absence of a typical DOE was spurious in the present experiment, or the result of some other cause (e.g., age or number of subjects).

Overall, the results of the present experiments add to our knowledge of the differential outcomes effect. Experiment 1 found some evidence that might suggest that the unpredictable delivery of a high value reinforcer in a mixed-outcomes procedure might disrupt acquisition as opposed to differential outcomes facilitating acquisition. This finding

would change the interpretation of nearly all previous differential outcomes research since the MO procedure is used almost exclusively as a control in the extant literature. However, more research needs to be conducted examining differences between different control procedures (e.g., CO vs. MO) and manipulating training conditions with non-hedonic outcomes. The results of Experiment 2 are in-line with outcome mediation theories of the DOE, as preestablishing R-O associations did not have the same facilitative effect as establishing S-O relations previously demonstrated in past research (e.g., Trapold, 1970 and Ramos & Savage, 2003). Moreover, preestablishing differential R-O associations resulted in a response bias for the lever associated with pellets early in training, which perhaps resulted in slower acquisition of the S-O association. A replication of Experiment 2 is needed to further examine why a typical DOE was not obtained. Overall, the current findings add to the existing knowledge of the mechanism driving the DOE. More specifically, although outcome-mediation theory was the leading theory of the DOE, no research had been conducted to tease apart the relative role of R-O and S-O associations.

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Nerz, J., Elliott, C. E., Melo, M., & Leising, K. J. (April, 2023). *Emotion Labeling Using Visual Stimuli in the Absence of Language* [Poster presentation]. The Southwestern Psychological Association Convention, Frisco, TX.

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ABSTRACT

THE EFFECTS OF OUTCOME VALUE AND PRETRAINING ON THE DIFFERENTIAL
OUTCOMES EFFECT IN A VISUAL DISCRIMINATION TASK WITH RATS

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The differential outcomes effect (DOE) occurs when learning is facilitated by the delivery of

different outcomes (e.g., food vs. water) correlated with different responses. The current

experiments examined the effects of reinforcer value and pretraining with different outcomes

compared to mixed-outcomes (MO) groups, in which the two outcomes are uncorrelated.

Rats were trained to press the left lever during one stimulus (a steady light) and right lever

during another (a flashing light). Experiment 1 compared DO and MO groups when using

higher-valued versus lower-valued reinforcers. The higher value DO group acquired the

discrimination faster relative to its respective MO group. Experiment 2 examined pretraining

with DO or MO prior to DO or MO discrimination training. There was no direct effect of

pretraining, but only the group with MO pretraining demonstrated a typical DOE. Though

more research is needed, higher-value rewards may facilitate learning, but only after

overcoming a response bias.