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**Positive Reinforcer Identification and Behavioral Training with Goats (*Capra hircus)*

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PSH 399: Behavioral Experiment

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Library Resources Statement: The Drake Memorial Library staff's help was integral to my completion of this paper! I frequently wished to use sources that simply did not exist in full-text versions in databases, and several times wonderful librarians dug through journals on the lower level to find me what I needed. The topic of this paper, behavioral training, is rooted in operant conditioning. Operant conditioning was the focus of this experiment, which is why my paper focuses so heavily on it. Operant conditioning is still used today, but it was the center of publications far before the existence of psychology databases. I wanted to use the original articles psychologists wrote about the technique when it was a new discovery, so I could ground my claim in a long history of well-validated scientific practice. Thankfully, I had access to a wonderful library that has physical copies of journals! One instance, which I still feel a little bit badly about, was a time when I needed a journal article from the 1970s. It was a classic article on operant conditioning, but it just wasn't in my trusty psycARTICLES or ScienceDirect. I couldn't find it, the desk attendant couldn't find it, but a librarian swooped in and assured me they would. Thirty minutes later, they emerged from the lower level, red-faced and flustered, but they had my article! I was amazed. If it had been just me, I would have probably given up. This was a somewhat difficult paper to write due to the age of some of my sources, but I truly appreciate all the help I received in writing it from the desk attendants who helped me place requests, the librarians who found me the correct materials, and the employees at the Raj Madan who kept me supplied with coffee.

Abstract

As opposition to pesticides increases, the agricultural community has shown interest in using animals to control the spread of invasive species. Operant conditioning is a useful way to teach an animal to perform a desired behavior, including but not limited to consumption of an invasive species. For operant conditioning to be successful, a highly preferred reinforcer must be identified. Identification of a highly preferred reinforcer requires the use of preference assessments, which yield conclusive and long-lasting results. The results of a preference assessment can then be tested with a concurrent operant reinforcer assessment, which assesses the effectiveness of the highly preferred item as a reinforcer. This study utilized preference, concurrent operant reinforcer and progressive ratio reinforcement assessments to prepare a goat for successful behavioral training in consuming invasive species.

Keywords: operant conditioning, behavioral training, preference assessment, concurrent operant reinforcer assessment

**Positive Reinforcer Identification and Behavioral Training with Goats (*Capra hircus)*

As more issues come to light regarding the dangers of pesticides in the management of invasive species, researchers have looked to animals, goats specifically, as an environmentally

friendly alternative to pesticides (Silliman et al., 2014). In order for goats to serve as a successful alternative to pesticides, they must first be trained to consume invasive species. This training can be done through the process of operant conditioning.

Psychologists have utilized operant conditioning, changing behavior by changing its consequences (Skinner, 1951) in a variety of animal studies. Some examples are the Vaughan et al. (2014) study using operant conditioning to control urination in calves and Poling et al.'s (2011) study using operant conditioning to train rats to detect land mines. One form of operant conditioning is positive reinforcement. Positive reinforcement of an animal occurs when it performs a desired behavior. The immediate delivery of a positive reinforcer results in an increase in the chances that the animal will perform that behavior again (Cooper et al., 2020). Operant conditioning can be used to teach animals desired behaviors quickly, especially when using a food item as a positive reinforcer (Skinner, 1951). Operant conditioning using a clicker as the secondary reinforcer in conjunction with a food item as a primary reinforcer has been shown to be effective as well (Feng, et al., 2016).

Gillis et al (2012) used a food item and a clicker as primary and secondary reinforcers, respectively. A secondary reinforcer is an item that becomes a reinforcer through repeated pairing with a primary reinforcer. Gillis et al. were able to successfully train squirrel monkeys to perform several different behaviors within 50-70 days using the operant conditioning techniques that Skinner (1951) and Feng et al. (2016) described. A similar study used horses as subjects, and the horses were successfully trained to touch an object with their noses (Williams et al., 2004). This study also used the same operant conditioning technique as in the Gillis et al. (2012) study: a clicker as the secondary reinforcer and a food item (alfalfa) as the primary reinforcer (Williams et al., 2004).

Researchers have also used operant conditioning with goats in past studies. Baldwin (1979) used operant conditioning to train goats to discriminate between shapes using oats as a primary reinforcer. Similarly, Franz et al. (2002) trained goats to discriminate between shapes using water as a reinforcer. A screen with four panels and one switch per panel was placed in the housing of the goats. The goats received a reinforcement of water for choosing the S+ stimulus. The goats also had access to food and water outside of the water being used as a reinforcer (Franz et al., 2002). There were many controls in place to support the study's internal validity. Identical housing was provided to all the subjects, and a trial where the subjects had to choose "correct" shapes from different locations to counteract position bias was conducted (Franz et al., 2002). The subjects learned to distinguish between shapes in conjunction with reinforcement in as little five to six trials across five to six days, suggesting that reinforcement can be quite effective in learning new behaviors.

There is ample evidence that operant conditioning can be successfully used to train animals to perform desired behavior (Vaughan et al., 2015; Poling et al., 2011). This is significant because using goats to control the spread of invasive species relies heavily on operant conditioning. While goats are known for consuming a variety of foods, it was important that the goats were trained to associate the invasive weeds with positive reinforcement. This way, the goat would be more likely to eat the invasive weeds as opposed to any vegetation, such as native plants, it came across.

 To implement a positive reinforcement procedure, a strong positive reinforcer must be identified. There are several methods used to identify positive reinforcers including paired-stimulus preference assessment, concurrent operant reinforcer assessment and progressive ratio reinforcer assessment.

A food item paired-stimulus preference assessment is the process of presenting animals with two food items in randomly arranged pairs during assessment trials. The subject receives the food item that has been selected for consumption (Vicars et al., 2014). The preference assessment has been previously used in a study using dogs as subjects by Vicars et al., (2014). The study found that the food item the dog selected most frequently during the preference assessment was most effective as a reinforcement during behavioral training (Vicars et al., 2014). A study by Martin et al. (2018) using rhesus macaques as subjects utilized a multiple stimulus without-replacement preference assessment (MSWO) to select an appropriate reinforcer for the macaques. An MSWO preference assessment presents several food items to the subject at the same time, then the subject may choose an item. After the item has been chosen, the remaining items are taken away. Then the items the subject has not chosen are presented again until there are no more items left to be chosen (Martin et al., 2018). The MSWO preference assessment identified strong food preferences the macaques held and the reinforcers were useful for an entire year after the MSWO preference assessment was conducted (Martin et al., 2018). This study found that frequent preference assessments were successful in identifying food items that were highly preferred by the subjects (Martin et al., 2018). As shown by the Vicars et al. (2014) and Martin et al. (2018) studies, preference assessments can be useful in selecting an appropriate reinforcer.

The Vicars et al. (2014) study also utilized the concurrent operant reinforcer assessment to select an appropriate reinforcer. A concurrent operant reinforcer assessment is when two or more stimuli are presented and once the subject responds to one stimulus the food item is delivered. The subject can then make continuous selections (Cooper et al., 2020). The concurrent operant reinforcer assessment is used to determine which of the food items the

subject would respond to a stimulus to receive. During the concurrent operant reinforcer assessment in the Vicars et al. (2014) study, the least preferred food item and most preferred food item were paired with either a black or white glove worn on the trainer's hand. The colors of the gloves were counterbalanced across subjects but stayed consistent for each individual subject. The foods designated most and least preferred were determined by the previously conducted paired stimulus preference assessment. The food items were held in the trainer's gloved fist, and the dogs touched their nose to the fist containing the food item they chose as indicated by the glove on the fist. Once the dog touched its nose to the trainer's fist, the food item was dropped into a bowl and the dog was free to consume the item. The results of this study showed that subjects were more willing to engage in the desired behavior, nose-to-fist press, to receive the food item determined to be most preferred by the paired preference assessment. The food item acted as a primary reinforcer for engaging in the desired behavior, and in this study the most preferred food item worked more successfully as a reinforcer than the least preferred food item. As shown by the Vicars et al. (2014) study, the concurrent operant reinforcer assessment can successfully test the results of the paired preference assessment to determine if the highly preferred food item would be successful when being used as a positive reinforcer.

The Vicars et al. (2014) study also used a progressive ratio reinforcer assessment to help in reinforcer selection. A progressive ratio reinforcer assessment is when increasing amounts of a certain behavior by the subject is required to access the item until a breaking point, a lack of responding in the subject, is reached (Cooper et al., 2020). The purpose of conducting a progressive ratio reinforcer assessment is to determine the maximum amount of the desired behavior the subject will perform to receive a food item. During the Vicars et al. (2014) study, the progressive ratio reinforcer assessment was conducted using the most preferred food item for

three trials and the least preferred food item for three trials for a total of six trials. The procedure

was somewhat similar to the concurrent operant reinforcer assessment, as the dogs had to touch

their nose to the trainer's gloved fist, with the color of the glove corresponding to either the least

or most preferred food item, in order to receive the food item. What differed during the

progressive ratio reinforcer assessment was the amount of times the dog had to touch its nose to

the trainer's fist. For the first trial, the dog had to perform the desired behavior once to get the

food item. For the second trial, the dog had to perform the desired behavior twice to get the food

item, etc. The results of the progressive ratio reinforcer assessment supported the results of the

paired preference assessment and the concurrent operant reinforcer assessment: the dog engaged

in the desired behavior more often when the most preferred food item was the reinforcer. This

can be measured by the breaking point, or how many times the subject has performed the desired

behavior before it will stop. For the trials conducted with the most preferred food items, the

average breaking point was two. For trials conducted with the least preferred food item, the

average breaking point was zero. Some dogs refused to engage in the desired behavior to obtain

the least preferred food item. The progressive ratio reinforcer assessment supported the results

found from the paired stimulus preference assessment and the concurrent operant reinforcer

assessment: the most preferred food item is effective when used as a positive reinforcement.

It was hypothesized that the use of a paired stimulus preference assessment would

identify a highly preferred food item that would be successful when used as a positive reinforcer.

It was also hypothesized that the subject had strong preferences for certain food items, making

the identification of a highly preferred food item valuable for use in positive reinforcement. The

usefulness of the highly preferred food item as a reinforcer was to be tested by the conducting of a concurrent operant reinforcer assessment and a progressive ratio reinforcer assessment. The preference assessment would have been successful in identifying a highly preferred food item, while the concurrent operant reinforcer assessment and progressive ratio reinforcer assessment would test the highly preferred food item's usefulness as a reinforcer. This outcome would support results reported by Vicars et al. (2014) and Martin et al. (2018).

Method

Subjects

The subject was one three-year-old female goat (*Capra hircus)* housed at Springdale Farm in Spencerport, New York, United States of America. The subject was pregnant for the duration of the study. The subject is housed with 2-3 other goats and has had regular exposure to humans.

Materials

A large wooden trough with six openings was used in both the preference assessments and experimental trials. Both plastic plates and feeders were placed inside the trough for stability purposes. Black plastic plates were used to hold food stimuli during preference assessments. During later preference assessments and experimental trials, three feeders were used.

The feeders were metal dog food bowls with a colored ball affixed to the outside with Velcro. The colored ball corresponded to the food item inside the feeder: a yellow ball indicated corn cereal, a white ball indicated a goat treat and an orange ball indicated a carrot. The feeders had lids which could be opened and closed using wooden rods that were attached to the lids with strings tied to hooks drilled into the lids. The lids on the feeders had holes in the top where a

PVC pipe fit in for food disbursement. The PVC pipe was affixed to the inside of the feeder using a zip tie.

A red leash that was regularly used by the subject's owners was used to lead the subject into the stall. A small metal S-hook was used to be put into a hole in the wall to hold the subject's leash when needed.

A digital camera mounted on a tripod was placed at the edge of the stall to record all sessions for later coding and analysis. The subject never interacted with the camera.

The food items used in the study were as follows: carrots (cut into half-inch triangles), popcorn, a dried fruit medley (a banana and a raisin presented together), goat treats, individual pieces of Cheerios cereal and individual animal crackers.

Setting

The setting was an empty stall, 3 meters by 2 meters, in the goat barn where the subject was housed in Spencerport, New York. The stall was free from decoration save one window, one clock and two wire feeders.

Research Design

A descriptive design using an assessment method was used for this study. The subject was chosen based on the length of time she would be available for use in the study.

Controls

Food items were kept consistent in size and color throughout the study. Trials were always conducted in the same stall. The subject was always handled by the same researcher.

Trials were also conducted at approximately the same time each day, within a window of 3:30 p.m.-5:30 p.m. each day.

Procedure

There were three difference assessment procedures implemented: paired stimulus preference assessment, concurrent operant reinforcer assessment, and progressive ratio reinforcer assessment.

Paired Stimulus Preference Assessment

A paired stimulus preference assessment was conducted over one month. A trial-based research design was used for the paired preference assessments. The food items presented were carrots (cut into half-inch triangles), popcorn, a dried fruit medley (a dried banana and a dried raisin presented together), goat treats, individual pieces of Cheerios cereal and individual animal crackers. All possible pairs were randomly presented twice with counterbalancing across trials to avoid any side preferences. Each session lasted thirty minutes with two food items being compared during each trial. Two black plastic plates were placed at either end of the wooden trough. The food items were placed onto plates in a preset, counterbalanced order. The only human in the stall during trials was the researcher who handled the subject. Food items were handed to the researcher by an assistant who stood outside of the stall. The subject would be led to the middle of the trough, held there for three seconds, then allowed to choose which food item to consume. If the subject took longer than five seconds to place a food item into its mouth, the trial was restarted.

A visual analysis of the data was conducted and the first set of paired stimulus preference assessment sessions were terminated after eleven sessions because the subject's preference for

carrots and least preferred item of goat treats was established as being consistent across ten days. Two three stimuli paired preference assessments were then conducted using the same procedure as the paired stimulus preference assessment. The three stimuli paired preference assessments were done to confirm that carrots were the most preferred and not a neutral food item. The first three stimuli paired preference assessment presented carrots, goat treats and grain as stimuli. The second three stimuli paired preference assessment presented carrots, honeycomb cereal and corn cereal as stimuli.

Concurrent Operant Reinforcer Assessment

Next, a concurrent operant reinforcer assessment was conducted, to further validate the results of the preference assessment. In other terms, the purpose was to see if the food item identified as highly preferred as a result of the preference assessment would serve as a reinforcer by using the food item identified as highly preferred as a positive reinforcement for engaging in desired behavior.

The wooden trough and the three feeders were used in this assessment. Two of the feeders were placed in the openings on opposite ends of the trough and one feeder was placed directly in the middle of the feeder. Two assistants stood on opposite sides of the feeder. One assistant was responsible for placing food into two feeders and operating the lid of one feeder, while the other assistant was responsible for operating two feeders and placing food into one feeder. The food items and corresponding feeders were rearranged every trial in a preset, randomized and counterbalanced order. The subject was lead to the middle of the trough by the researcher, held there for three seconds, then was allowed to choose its food item by pressing her nose to the ball on the outside of the feeder. After the ball had been in contact with the subject's nose, the lid on the feeder was opened by an assistant for the subject to obtain the food. Once the

subject had obtained the food and withdrawn its head, the lid was closed immediately by the assistant.

Progressive Ratio Reinforcer Assessment

A progressive ratio reinforcer assessment was conducted to support the findings of the concurrent operant preference assessment: that carrots were effective when used as a positive reinforcer.

The wooden trough and one feeder per trial were used during this assessment. The order in which the feeders were presented to the subject was randomized. The feeder was placed in the center compartment of the wooden trough. Two assistants stood on either side of the feeder; one to operate the lid and one to dispense the food item. The subject was led to the feeder and was then allowed to press its nose to the ball to receive the food item. For the first trial, the subject had to engage in the desired behavior, nose-to-ball press once, for the second trial, twice, etc. If the subject walked more than a half meter away from the feeder or the subject did not engage in the desired behavior for twenty seconds, a new trial with a different feeder was started.

Results

Generally, carrots were the most preferred food item among all food items presented to the subject. This was true for all four types of assessments that were conducted: paired stimulus

preference assessment, three stimuli paired preference assessment, concurrent operant reinforcer assessment and progressive ratio reinforcer assessment.

Of the items presented to the subject during the paired stimulus preference assessment across ten sessions, carrots were selected the most often, with an $M = 7.1$. Animal crackers were second preferred, with an $M = 5.1$. Fruit medley followed with an $M = 5.0$. Cereal had an $M = 4.3$, popcorn had an $M = 3.7$ and goat treats had an $M = 3.6$.

For the three stimuli paired preference assessment, carrots were the most preferred, with an $M = 2.7$ across nine sessions. Goat treats had an $M = 1.7$ and grain had an $M = 1.4$

For the concurrent operant reinforcer assessment, carrots were the most preferred item, with an $M = 5.0$ across ten sessions. Corn cereal had an $M = 3.0$ and goat treats had an $M = 1.9$.

For the progressive ratio reinforcer assessment, carrots were the most preferred item with an average breaking point of $M = 6.25$ across four sessions. Goat treats had an average breaking point of $M = 3.25$ and corn cereal had an average breaking point of $M = 3.25$.

The values from the paired stimuli preference assessment produced a statistically significant chi-square value of 17.33. The chi-square value of 17.33 was obtained by using the average numbers at which carrots, goat treats and corn cereal were selected by the subject during the paired stimulus preference assessment and using the data in a chi-square analysis. The resulting chi-square value of the analysis, 17.33, has an exact p value of $p = 0.004$. The $p = 0.004$ for the chi-square value of 17.33 is significantly smaller than the minimum chi-square value required to determine a statistically significant hypothesis (11.07 with a value of $p = 0.05$). Therefore, the null hypothesis that the subject had no preference can be rejected and the alternate hypothesis that the subject had a strong preference for carrots accepted.

Discussion

It was hypothesized that the use of a paired stimulus preference assessment would identify a highly preferred food item that would be successful when used as a positive reinforcer. It was also hypothesized that the subject had strong preferences for certain food items, making the identification of a highly preferred food item valuable for use in positive reinforcement. The usefulness of the highly preferred food item as a reinforcer was to be tested by the conducting of a concurrent operant reinforcer assessment and a progressive ratio reinforcer assessment. While the full hypothesis was not able to be fully tested during the Spring 2020 semester due to the implications of COVID-19, the preliminary results support the hypothesis. The paired stimulus preference assessment and the three stimuli paired preference assessment successfully identified a highly preferred food item: carrots. The concurrent operant reinforcer assessment utilized a secondary reinforcer (colored ball) followed by a primary reinforcer (food item). The subject was willing to engage with the secondary reinforcer by touching its nose to the ball to subsequently receive the food item. The subject engaged in the desired behavior (nose-to-ball touch) more when carrots were the food item serving as the primary reinforcer and less when other food items were available (e.g., corn cereal), suggesting that the preference assessments were successful at determining a highly preferred food item that could serve as a reinforcer. The progressive ratio reinforcer assessment supported the findings of the concurrent operant reinforcer assessment: that carrots were an effective positive reinforcer. The subject had a much higher average breaking point when carrots were used as a positive reinforcer than any other food item.

Since the subject engaged in desired behavior to obtain a highly preferred primary reinforcer, it is reasonable to suggest that had the study been permitted to progress the behavioral training to consume invasive species would have been successful. However, the preliminary

results reported in this study do support the work of previously mentioned researchers. The

success of the preference assessments in identifying highly preferred food items support the

work of Vicars et al. (2014) who also used preference assessments to determine an appropriate

food item to use in behavioral training using dogs as subjects. The results of the preference

assessments also support the work of Martin et al. (2018) who used an MSWO preference

assessment to determine food preferences in macaques. The results of the concurrent operant

reinforcer assessment and progressive ratio reinforcer assessment also supported the Vicars et al.

(2014) study. The Vicars et al. (2014) study determined that the item identified as highly

preferred during preference assessments was most likely to be chosen most often during the

concurrent operant reinforcer assessment and have a higher average breaking point during the

progressive ratio reinforcer assessment, which is exactly what happened in this study.

There are some limitations of this study that must be addressed. The subject was pregnant

for the duration of the study and was moved to a different stall roughly halfway through the

study. The subject's pregnancy may have affected the strength of her preferences and her

relocation may have disoriented her; both events may have had an impact on the results of the

assessments. The area where the assessments were conducted was changed in its layout a few

times, i.e., some cages were moved from one wall to the other and hay was cleared off the floor

for some trials. The change in layout on these occasions made the subject anxious, which

negatively affected her willingness to engage in the desired behavior. These events may have

affected the consistency of the results of the assessments.

This study clearly demonstrates the usefulness of the preference assessment. It is because

of the preference assessments that a highly preferred food item was identified and showed

indications of serving as a successful primary reinforcer during the concurrent operant reinforcer

assessment and progressive ratio reinforcer assessment. If the subject used in this study were ever to be trained using operant conditioning, the results of the paired stimulus preference assessment, concurrent operant reinforcer assessment and progressive ratio reinforcer assessment would provide valuable information concerning effective reinforcers.

The paired stimulus preference assessment is the first step in identifying an appropriate reinforcer, then the concurrent operant reinforcer assessment and progressive ratio reinforcer assessment test the highly preferred item's usefulness as a reinforcer. The paired stimulus preference assessment is useful in determining the subject's most basic preferences. The concurrent operant reinforcer assessment tests the subject's willingness to perform a desired behavior for the preferred item. The progressive ratio reinforcer assessment tests the subject's willingness to work for the preferred item, if successful, confirming the results of the previous two assessments. While each assessment is certainly useful by itself, the results of all three can provide useful information to anyone seeking to use operant conditioning.

Future research should examine new ways of utilizing the preference assessment, even perhaps examining its efficiency. While the results of a preference assessment are undoubtably useful, preference assessments are, unfortunately, time-consuming. Perhaps if there was a more time-efficient way to conduct preference assessments, more researchers would be able to utilize them in their studies. Seeing as preference assessments yield such useful results, it is only logical to increase their accessibility through further innovation.

Future research should test to find if there is an ideal number of trials to run with a concurrent operant reinforcer assessment and progressive ratio reinforcer assessment. Perhaps it is not necessary to conduct all ten or twenty trials during an assessment if a majority can be gained with five trials. While the results may not be generalizable to all species, it could certainly

be helpful to have an ideal number of trials to run for a commonly used lab animal, such as the

rat. Research in this area could help to avoid fatigue in experimental subjects, which could help

avoid potential confounds in research.

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Figure 1

*Line graph depicting the subject's selection of food items across ten sessions during the paired
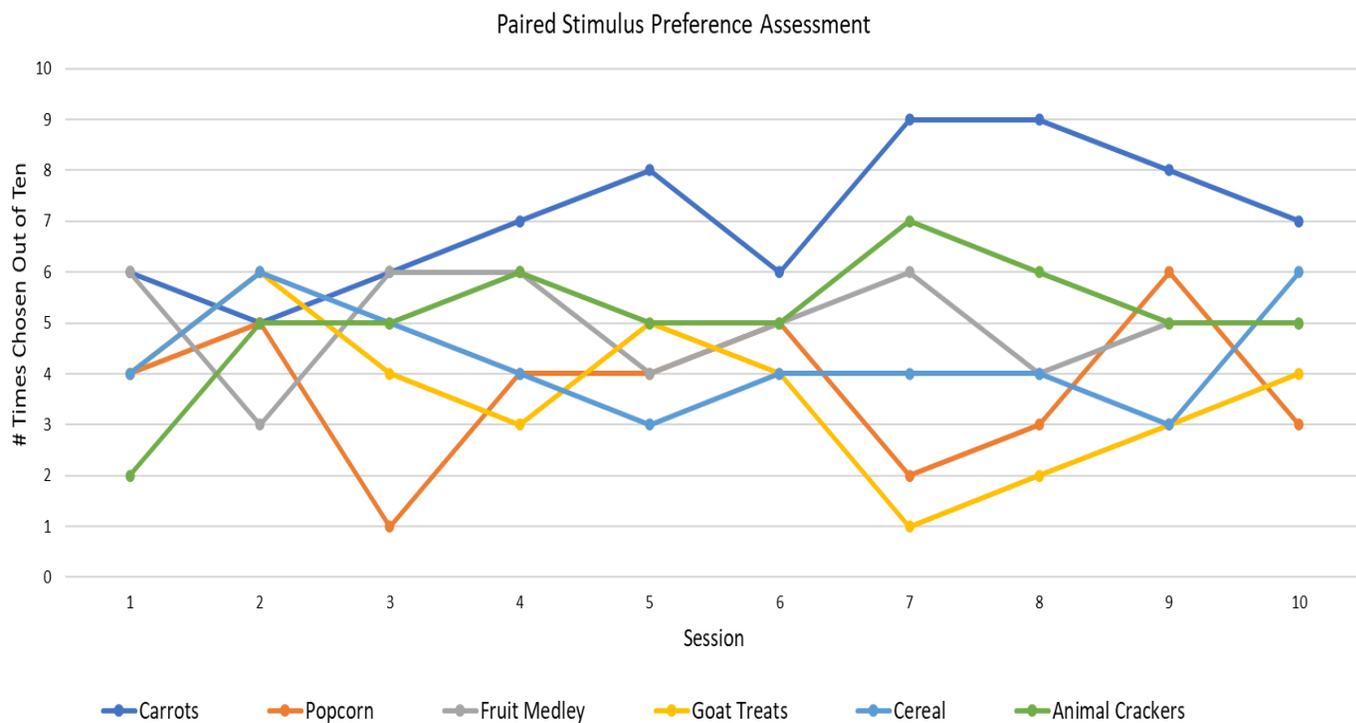stimulus preference assessment*

Figure 2

Line graph depicting the percentage each food item was selected across ten sessions during the
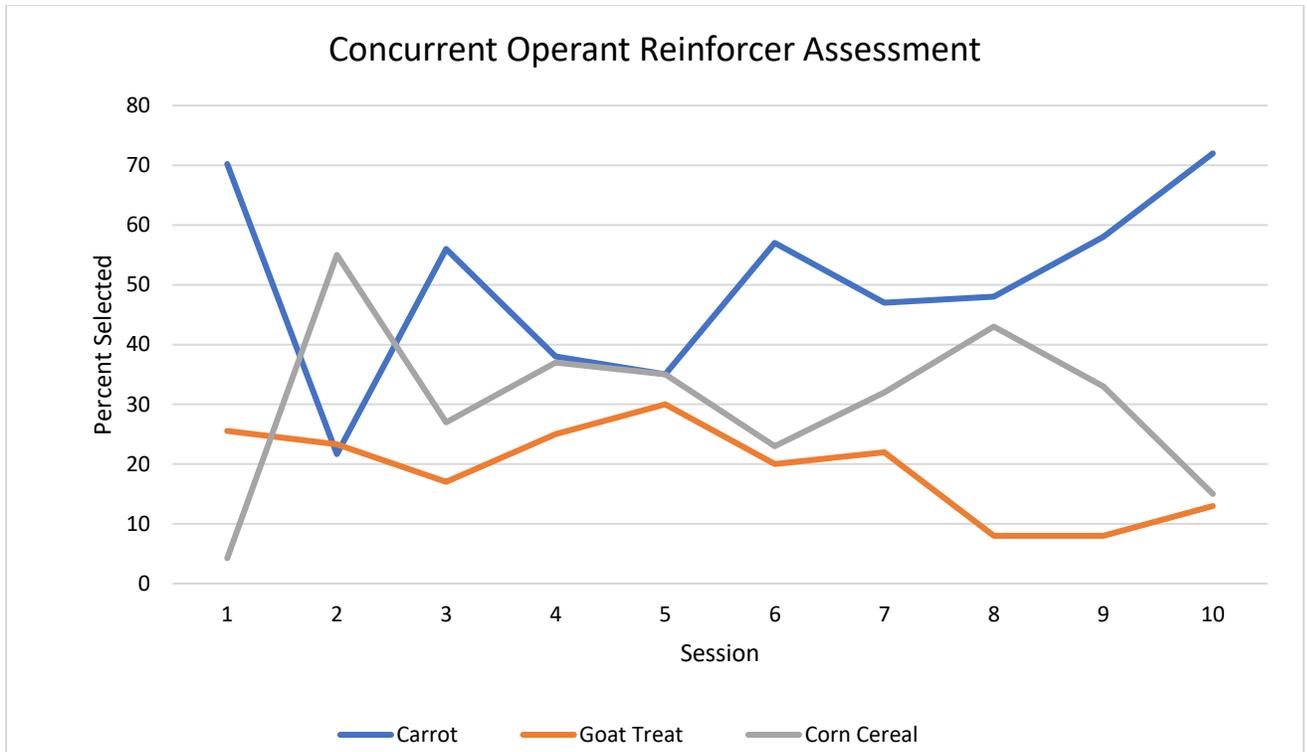
concurrent operant reinforcer assessment

Figure 3

Line graph depicting the breaking points during the progressive ratio reinforcer assessment

across four sessions

Progressive Ratio Reinforcer Assessment