THE EFFECTS OF DIFFERENTIAL OUTCOMES AND MAGNITUDE OF REINFORCEMENT ON PIGEONS ACQUISITION RATES IN DELAYED MATCHING TO SAMPLE

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By David Reyes May 2013
CERTIFICATION OF APPROVAL

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by
David Reyes

Signed Certification of Approval Page is on file with the University Library

Dr. Bruce Hesse
Professor of Psychology

Dr. William Potter
Professor of Psychology

Dr. Carrie M. Dempsey
Associate Professor of Psychology

Date
DEDICATION

I would like to dedicate this thesis project to my family. This thesis project was possible because my mom and dad have always supported me and helped create a strong work ethic that allowed me to continue with my education. They were my first teachers and always made sure I not only did my homework but that I understood it.

I also dedicate this thesis project to my sister because she helped me by being my spell checker and reader even while she was busy with her own school work at UC Davis.

“The only place you’ll find success before work is in the dictionary”
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ABSTRACT

The differential outcome effect refers to the increase in accuracy obtained in discrimination tasks when rewards provided for correct responses vary according to the stimulus presented. The current research compared a higher magnitude of reinforcement with a differential outcome to determine which condition would produce a higher rate of learning in a delayed matching to sample task. The participants were four White Carneaux pigeons. There were three conditions, one with the same outcomes of immediate access to 4s reinforcement serving as the control and two with differential outcomes involving a 2s delay to reinforcement for one outcome and immediate reinforcement for the other outcome. One differential outcome condition had 2 seconds of reinforcement and the other differential outcome condition had 4 seconds of reinforcement. An alternating treatment design was used for this study. Two of the four pigeons met mastery criteria for all three conditions. Results were mixed but the differential outcome condition with 2s reinforcement was mastered in fewer trials by two of the birds. Most birds mastered the colors fastest with immediate outcomes versus delayed outcomes.
CHAPTER I
INTRODUCTION

When teaching a new concept to a student, it is necessary to provide praise for every correct response that is produced by the student. The basic reasoning is that the student will continue to engage in the response that produces praise or reinforcement. If the correct response continues to occur over and over again in the presence of the discriminative stimulus, then the praise that was delivered would be considered a positive reinforcer. This is what is commonly known as the three term contingency. The three term contingency is made up of three parts (Miltenberger, 2008). The antecedent is an event or stimulus that precedes behavior and sets the stage for behavior to occur. Behavior is an action produced by an individual or other learning organism that is a result of the antecedent event. The consequence is what occurs after the behavior. Consequences that increase the likelihood of the behavior occurring in the presence of the antecedent event are referred to as reinforcers and consequences that reduce or eliminate the behavior following the antecedent are referred to as punishers. This has also been stated in Alberto and Troutman (2008) that learning occurs as a result of the consequence of behavior and that behavior that is followed by reinforcing consequences tends to be repeated and thus learned. Behavior that is followed by an aversive consequence tends not to be repeated and thus not learned. (pg. 12)
An expansion on the three term contingency would be the motivating operation or MO. Motivating operations (MO) have two effects: a value altering effect, changes strength of consequences, and a behavior altering effect, evokes or abates behavior that produce consequences (Laraway, et. al, 2003). This is a set of environmental events that temporarily alter the value of other stimulus events as reinforcers. Horner, Day, and Day (1997) studied the effects of motivation operations (MO) on problem behaviors. They studied three adolescent boys with severe developmental disabilities that had a history of self injury and aggressive behavior. The researchers assigned a specific MO for each of the participants. The different MO consisted of either, delaying a planned or preferred activity for 15 minutes, postponing a planned or preferred activity to the next day or receiving less than five hours of sleep the night before. The researchers used an ABAB reversal design and measured aggressive behavior and self injurious behavior SIB for each participant.

Using a functional analysis, the participants experienced a tangible condition, no-attention control condition, an escape condition and an attention condition. The study was conducted in the home of the participants and involved a 15 minute instructional session. In the conditions that included an MO factor, the MO was presented at least 1 hour prior to the instructional session. The results from the study
indicated that SIB and or aggressive behavior occurred at a higher probability when a MO was followed by a discriminative stimulus. The study indicates that an MO can act as part of the three term contingency by establishing that when there is a change in the environment it can effect the behavior when presented with a discriminative stimuli because there is a change in the value of the consequence.

Reinforcement Schedules

Essentially when teaching a new concept, the ratio of reinforcement following a correct behavior should be on a fixed ratio of 1. Over time, that rate of reinforcement can be changed so that more behaviors are required before the presentation of reinforcement is delivered. Providing a 1 to 1 ratio of reinforcement is effective, however, it is not possible in a classroom setting where lessons and concepts are presented quickly. The opportunity to provide immediate reinforcement in a classroom might not be possible simply because of the size of the classroom and time constraints that are placed on the instructor. As a result, the presentation of the reinforcement must adapt to the environment of the classroom. A student who learns the concepts quickly and accurately will be able to be successful in the classroom. A shift from a 1:1 ratio of reinforcement to a more efficient ratio would also provide the instructor with more time to teach and less time spent with remedial work. A better understanding of the different types or schedules of reinforcement could maximize the learning process and promote a more efficient learning environment.

Trapold (1970) wrote about how the reinforcer becomes part of the three term contingency and how the organism begins to engage in the behavior that has been
reinforced in the past. As a result a better discrimination is formed. Errors that occur in learning can be described as having a weak control between the discriminative stimulus and the appropriate behavior that should occur in the presence of the discriminative stimulus. When an organism begins engaging in the behaviors that have been reinforced in the past, the correlation is strengthened and the appropriate behavior is more likely to occur when presented with the discriminative stimulus.

**Conditional Discrimination and Matching to Sample**

Conditional discrimination is a process in which correct selection of stimuli is contingent upon an additional stimulus. When given two discriminative stimuli, B1 and B2, selection of B1 is correct when presented with the stimulus A1 and selection of B1 would be considered incorrect if presented with the stimulus A2. The same principle follows selection of B2 is considered correct when presented with A2 and incorrect if presented with A1 (Sidman & Tailby, 1982). The use of matching to sample is an example of how a conditional discrimination is used to demonstrate equivalence relations between stimuli. In an identical matching to sample, the comparison stimuli are similar to the sample stimuli. Lashley (1938) stated that in the matching-to-sample task, the subject’s choice-response must be based on some common property of the sample and comparisons stimuli. Since correct performance is based on two stimuli, rather than one, the discrimination is said to be “conditional”. Kohts (1928) added to this by saying that it represents a “higher mental process” involving not a single, specific response, but rather a larger and more complex segment of behavior (Berryman, Cumming, & Nevin, 1963).
In Delayed Matching to Sample (DMTS) there is a delay between the offset of the sample stimuli and the onset of the comparison stimuli. Different delay times were one of the variables that Allen (2007) looked at in his thesis. Allen’s study consisted of the pigeons pecking at the sample stimuli ten times before the offset of the sample stimuli occurred. During the offset, any pecking to the keys by the pigeon did not affect the onset of the comparison stimuli. The use of delayed matching to sample (DMTS) is the common method when studying remembering and learning with nonhumans. When correct matching occurs it is said that the sample was “remembered” by the organism and the sample is said to have been “forgotten” if the incorrect stimuli was selected.

The DMTS makes learning the task more difficult and for this reason the matching procedure has been used extensively in the study of discriminative processes (Berryman, et.al, 1963). Berryman, et.al, (1963) used pigeons to see what kind of effect would be seen with differentiating the delay of the offset of the sample key to the onset of the comparison keys. The six delays they looked at were 0, 1, 2, 4, 10, and 24 second delays. They conducted three experiments. The first experiment consisted of the pigeons making one peck to the sample stimuli then being randomly presented with any of the six different delays before the onset of the comparison stimuli is presented. In their second experiment, a fixed ratio of five responses or pecks to the sample stimulus was introduced. Experiment 3 consisted of modifications to the conditions of experiments 1 and 2.
The first experiment used all seven pigeons. All pigeons were exposed to the zero second delay and the variable delay conditions. Correct responses to the matching stimulus resulted in a 3 second presentation of the grain magazine. Incorrect responses resulted in a 3 second blackout in which all the illumination in the cage was turned off. A 25 second intertrial interval in which all the illumination in the cage was turned off, followed both correct and incorrect responses. There were two conditions in this experiment. The simultaneous condition consisted of the sample key staying illuminated at the same time as the comparison stimuli. In the zero delay, the sample key turned off following a response to the sample key and simultaneously the comparison stimuli turned on. The results indicated that none of the seven pigeons showed any tendency to acquire the matching performance. The pigeons actually performed below chance level on 60 percent of the experimental sessions.

Experiment 2 consisted of only the simultaneous condition from experiment 1, with a fixed ratio of five responses to the center key required for the onset of the comparison stimuli. Under this condition, the pigeons reached a 75 percent correct performance level with a group mean of 705 trials. The range for the group was 475 to 855 trials.

In experiment 3 only three out of the seven pigeon were used. Those pigeons were placed in the same conditions as experiment 1 with the only change being that five responses to the center were required for the onset of the comparison stimuli. In this experiment pigeons performed at 80 percent and above during the zero delay and
the 1 and 2 second delay. All three pigeons performed at chance level in the 4, 10, and 24 second delay. The study demonstrated how the increase to the delay causes the task to be more difficult.

**Differential Outcomes**

Using differential outcomes were first researched by Trapold (1970). He found that when different outcomes were associated with different behaviors, there was faster learning of discriminations and greater accuracy occurred. Trapold (1970) used food as reinforcement for correct responses to one discriminative stimulus and liquid sucrose as reinforcement for correct responses to the other discriminative stimulus. Experiments on differential outcomes range from using food and water as outcomes (Goeters, Blakely, & Poling, 1992), toys and food (Estevez, Fuentes, Mari-Beffa, Gonzalez, & Alvarez, 2001), and even using the same type of reinforcement and varying the amount, to even using the same amount but just delaying the delivery of the reinforcement (Allen, 2005).

A basic principle of operant conditioning is that a behavior that is followed by a reinforcing outcome is more likely to occur at a higher frequency. However, the value of the reinforcer decreases, as the delay to the receipt of a reinforcer increases (Green, Myerson, Shah, Estle, & Holt, 2007). This means the longer it takes to receive a reinforcer, the less likely the behavior will reoccur under similar situations. Extinction occurs when a behavior that was previously reinforced no longer occurs because no reinforcement is produced. Delaying a reinforcer too long could also produce extinction.
Differential Outcome Effect

The differential outcome effect (DOE) has proven on multiple occasions to serve as a method to increase learning and provide higher productivity. Trapold (1970) reported in his study that when correct responses to two different sets of comparison stimuli are followed not by common outcomes, but by outcomes that depend on the particular sample-comparison pair, that there is an increase in the rate of task acquisition.

Trapold (1970) investigated the effect of having two types of reinforcers associated with two different discriminative stimuli. There were two experiments in his study. The first experiment used 24 experimentally naive rats with food pellets and sucrose as the differential outcomes. Trapold used a tone and a clicker as the different discriminative stimuli and the rats responded by pressing on one or two levels depending on which stimulus was presented. The rats were separated into two main groups. In the experimental group, half of that group was presented with food for correct responses to the clicker and sucrose for correct responses to the tone. The other half of the group had their stimulus-reinforcement combinations reversed. The control group was also divided into two groups which one group would be presented with food only following a correct response and the other half would receive sucrose only following a correct response. The experiment consisted of 22 sessions, with each session consisting of 50 trials that used a tone and clicker combined. The trials were irregularly intermixed and presented on a VI 22.5 second schedule. The results from the study indicated that while rats generally learned the discrimination problem
slowly, it was learned even more slowly when the reinforcer was the same versus when a different reinforcer was used for clicker versus tone responding. The study also showed that the rats who received the food pellets had higher correct response percentage than the rats that received the sucrose. This could further support the use of food pellets as an appropriate source of a reinforcer when working with an animal population that is maintained at 80% of their free feeding weight. The results of the study showed that learning occurs faster when a different reinforcer is used for each S-R combination and the study suggests that the subjects, based on the stimulus presented, would engage in different behavior depending on the consequence delivered. Experiment 2 in the Trapold study looked at how to manipulate the learning of the discrimination problem by conditioning the consequence to follow the behavior. The results from the second experiment showed that rats in the pretraining group had a higher correct response percentage than the rats that did not receive pretraining.

Research by Urcuioli (2005) with pigeons supports the Trapold (1970) study with rats. The number of pecks that the pigeon made was the dependent variable and the independent variables were food or water. The pigeon would have to match a comparison stimulus to the sample stimulus. Based on which set the pigeon was matching, the reinforcement was either the water or food. The researchers found that pecking occurred at a higher rate for the higher-probability food than for the lower-probability water. Urcuioli considered the reinforcer itself to be part of what was learned. This finding is similar to what Trapold stated in his 1970 study. Urcuioli
(2005) theorized that animals may have evolved such sensitivities that would allow them to adapt quickly and appropriately to changing circumstances. This concept should not be a surprise when applied to the animal world. In the essence of survival, it would benefit animals to be sensitive to a combination of stimuli that provide a signal of upcoming events. Being able to use past experiences under certain environmental conditions allows them to adapt quickly and appropriately to the changing environment. Knowing what behaviors will provide specific outcomes is essential to survival. In other words, the stimulus in the environmental controls the specific behaviors that animals engage in based on previous outcomes and that acts as a reliable signal for upcoming events.

Carlson and Wielkiewicz (1972) showed how withholding reinforcement could produce the differential outcome effect (DOE). Their study consisted of 32 albino rats in a two choice auditory discrimination procedure. The rats made up four different groups. The researchers used a tone or a click as the discriminative stimuli. There was a right and left lever used with the right lever designated as correct on tone trials and the left lever designated as correct on the click trials.

In the consistent-delay condition, involving differential outcomes, all the reinforcement was delayed by 5 seconds for one of the two levers. Half of the subjects had the delay following correct responses to the left lever and the other half had a delay following correct responses to the right lever. The random-delay condition (nondifferential outcomes) had the reinforcement delayed by 5 seconds on a random 50% of the trials on each of the levers. In the all-delay condition all
reinforcement was delayed on both levers by 5 seconds. And in the no-delay condition (nondifferential outcomes) all the reinforcement on both levers was delivered immediately following a correct response. The results from the study indicated that the consistent-delayed (differential outcomes) condition produced a higher mean percent or correct responses. Using an ANOVA the results indicated that performance was found to be significantly higher than the no-delay group as well as the random-delay and all-delay. The condition that produced the lowest percent of correct responses was the random-delay condition. By session 11 the consistent-delay group had a mean percent correct response at 90 percent correct while no-delay produced a 70 percent correct and both random and all-delay producing a 55 percent correct. The no-delay condition did not reach 90 percent correct until session 23 with neither random nor all-delay reaching 90% correct.

A study by Peterson, Wheeler, and Trapold (1980) looked at how withholding the reinforcer also produced a DOE. Their study consisted of four experiments in which one of the groups used food and tone as one of the reinforcing outcomes and tone only for the other reinforcing outcome. The food was used to condition the tone as a reinforcer. The two control groups for Experiment 1 consisted of one group receiving both food and tone as a reinforcing outcome and the other control group receiving food and tone for the first half of their correct responses, and then only tone for the last half of their correct responses.

They used 12 pigeons as participants. The pigeons were given a conditional discrimination task in which responses to a vertical line were correct when presented
with a green light and responses to a horizontal line were correct when presented with a red light. Correct responses resulted in 3 second access to food that was paired with a tone followed by a 5 second intertrial interval. Incorrect responses were followed by a 10 second blackout and a 5 second intertrial interval.

The results for the experiment demonstrated that the group that received food and tone for one of the correct outcomes and only tone for the other correct outcome, scored higher than the other two groups. Experiments 2-4 looked at how the delay of the onset of the comparisons stimuli from the offset of the sample stimuli affected the percent correct of the three groups. In each of the experiments the group that had food and tone as one condition and tone only for the other condition scored higher than the other two groups.

**Magnitude of Reinforcement**

Many studies have focused on the differential outcome effect but few have looked at how magnitude of reinforcement affects learning and whether or not it would be an advantage to use more of a reinforcer versus having to use different types. There have been contradicting reports of the benefits of using magnitude of reinforcement as a way to improve learning. A study by Volkert, Lerman, and Vorndran (2005) looked at the effects of reinforcement magnitude on functional analysis outcomes and more specifically the effects on severe problem behavior. They reported that prior studies had yielded inconsistent outcomes relating to response rates being increased as reinforcement magnitude increased. There are studies that have supported that when there is a reinforcement magnitude increase that
there is an increase in response rate. Jenkins and Clayton (1949) found that key pecking in pigeons was higher when followed by 5 second access to food than when followed by 2 seconds access to food. The purpose of their study was to determine the effect of two different amounts of reinforcement, determined by eating time, upon rate of responding in pigeons. They used five pigeons. Two of the pigeons were exposed to 2, 4, 8, or 12 seconds of eating time. Response rates were recorded based on eating time. Once an eating time was selected it was used for three successive days. Reinforcement was presented on a variable interval schedule of 120 seconds. The mean for five pigeons in the 2 second condition was 1205 key pecks. In the 5 second condition it was 1557 key pecks. There was a difference of 352 key pecks with a SD of 294 and \( p = .04 \). This could help support that magnitude of reinforcement can produce a change in behavior. Other studies have also shown that one of the problems with an increase in reinforcement magnitude is that there is a possibility of a satiation effect which would result in a decrease of the response rate. Belke (1997), showed a decrease in lever presses by rats as the reinforcement duration increased.

The purpose of the study by Volkert, Lerman and Vorndran (2005), was to examine the impact of reinforcement magnitude on the results of functional analyses. In their study they had six children with the diagnoses of autism spectrum disorder or moderate to severe developmental disabilities who displayed either aggression or self-injurious behavior. There were three different reinforcement intervals. The 3 seconds access to the reinforcement was considered the small-magnitude
reinforcement, a 20 second access to the reinforcement was considered the medium magnitude reinforcement and the 120 second access to the reinforcement was considered the large magnitude reinforcement. During the access of reinforcement, the participant received either, attention, a break or access to materials. The results from their study showed that reinforcement magnitude was not a critical determinant of functional analysis outcomes.

Based on the basic principles of behavior it would seem that providing a greater amount of reinforcement contingent on a specific behavior would result in that behavior occurring at a higher rate. Reed and Wright (1988) found that the magnitude of reinforcement had an effect on response rate of rats. In their study, they found that rats had a higher rate of responses when they had a greater amount of reinforcement. One thing that was found in a study by Balsam, Brownstein, and Shull (1978), was that increased amounts of reinforcement lead to an increase in responding. They found that when an animal is permitted to choose between two different responses that yield different amounts of reinforcement that the animal has a stronger preference to selecting the greater reinforcer. Yet there are studies that indicate that the variation in the amount of the reinforcer is not a powerful technique in altering behavior (Morse, 1966). The use of a larger amount of reinforcement does have its disadvantages in that the organism becomes satiated sooner with the larger amount, and as a result lowers the MO for wanting to engage in the behavior. However, a study by Nevin and Grosch (1990) found that a larger amount of reinforcement can produce higher levels of accuracy. Their study used pigeons that
were trained in delayed matching-to-sample with red and green key lights. Their large reinforcer consisted of access to food pellets for 4.5 seconds versus their small reinforcer which consisted of access to food for 1.5 seconds. Their study showed that the accuracy was higher for the 4.5s reinforcers. Other studies have also shown that response rate and resistance to extinction were greater when the larger amount of reinforcement was the outcome (Shettleworth and Nevin, 1965; Nevin, 1974; Nevin, Mandell, and Yarensky, 1981).

**The Purpose of the Current Study**

Allen (2005) master’s thesis, found that the optimal rate of learning occurred with the presentation of a 2 second delay between the offset of the sample stimulus and the onset of the comparison stimulus. The 2 second delay produced a higher rate of accuracy because the pigeons in Allen’s study had already been exposed to the different conditions and the manipulation in his study was the length of the delay between of offset of the sample stimuli and the onset of the comparison stimuli. Of course in his study he also found that delaying the reinforcement could serve as a differential outcome.

The purpose of Allen’s study was to see if pigeons would be able to learn to match colors using a matching to sample procedure and also if they would be able to maintain it while presenting a delay between the offset of the sample stimulus and the onset of the comparison stimulus. Allen used a 0, 1, 2, 3, and 5 second delay between the offset of the sample stimulus and the onset of the comparison stimulus. More importantly he used a delay to reinforcement to serve as a differential outcome.
Correct responses to one stimuli resulted in immediate presentation of the reinforcement and correct responses to the other stimulus would result in a 2 second delay to the presentation of the reinforcement.

In Allen’s study, he started with a zero second delay for his matching to sample. The pigeons were presented with the sample stimulus and once they had pecked it 10 times the sample stimulus would turn off and immediately the comparison stimulus were presented. Once the birds had reached mastery criteria a delay was introduced follow the offset of the sample stimulus. The delay would increase once birds reached mastery criteria under each condition. Using the differential outcome by delaying access to the reinforcement by two seconds, demonstrate that even a slight delay in the delivery of the reinforcer could produce differential outcome effect.

Although Allen ended his data collection sessions early, the pigeons displayed different learning rates when compared to the condition in which there was no differential outcome. Overall, the pigeon’s performance during the differential outcome condition was higher than the same outcome condition. Allen used four pigeons and one of the more significant results was during the three second delay from offset of sample to onset of comparison in which one of the pigeons was 81 percent accurate under the same outcome condition versus 92 percent accurate under the differential outcome condition. In Allen’s thesis is was found that delayed reinforcement was successful as a part of the differential outcomes procedure.
The purpose of the current study was to compare the effect of magnitude of reinforcement to the effect of differentiated outcomes on learning a delayed matching to sample task. Using differential outcomes and magnitude of reinforcement as independent variables, the researcher wanted to see which type of reinforcement will require fewer trials to learn a delayed-matching-to-sample task. This could benefit the education field in deciding how to be more efficient in teaching learning tasks to students. By having a better understanding of reinforcement and how it affects the rate in learning a task, one could develop a different approach that is more efficient, and helps a student learn faster.

Research indicates that using differential forms of reinforcement is more effective than using the same type of reinforcement for every correct response (Urcuioli, 1990, Nevin, Ward, Jimenez-Gomez, et. al., 2009, Urcuioli, 2005). The findings in these studies have been replicated using different types of reinforcement such as water and food (Urcuioli, 2005), different amounts of reinforcement (Nevin & Grosch, 1990), food and tone (Peterson, Wheeler, & Trapold, 1980) and even delaying the reinforcement. Each of these studies has shown similar results and can be summarized by what is known as the differential outcome effect. The purpose of the current study was to compare the rate of acquisition in a learning task using magnitude of reinforcement and using differential outcomes as reinforcement. Using pigeons as the subjects will help a better understanding of reinforcement and be able to use it as efficiently as possible. The magnitude of reinforcement will be established by allowing more time to access the food following a correct response.
The differential outcome condition will use delayed reinforcement as in Allen’s thesis. The current study is looking to see if the amount of reinforcement is more critical in the learning behavior or if it is more critical to have a differential outcome.
CHAPTER III

METHODOLOGY

Participants

Four King-Hubbard/White-Carneaux pigeons will be used in this experiment. The pigeons were maintained at approximately 80% of their free-feeding weight. Food was obtained during experimental sessions and water was continuously available in the pigeon’s home cages. When necessary, the pigeons were fed post-session to maintain their weight. The experiment ran seven days a week at approximately the same time each day. The pigeons were housed in their home cages on a 16/8 hour light/dark cycle.

Apparatus

Two BRS/LVE operant chambers were used in this experiment. Each was equipped with a food hopper, a hopper light, and a house light. Additionally, they had three horizontally arranged keys on the intelligence panel. These three keys were arranged above the food hopper. These keys were used as the sample and comparison keys during the study. A fan was attached to each operant chamber to mask extraneous noise.

An IBM (Microsoft© Windows XP) compatible computer using MED-PC controlled the functions of the operant chamber. The IBM compatible computer controlled which stimuli would be displayed and recorded all data.
**Design**

An alternating treatment design was used. There were three treatment conditions, two involved differential outcomes and one had nondifferential outcomes. All conditions used a delayed-matching-to sample (DMTS) task using an identity matching procedure with the same 2s delay between the offset of the sample stimulus and the onset of the two comparison stimuli. A schedule was created to insure that the pigeons participated in all conditions evenly. The pigeons alternated conditions each day.

**Procedure**

The procedures that were used in this study were similar to those used in Allen (2007). Each trial started with the center key being lit with the unique colors of that day’s condition. Ten pecks to the center sample key were required to ensure that the pigeon was attending to the sample key. On the 10th peck the sample center key went dark and a 2s delay started where no key lights were on but the house light was still light. The 2s delay was based on Allen’s 2007 results where, on average, the 2 second delay produced the most reliable outcomes. After this delay, the two comparison colors were presented on the right and left keys, the center key remained unlighted. The correct comparison key was randomly assigned to either the left or right of the sample. Selection of the correct match resulted in either immediate access to reinforcement or a 2 second delay to reinforcement. An incorrect match or two pecks to the dark center key, resulted in a timeout (all keys and house light turned off) equal to that condition’s reinforcement period. After each time out, the same trial
was presented again until a correct match occurred (the correction procedure). Correction procedure trials were not included in the session calculations of percent correct for each color but were recorded separately. A trial ended after blackout for an incorrect comparison key peck or reinforcement for a correct comparison key peck or 65 seconds with no comparison or sample key peck. Trials were separated by a 10s intertrial interval where all keylights were off but the house light was on. Pecks to keys during this interval reset the 10s intertrial interval timer and were recorded. The program ended after 60 minutes or 50 reinforcers, whichever came first.

The experiment ended when all pigeons met mastery criteria for all conditions. The pigeons that did not meet mastery criteria in a condition were presented with the nonalternating condition trials and the experiment ended when mastery was not achieved after 11 weeks of training. Mastery criteria was 80% correct across 3 consecutive sessions for each color. (Allen, 2007).

**DMTS with Differential Outcomes Conditions**

One of the differential outcome conditions (DO2) used the colors red and green with a 2 second delay to reinforcement for correct matches to one of the colors and immediate reinforcement for correct matches to the other color. Reinforcement was 2 second access to food for any correct match in this condition.

The other differential outcome condition (DO4) had 4s access to food for matching the colors purple and yellow. It used the same differential outcome method as DO2 consisting of a 2 second delay to reinforcement for correct matches to one of
the colors and immediate access to food reinforcement for correct matches of the other color.

**DMTS with Same Outcomes Condition**

The same outcome condition (SO4) provided immediate access to 4s of food reinforcement following correct identity matches of blue and orange.

Data were collected by the Med-PC program that calculated correct trials, incorrect trials, aborted trials, and percent correct at the end of each session. The raw data were transferred into a Microsoft Excel file using the Med-PC to Microsoft Excel program.

The data point for each session was calculated by taking the total number of correct matches for each color and dividing it by the total number of trials. Correction trials were not included in these totals.

Magnitude of reinforcement and differential reinforcement were the manipulated independent variables and the percent correct was the dependent variable.
Table 1

*Color Assignments for all Subjects*

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Box</th>
<th>Differential Outcome</th>
<th>Same Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird 25</td>
<td>#3</td>
<td>Red delayed</td>
<td>(SO4) Blue and Orange both</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO2) Green immediate</td>
<td>(DO4) Purple immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yellow delayed immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO2) Red immediate</td>
<td>(DO4) Yellow immediate</td>
</tr>
<tr>
<td>Bird 55</td>
<td>#2</td>
<td>Green delayed</td>
<td>(SO4) Blue and Orange both</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO2) Green immediate</td>
<td>Purple delayed immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO4) Yellow immediate</td>
<td>(DO4) Purple immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yellow delayed immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO2) Red immediate</td>
<td>(DO2) Red immediate</td>
</tr>
<tr>
<td>Bird 58</td>
<td>#2</td>
<td>Red delayed</td>
<td>(SO4) Blue and Orange both</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(DO4) Purple immediate</td>
<td>Purple delayed immediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(DO2) Red immediate</td>
</tr>
<tr>
<td>Bird 63</td>
<td>#3</td>
<td>Green delayed</td>
<td>(SO4) Blue and Orange both</td>
</tr>
<tr>
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<td>(DO4) Yellow immediate</td>
<td>Purple delayed immediate</td>
</tr>
</tbody>
</table>
CHAPTER IV

RESULTS

Same Outcome Condition (SO4) Completions

The same-outcome (SO4) condition, with immediate delivery of 4 seconds access to reinforcement, served as the control condition in this study and 3 out of the 4 pigeons, birds 25, 58, and 63, completed the experiment by meeting the mastery criteria in this condition. Bird 55 did not meet mastery criteria and ended the experiment after 32 sessions in this condition with no progress. Bird 55 averaged 20.5 sessions for completion of this condition. Thirty two sessions were used as the total to calculate the average when mastery was not reached. This number was used because it was the maximum number of sessions in any given condition where the mastery criteria was not met. Bird 63 reached mastery criteria for the SO4 condition after an average of 21.5 sessions. Bird 58 reached mastery criteria for the SO4 condition after an average of 16 sessions. Bird 25 reached mastery criteria after an average of 9.5 sessions.

Differential Outcome Conditions (DO2 and DO4) Completions

In the differential outcome condition, with 2 seconds access to reinforcement (DO2), 2 out of the 4 pigeons, birds 25 and 63, completed the experiment by meeting the mastery criteria. Birds 55 and 58 did not meet mastery criteria under this condition. Bird 55 reached mastery criteria for the delayed reinforcer option, but did not meet mastery criteria for the immediate reinforcer option and averaged 19.5
sessions for mastery. Bird 58 reached mastery criteria for the immediate reinforcer option, but not for the delayed reinforcer option and averaged 21.5 sessions for mastery. Bird 25 averaged 15 sessions to reach mastery criteria and bird 63 averaged 18 sessions to reach mastery criteria in the DO2 condition.

In the differential outcome condition, with 4 seconds access to reinforcement (DO4), 2 out of the 4 pigeons, birds 25 and 63, completed the experiment by meeting the mastery criteria. Bird 55 did not meet the mastery criteria in both the immediate and the delayed reinforcement options. Bird 55 completed a total of 32 sessions in this condition. Bird 58 reached mastery criteria for the immediate reinforcer but did not reach mastery criteria in the delayed reinforcer option and averaged 26.5 sessions to mastery. Bird 25 averaged 17.5 sessions to reach mastery criteria and bird 63 averaged 26.5 sessions to reach mastery criteria.

Bird 25 and 63 reached mastery criteria for this condition with both of the birds performing at a higher accuracy when the reinforcement was immediately delivered versus when there was a 2s delay to the reinforcement. Bird 25 performed better than the other birds in this condition.

**Individual Bird Alternating Treatments Comparison across Sessions**

Bird 25

Bird 25’s performance was similar across the three conditions (figure 1). By sessions 5 and 6 of the SO4 and DO2 conditions the percent correct was above 80% while performance in the DO4 condition was at about 60% correct. Performance in the DO4 condition showed an upward trend after the third time in that condition but
did not approach 80% until session 9. Bird 25 had a higher percent correct in the DO2 and SO4 condition than in the DO4 condition.

*Figure 1.* Session Data for all conditions.

Bird 25 reached mastery criteria in fewer sessions when the reinforcement was immediately presented following a correct response (figure 2). There were 6 sessions required for mastery in the DO2 condition, 9 sessions in the DO4 condition and 7 and 12 sessions for mastery in the SO4 condition, when the reinforcement was immediately presented following a correct response.
Bird 63 showed a steady rate of learning across all three conditions (see Figure 3). He performed below chance level during the first 5 sessions but by session six was above 60% accuracy. Bird 63 had a higher percent correct in the DO2 condition than in the other conditions. He performed at around 50% correct during the first sessions in the DO2 condition. Bird 63 also showed an upward trend in the DO2 condition and only one time did bird 63 perform better in the SO4 condition than in the DO2 condition. His weakest performance was in the SO4 condition. This condition did show an upward trend in percent correct but was never higher than the DO2 or the SO4 conditions.
Bird 63 did not appear to be effected by the delay to the reinforcer (figure 4). The range of sessions to mastery was 16-28 sessions. The DO2 condition had the fewest sessions to mastery and the DO4 required the most sessions to reach mastery criteria.
Bird 55

Matching was best under the DO2 condition for Bird 55. It was at chance level during the early sessions in both the SO4 and DO2 condition (see Figure 5). In the DO4 condition, Bird 55 did not perform well in the first session. In the later sessions, he showed improvement in percent correct across the three different conditions but only once reached 80% correct in the DO4 condition. In the DO2 condition, bird 55 had a sharp upward trend after the 3rd session but then performance leveled off and stayed within the mid 70% range. Additional sessions were conducted in the DO2 and SO4 conditions for Bird 55 using a nonalternating format for sessions as a way to improve performance. This change did not improve performance in the DO2 condition but did increase accuracy slightly in the SO4 condition.
Figure 5. Session Data for all conditions.

Bird 55 only met mastery criteria in the SO4 condition for one of the colors and met mastery criteria in the DO2 condition when the reinforcer was delayed (Figure 6). The sessions ended due to lack of progress before Bird 55 reached mastery criteria for the other conditions.
Bird 58

Bird 58 (see Figure 7) showed a steady acquisition rate typical of birds 25 and 63. His inactivity during the first two sessions resulted in the sessions “timing out” after 60 minutes had elapsed. The program ended after 60 minutes or 50 reinforcers, whichever came first. By session 4, Bird 58 was responding at a rate that allowed the maximum 50 reinforcements to be delivered versus the 36 trials that occurred in the first session for both the DO2 and SO4 conditions. The DO4 condition in the early sessions showed greater accuracy than both the DO2 and the SO4, however, by the 13th session performance the DO2 condition had a higher percent correct before dropping lower than the DO4 and SO4 condition. For Bird 58, the performance levels fluctuated between all the conditions and did not give a definite clear result as to which condition had more accurate results.
Figure 7. Session Data for all conditions.

Bird 58 only met the mastery criteria in the SO4 condition. He performed best when the reinforcement was immediate (Figure 8).

Figure 8. Session Totals to Mastery.
CHAPTER V

DISCUSSION

This study examined learning using differential outcomes and magnitude of reinforcement in a delayed matching to sample task. In general, results were mixed with the birds showing a lot of variability across the conditions. The one condition that did show consistency across the birds was the DO4 condition. This condition produced the slowest learning rates across birds in all conditions. The SO4 condition and the DO2 condition showed faster learning, however, neither one proved to be the optimal learning condition. Also, most birds seemed to learn to match colors faster when reinforcement was immediate rather than delayed.

The Differential Outcomes Effect

Peterson, Wheeler, and Trapold (1980) found that pigeons in a differential outcomes group outperformed a second group of pigeons that were presented with more reinforcement with nondifferential outcomes. The current study showed mixed results. The birds typically performed more accurately in the differential outcome (DO2) condition with 2 seconds of reinforcement than in the differential outcome (DO4) condition with 4 seconds of reinforcement or in the same outcome (SO4) condition with 4 seconds of reinforcement. In the DO2 and DO4 conditions, there was a consistent difference in accuracy between the response that was immediately reinforced and the response that had a 2 second delay to reinforcement. When looking at the responses that where immediately reinforced, the birds had similar
accuracy levels in the SO4 condition. When both colors in the DO2 or DO4 conditions were totaled and compared to the totals of both colors in the SO4 condition, the birds in the DO2 and DO4 conditions did not show the differential outcome effect found in Trapold’s 1970 study. Trapold suggested that the differential outcomes effect is produced by the enhancement of discrimination accuracy that occurs when correct responses, based on different conditional cues, produce qualitatively or quantitatively different reinforcers. This indicates that the delay to the reinforcer should have acted to differentiate the reinforcers and the bird should have been affected by this, making the colors more discriminable.

An alternating treatment design was used where the birds changed conditions daily. Because of the low performance of birds 55 and 58, the alternating treatment design was changed to a nonalternating conditions design to facilitate learning the discrimination. In the nonalternating design the same stimulus condition was used across days versus alternating the conditions each day. The results indicated that performance improved for bird 58 when the condition was presented on consecutive days in the nonalternating condition design.

Overall, the differential outcome with 2 seconds of reinforcement (DO2) condition required fewer sessions to reach mastery criteria for both colors. Birds 25, 63, and 58 met mastery criteria under the DO2 condition with fewer sessions than the other conditions. In the differential outcome conditions, the number of sessions to reach mastery criteria was less for the color that was immediately reinforced than for the color that had a delay following a correct response. This was consistent with
previous research. Urcuioli (2005) and Nevin and Grosch (1990) found that immediately reinforced behaviors would occur at a higher frequency. When there is a delay between the comparison response and the reinforcement delivery, the bird could engage in other behaviors during the delay. As a result, the comparison response was not being directly reinforced.

**Issues with Delaying Reinforcement**

In behavior analysis, a reinforcer is something that maintains or increases the behavior that occurs prior to the presentation of the reinforcement. This is part of the three term contingency. The environment also has an effect on the three term contingency because there are many external variables that influence behavior. Often a behavior is being reinforced by other consequences in addition to the manipulated variable. Studies with pigeons in a delayed matching to sample task showed a decrease in correct matching behavior if there was a delay to the presentation of the reinforcement, (Berryman, Cumming, & Nevin, 1963). The pigeon’s responding is controlled by the consequences as they occur. A delay to reinforcement allows for multiple behaviors prior to the delivery of the reinforcement. For example, if the pigeon happened to be turning around at the moment that the reinforcement was delivered that behavior gets immediately reinforced and not the key peck to the comparison stimulus. Skinner (1948) described how a pigeon’s behavior was influenced when the food hopper appeared. The bird repeated the response that was closest to food presentation. When there was a delay between the targeted response
and the food delivery, more trials were required for the pigeon to learn the targeted response.

**Potential Confounds**

Bird 25 and 63’s performance in the SO condition could be attributed to prior experience in the operant chamber. The birds did require a few trials to select all three keys because their most recent training history was a task involving only two of the three response keys. The birds were not exposed to one of the side keys and during the first session would often not select that key. The low performance in the first few sessions was attributed to the novel matching to sample task, however, it could be possible that the session timed out because the birds would not select the less used side key position when it was the correct key.

Bird 63 met the mastery criteria for all three conditions in fewer sessions than the other birds. However, Bird 63 met mastery criteria in the DO2 condition with 2 second access to reinforcement sooner than in the DO4 condition with 4 seconds access to reinforcement and the SO4 condition.

Birds 63 and 25 performed at a higher accuracy level than birds 55 and 58. There were many variables that could have influenced these results. The first thing to look at is the stimuli. Some studies have shown that pigeons will develop a color or a side preference. To counterbalance for bird specific color preferences, birds 25 and 58 had the same key color combinations and birds 63 and 55 had the same key color combinations. In the DO2 and DO4 conditions the color that was reinforced immediately tended to have a higher accuracy and the color that had the delay had a
lower accuracy than the color immediately reinforced. One thing to note, in the SO4 condition, 2 out of the 4 birds reached mastery quicker for blue than orange with 1 bird being equal for both colors and only bird 63 reached mastery faster for the orange than for blue. Perhaps orange was less salient than blue in the operant chamber because the pigeons had prior exposure to blue.

The operant chambers could have affected the outcome. There was a malfunction in box 2 for the differential outcome with 4 seconds of reinforcement (DO4) condition that resulted in birds 55 and 58 not completing the condition. The malfunction in box 2 caused the left key to not light and the birds then selected only the right key. The malfunction was noticed when bird 58 had an uncharacteristically high number of correction trials during one of the sessions. There were 2 sessions where it was noted that a malfunction occurred with the left key not being lit during the comparison stimuli time. Birds 25 and 63 were not in this box and were the two higher performers in the group.

All the birds had prior experience in the operant chamber but there were no equipment problems in the box 3 for birds 25 and 63. Birds 55 and 58 in box 2 displayed similar behavior to each other in the DO4 condition. These birds continued to peck the comparison key after a correct response and during the reinforcement time. When they did this they did not get the full 4 seconds of the reinforcement. They did this even though the comparison key had gone dark. This was seen by both birds in box 2 and the researcher was unable to determine the reason for this behavior.
Responding During the Delay in DMTS

One thing to note for birds 55 and 58 was that they would peck at the unlit comparison keys during the 2 second delay between the offset of the sample key and the onset of the comparison keys. In this study, key pecks during the 2 second delay between the offset of the sample key and the onset of the comparison key had no programmed consequences. Some researchers punish dark key pecks with chamber blackouts or delayed onset of sample or comparison key lights. There were no punishment contingencies for dark key pecking in this study because programmed delays for comparison stimuli were being used and consistency was desired. However, a blackout contingency that restarted a trial might have decreased the number of key pecks to the unlit keys. It appeared that the birds were selecting the key that was previously reinforced when presented with particular stimuli because they did not always peck at the same unlit key each trial.

During the DO2 and DO4 conditions of the DMTS procedure, the birds typically preformed at a higher accuracy when the correct response was followed immediately by the reinforcer. However, bird 55 had a higher accuracy when the correct response was followed by the 2 second delay to reinforcement. During sessions 4-10, bird 55 actually met mastery criteria when the reinforcement was delayed following correct responses to green. By session 11, performance dropped when there was a delay to reinforcement from 92% correct to 62% correct and stayed at or just above chance level for both red and green. Bird 55 did not perform above 80% accuracy for three consecutive sessions with the immediate reinforcer following
a correct response. Bird 55 did not perform above 80% after 10 consecutive days in
the nonalternating phase. One thing that was interesting in this condition was that
bird 55 did meet mastery criteria in the delay to reinforcement option. The reason
that this stood out was that for the other birds, performance was higher when the
correct response was immediately followed by the presentation of the reinforcement.

Bird 55 met mastery criteria for the delayed reinforcer option after 7 sessions.
His performance in this condition was hard to explain especially since his level of
performance would fluctuate from 57% accuracy in one session to 84% accuracy the
following session. One observation was that Bird 55 would begin to peck at the
comparison keys during the time between the offset of the sample key and the onset
of the comparison keys. It appeared as if he was selecting the key that was previously
reinforced. Pecking prior to the onset of the comparison keys did not reset the sample
key nor did it produce a blackout of the keys. There were correction trials (same trial
represented when an error was made) and even with these trials Bird 55 would peck
the incorrect key. One other thing to note is that he would continue pecking the
correct comparison key even after it went dark and would sometimes miss the
reinforcement if it was delivered immediately following a correct response. This
could have been one of the reasons why performance was higher when the
reinforcement presentation was delayed. The delay gave bird 55 time to stop pecking
the comparison key and eat the food pellets.
Changing from Alternating Conditions to Nonalternating Conditions

A nonalternating format was used for birds 55 and 58 to expose the birds to the same condition in order to improve performance. A massed trials training format was used in teaching children diagnosed with autism. Lovass, (1987) demonstrated the effectiveness of a massed trials training format with an intensive intervention that enabled children diagnosed with autism to learn in regular education classrooms. The process of presenting the same discriminative stimulus over and over, typically 10 times in one sitting, facilitated learning. Typically one item in a particular category was introduced and repeated until mastered and then a new item was introduced and mastered before both items were taught together. For example, the color red was introduced first until the student demonstrated a correct response at least 80% of the time and then a new color was introduced and taught until mastery criteria was met. Once the mastery criteria was met, both items were presented together and the student was required to correctly discriminate between both colors. This produced more exposure to a single item without the possible distraction of another item being present. A massed trial design was used to teach children diagnosed with autism spectrum disorder (ASD) in a general education classroom. Jameson, McDonnell, Johnson, Riesen and Polychronis (2007) compared massed practice instruction with embedded instruction. This study used an alternating treatment format to compare the effectiveness of each type of instruction. Each of the students reached mastery level. There were two students that benefited more from the massed trail formant than the embedded formant. One student did not show a significant difference
between each of the formats and one student performed better with the embedded format than the massed trial format. The use of a massed trial design used repetition of the same stimuli to minimize possible distractions of competing stimuli. Additional research would be needed to determine what type of learner would benefit more from a massed trial format.

**Magnitude of Reinforcement**

The results from the DO4 condition with 4 second access to reinforcement were mixed. Previous research is inconsistent when determining magnitude of reinforcement as an effective manipulation to increase behavior. Luman, Van Meel, Oosterlaan, Sergeant, and Geurts (2009) found that there was no statistical significance when corrected responses were followed by a small reward or a larger reward. In their study, children between the ages 8-12 were required to do a matching task with no delay to the reinforcement. Students in the group that received a smaller reinforcement performed at the same level as the group that received a larger reinforcement. However, Nevin and Grosch (1990) found that birds were more accurate when they received a larger reinforcement then when they received a small reinforcer in a delayed matching to sample task.

A DO4 condition with 4 seconds of reinforcement was included to determine if amount of reinforcement affected the differential outcome effect. Birds 55 and 58 did not reach mastery criteria in this condition because of equipment malfunctions. Bird 55 completed only 19 sessions but did show a steady increase in accuracy in the immediate reinforcement color. Bird 55 averaged 81% accuracy during the last five
sessions in the immediate reinforcement color. Bird 55’s accuracy with the delayed reinforcement color was varied. It increased, then decreased then increased again but never reached mastery criteria even with the nonalternating condition. It appeared that the DO2 condition with 2 seconds of reinforcement produced better results than the DO4 condition with 4 seconds of reinforcement. Bird 55 did perform higher with the DO2 condition with 2 seconds than with the DO4 condition with 4 seconds during the first 19 trials. A possible reason could be that the access to 4 seconds of reinforcement caused satiation in the birds and as a result the food pellets were not as reinforcing for the correct behavior.

**Future Research**

The study by Allen (2007) found that delaying the outcome had a beneficial effect because the birds learned the discrimination faster. His results did not produce different levels of performance within a set of colors. Allen’s 2007 results were best represented by bird 63 in the DO2 condition with 2 second access to reinforcement. Bird 63’s best performance was in this condition when mastery was reached after 19 sessions. Bird 63 showed a steady rate of acquisition for both the delay to reinforcement and the immediate reinforcement following a correct response. Bird 63 would often finish a session within 20 minutes making few errors resulting in few correction trials.

In the current study, the use of the delay to the reinforcement created a reinforcer in which one outcome had a higher reinforcing value than the other outcome. Performance under one contingency resulted in immediate reinforcement
and as a result the motivating factor was greater under the stimulus that would produce an immediate reinforcement. For the stimuli that resulted in a delay to the reinforcer, it is possible that the value of the reinforcer decreased and resulted in a lower level of performance. It is possible that a shorter delay would not have resulted in less of a decrease in the value of the reinforcer.

There was a difference between the magnitude of reinforcement and the same outcome condition. The magnitude of reinforcement did not have as much of an effect on accuracy as did the differential outcome condition with 2 seconds of reinforcement. The smaller amount of reinforcement produced better results and reached mastery criteria sooner. It is possible that the larger amount of reinforcement caused the birds to become satiated and resulted in taking longer to reach mastery criteria. Another possibility could have been that the delay to the bigger reinforcer was more aversive than the delay to the smaller reinforcer.

Overall, there was a lot of variability between the birds that could be attributed to experimental conditions or history of reinforcement and as a result, further research should look into the limitations of this study.
REFERENCES
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