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The Effects of Stimulus Pairings on Surrogate Conditioned Motivation Operations

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The Effects of Stimulus Pairings on Surrogate Conditioned Motivation Operations

by

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Abstract

Research on the surrogate conditioned motivating operation (CMO-S) is sparce and typically produces unsuccessful outcomes. These failures suggest this concept may not be as simple as it is defined, and researchers must explore different strategies to produce the effect; in this case, without contriving for a motivating operation. Four participants recruited from a midwestern university were assigned to color or sound changing video games, in which certain colors or sounds were randomly assigned and then paired during conditioning sessions with specific edibles. Data were collected during probe sessions at the beginning, middle, and end of the study by recording the exact time an edible was selected; conditional probability analyses were then used to assess if participant responding began to outperform chance responding and thus suggest a CMO-S effect was developing. Data were analyzed on general and individual responding, meaning one analysis assessed any edible choice during any stimulus change, whereas additional analyses assessed a specific edible choice during its assigned intervals. Results show that a general effect likely occurred for two participants, one of which also showed a potential specific CMO-S effect. The two participants that failed to show an effect spur discussion on the role of preparedness in CMO-S designs; effects were demonstrated when edibles were paired with visual changes, but not when paired with auditory changes. Based on these results, more research is warranted to understand and explore how to effectively create the CMO-S effect and how it can be used to promote adaptive behavior change.

Keywords: surrogate conditioned motivating operation (CMO-S), motivating operations, conditional probability analyses

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Chapter 1: Introduction

The surrogate conditioned motivating operation (CMO-S) is a seemingly simple concept, yet successful demonstrations and replications are minimal in both the applied and basic literatures (e.g., Adelinis et al., 1997; Calvin et al., 1953; Lanovaz et al., 2014; McDiffett, 2019; McGill, 1999; Ormandy, 2018). Understanding the CMO-S concept is a requirement for practitioners pursuing their behavior analyst board certification under task list item B-12 (Behavior Analyst Certification Board, 2017), yet the definition of its key components (i.e., motivating operations) is not agreed upon (see Edwards et al., 2019; Langthorne & McGill, 2009; Laraway & Snycerski, 2019; Lotfizadeh et al., 2012; Poling et al., 2020). A common definition of this concept declares that a CMO-S effect will occur when an unconditioned motivating operation (UMO) is paired with a neutral stimulus, resulting in a relation where the paired stimulus will influence behavior similarly or identically to the way the UMO would (Ormandy, 2018). Essentially the paired stimulus will function as the UMO, even in the UMO's absence. One example used to explain this concept is eating lunch simply because it is noon[1]. If this is a true example of a CMO-S, this behavior occurs because, in the past, noon had been paired with the UMO of food deprivation; now, when noon is presented, despite no UMO of food deprivation, one will still eat or engage in food acquiring behavior.

A motivating operation (MO) occurs when there is a momentary increase (establishing operation or EO) or decrease (abolishing operation or AO) in the value of a reinforcer, which will therefore increase or decrease the frequency of behavior (Langthorne & McGill, 2009). Effects of the MO are measured in two ways; through value-altering effects and behavior-

[1] All things being equal—consider that this does not count restrictions like a lunch break being allowed only at noon

altering effects. Value-altering effects are determined by rate of acquisition, meaning that one will learn faster when an MO is in place and the reinforcer is available (Malott, 2007). For example, if water were the reinforcer during skill acquisition sessions, the individual would have more independent correct responses if they had just exercised or consumed salty foods, given that both serve as EOs for water consumption. Thus, the value of water is increased and therefore so is the value of engaging in behaviors that will provide that reinforcer. The second factor of an MO is the behavior-altering effect, which is determined by a change in the frequency of a behavior historically related to the reinforcer; behaviors that produced that reinforcer in the past will occur more often than behaviors that did not when the EO is present. Continuing with the example of water as a reinforcer, one will be more likely to walk to a water fountain, as opposed to asking a friend for water, if in the past, the water fountain produced water and the friend did not.

The CMO-S, too, is evaluated based on its ability to produce behavior-altering and value-altering effects, given that the definition requires an MO to be present for pairing purposes. When analyzing failed demonstrations or replications, it is possible that their failure is less dependent on the faults of paired stimuli or competing stimuli, but rather the MO occurred variably or not at all, and thus limited true pairings could occur. Without distinctly testing for behavior and value-altering effects to prove the MO is present in each pairing session, one cannot rule out this confound. However, it is currently unclear how researchers could effectively test for these relations during pairing sessions without disrupting the procedure.

Furthermore, MOs are, by nature, transient and their effects on behavior and the value of its reinforcers are only relevant to the present moment, rather than as a means to predict future responding (Ormandy, 2018). Further complicating analyses is the range of responding that can often satisfy the MO, and thus it might be beneficial to consider response classes over individual responses unless the study permits finer-grained analyses. For example, when one is cold, there are myriad behaviors that produce warmth, such as putting on a sweater, turning up the thermostat, or closing a window. In this example, then, predicting that the response class "getting warm" will increase in probability is more beneficial than trying to predict "putting on the green sweater you got for the holidays back in 2014". Care must also be taken in selecting response classes for analysis, as some responding can go undetected, such as with "getting warm" through metabolic processes unseen by the researcher. The aforementioned limitations draw question to how, or if, researchers can effectively program for a CMO-S relation by artificially arranging MOs.

Basic Literature

The basic experimental literature contains few attempts at creating the CMO-S effect, with most attempts and replications failing or producing unconvincing results (e.g., see McDiffett, 2019; Ormandy, 2018). As an example of CMO-S work conducted prior to its formal conceptualization, Calvin et al. (1953) contrived the UMO of food deprivation in rats paired with the NS of a black and white striped box. To establish an EO for food consumption, some rats were food deprived for 22 hours, whereas a comparison group was food deprived for only an hour, before all rats entered the box. This pairing procedure occurred each day for 24 days before test sessions began. During these sessions both groups of rats were deprived of food for 12 hours before being placed in the striped box; therefore, the UMO of food deprivation should have been equal for both groups at the time of the test session. Food was introduced as they entered the box and researchers measured total food consumption at the 5- and 15-minute mark of each test session. Results found food consumption was higher for the group of rats who experienced pairing at 22 hours of deprivation, despite the UMO of food deprivation during test sessions being equal among all rats, thus suggesting food consumption should have been equal. Therefore, the researchers concluded the striped box no longer served a neutral function, but now served as a surrogate for food deprivation, thus increasing the effectiveness of food reinforcement in its presence.

While Calvin et al. (1953) demonstrated successful results, Siegel and Macdonnell (1954) attempted to replicate this study, while making a few adjustments (e.g., adding a systematic approach to measuring the rats' weight and thus potential deprivation levels), but were unable to produce a successful replication. Given the lack of other successful demonstrations and replications in the literature, and thus lack of empirical base for this concept, it is unclear whether the changes the researchers made to the original study were the downfall of this replication or if there is a bigger issue at hand. While it remains unclear why this trend of failures is occurring, two possibilities are apparent. First, the CMO-S effect might not exist. Second, the CMO-S might be difficult to produce, and therefore care must be taken in setting up experimental preparations and measuring appropriate dependent variables.

When designing a study to establish the CMO-S effect, several processes must be established. First, the researcher must identify a neutral stimulus and a UMO or MO (U/MO) with which to pair it. While there are no criteria for what this stimulus can or cannot be topographically, it must serve a neutral function with respect to the U/MO. Therefore, testing must occur prior to pairing sessions to ensure that the presence of the chosen stimulus does not reliably produce or eliminate particular behaviors when compared to its absence.

There have been some recommendations for what types of U/MOs to include or avoid when working with certain populations. For example, for some species food deprivation or satiation might take longer periods to establish which could make them difficult to work with (Ormandy, 2018), particularly when compared to other concerns like stereotypy or temperature changes (McGill, 1999; Michael, 1993). Therefore, it might be best to avoid these slow changing U/MOs as they are more difficult to control and thus could disrupt the pairing process. Consider also the different digestive processes of the animals used in experimental studies. For example, pigeons can store food, rather than immediately digesting it, which makes establishing food deprivation more difficult to control (McDiffett, 2019). Similarly, each human has different metabolic processes and thus two individuals can consume the same amount of food, yet one will be full, and one will not.

Once a U/MO and neutral stimulus have been identified, pairing procedures can begin. When the U/MO is in effect, the neutral stimulus (NS) will be introduced. Due to limited successful demonstrations, it is unclear how the pairing procedure between the U/MO and NS should be arranged. For example, one study attempted to pair the UMO of heat with the NS of a solid red light (Ormandy, 2018). During pairing sessions, the light was turned on the moment the participant entered the heated room. This process contrasts the methods used by Lanovaz et al. (2014) in which they paired the UMO of stereotypy with the NS of colored poster boards after eight minutes passed of a ten-minute session, given that they hypothesized the UMO would be stronger towards the end of the session. Given that Lanovaz et al. (2014) had successful results, whereas Ormandy (2018) did not, one could conclude that introducing the NS later in the session, or when the UMO is considered to be most potent, may be necessary to ensure accurate pairings. Other considerations, such as time between and number of pairings, also lack empirical base given lack of successful demonstrations, and thus there remain no effective guidelines for these processes.

The pairing process, whatever it may look like, will continue until the relation is established, which is assessed through test probes. These probes present the NS in the absence of the UMO and assess whether behaviors related to the UMO are produced. For example, if a blue light was the NS paired with the UMO of food deprivation, and food was made available, after pairing sessions occurred, the researcher would present the blue light when the participant was not food deprived (but perhaps not satiated) to see if they would engage in the same (or some) consumption behaviors they would during pairing sessions. If pairing was successful, such that more consumption occurred in test probes than in pre-pairing sessions, the NS would now be considered a CMO-S.

Just as there are no guidelines for pairing procedures, there are no guidelines for test probe procedures. That is, there are no criteria regarding how many test probes must occur, nor what data these probes must provide, before a researcher can conclude success or failure. The lack of guidelines is a concern with the CMO-S; while researchers and practitioners can provide its definition, they cannot reliably create it, test for it, or use it. Consider, for example, what would happen if probing occurred too frequently: a procedure that would otherwise result in a CMO-S would be sullied by a respondent-extinction-like preparation or a pre-exposure-like condition in which the NS is presented with no U/MO too often.

Applied Literature

The applied literature on the CMO-S is limited, given that most mentions of the CMO-S effect occur in the discussion section of articles as a possible explanation for results, rather than as the purpose of the study (see, e.g., Adelinis et al., 1997; McGill, 1999). Only a few studies have set out to demonstrate the CMO-S effect, one of which found success (Lanovaz et al., 2014). In this study, stimuli that were known to serve as EOs for stereotypic behaviors (e.g., music player) were paired with an NS (i.e., black and white poster boards) to assess if stereotypic behaviors would increase in the presence of the posterboards after pairing sessions. These are precisely the results they found and thus their work suggests that the CMO-S might have clinical merit; if behavior can be consistently altered by the presence of any stimuli, clinicians could use these stimuli to act as EOs during appropriate times and AO during inappropriate times. For example, for clients that engage in stereotypy that interfere with academic or daily living activities, clinicians could create a surrogate conditioned establishing operation (CEO-S) to evoke those stereotypic behaviors during free times and potentially produce a satiation effect; alternatively, they could create a surrogate conditioned abolishing operation (CAO-S) for these behaviors during work times. Both these strategies could increase learning opportunities for the client and provide clinicians with a tool to encourage stereotypic behaviors at appropriate times, rather than attempting to extinguish the behavior entirely. While this method has potential merit, more work is needed before this concept can be considered against other best practices.

Purpose

Much of the confusion of the CMO-S concept might be owed to the lack of clarity over essential conditions. For example, in the quintessential CMO-S example, a worker’s lunch break occurs at noon daily, about the time one is maximally food deprived prior to eating; thus, 12:00 and eating are paired, and 12:00 begins to assume the role of food deprivation (the UMO). The pairing of 12:00 and eating eventually gives rise to operant responding (value-altering effect) related to eating. However, as has been explored elsewhere, short-term or small-scale food deprivation might not be enough to evoke responding with respect to eating, and indeed eating often occurs in the absence of food deprivation (e.g., see Skinner, 1953, Chapter 9). From this, we might question the necessary role of UMOs in the development of a CMO-S effect, and if instead any response related to any MO might lead to the same outcome, as in the example above no UMO can be guaranteed, but only implied.

To test the assumption that the U/MO might not need to be present, a study could be conducted in which probes provide free operant access to some U/MO-related stimulus (e.g., food) that has been paired with some stimulus event (e.g., sound) when no programmed U/MO is present. As a CMO-S, the sound stimulus' sole function should be to alter the value of the food, not signal its differential availability, and therefore the sound should not function as a discriminative stimulus. Additionally, as it is a free operant procedure, free access to the reinforcer and any response resulting in the reinforcer must not be blocked in any way, which will permit a conditional probability analysis. The test of a CMO-S effect would come in two ways. First, if the probability of overall food consumption is higher in the presence, but not the absence of sound stimuli after (and only after) pairing, a moderate case for a CMO-S effect can be made. Second, if multiple sound stimuli are individually paired with certain edibles and other sounds paired with no edibles are programmed as control sounds, then a strong argument for a

CMO-S effect can be made if the results of the analyses show an increased probability of specific edible consumption when its paired stimuli is presented.

A working model of this study exists in partial form in episode 16 of season 3 of The Office (Kalling & Einhorn, 2007). In this episode, Jim Halpert offers his desk-mate Dwight an Altoid immediately following his computer emitting its reboot sound. Throughout the scene, these pairings consistently occur, until an instance rises in which Jim's computer emits the reboot sound, yet Jim does not offer Dwight an Altoid. Instead, Jim responds to Dwight's outstretched hand with confusion, in which Dwight responds his mouth suddenly had a bad taste. Two outcomes of Jim's efforts are important to the present study. First, the sound stimulus produced from restarting the computer likely served, or functioned, more like a discriminative stimulus signaling the differential availability of reinforcement. Consider what would happen if Dwight held out his hand toward Jim in the absence of the computer restarting; the probability of receiving a mint would be lower. Second, any perceived CMO-S effect is likely best represented by Dwight's reaction to not receiving the mint on the final presentation of the sound stimulus in which Dwight comments on how his mouth suddenly tastes quite bad—perhaps it is here where the value of the mint is established.

Recognizing that this scene from The Office was written as a bit of humor, with no formal training in behavior analysis nor a focus on exploring refinement of the CMO-S effect, we can turn to it only as inspiration and improve upon it for research purposes. To that end, the following study provided participants with an array of edibles, some of which were paired with specific sound or color changing stimuli on a random schedule while they were engaged in a computer task. No U/MO was contrived during these sessions and given that no response was required to receive an edible due to their random time-based delivery being independent of task completion or accuracy, edibles could not serve as discriminative stimuli. Test probes were introduced to determine whether a change in responding had occurred, suggesting a CMO-S effect occurred. The purpose, therefore, was to test if, like Dwight, no U/MO need necessarily be present for a CMO-S effect to be established and thus inform what steps the field should take to clarify this concept's role in behavior analysis.

Chapter 2: Method

Participants

Four undergraduate students were recruited from a mid-sized Midwestern university. To participate in this study, students had to be willing and able to consume a variety of edibles and could not have any interfering sensory impairments (e.g., color-blindness). No compensation was provided for their participation; however, each participant did receive course credit in their undergraduate class for participating in this research.

Setting and Materials

All sessions for this study took place in an approximate 9'x19.5' office, with the participant seated at a desk facing a blank wall and with a computer monitor in front of them (see Appendix A for diagram). The primary researcher was present for all sessions and sat at a desk behind the participants to collect data during probe sessions and deliver edibles during conditioning sessions. Each session was also recorded by a hidden camera located on top of a cabinet behind the participant's desk.

Materials included a computer, computer monitor, computer mouse, keyboard, video camera, three types of similar sized edible for each participant (i.e., E1, E2, E3), plates to store edibles, water bottles, a flashdrive, and a session checklist (see Appendix B and Appendix C). There were also six PsychoPy3 computer programmed games, referred to as G1-S, G2-S, G3-S, G1-C, G2-C, G3-C. To clarify, E stands for edible, G stands for game, S stands for sound, and C stands for color, such that E1 refers to edible 1, G1-S refers to Game 1 for sound sessions, G1-C refers to Game 1 for color sessions, C1 refers to color 1, P1 refers to participant 1, and so on. Each individual game was programmed to present either three supplemental sounds (i.e., S1, S2, S3) or three alternative colors (i.e., C1, C2, C3) for fifteen seconds at a time, four times each, throughout the fifteen minutes.

PsychoPy3 Game Details

The system used to create these games was PsychoPy3 (Peirce et al., 2019). During the game, participants were presented with a screen depicting their total score earned so far at the top center of the screen and a white circle that moved around the screen each time it was clicked. Clicks were worth one point during intervals with the default color/sound, whereas clicks were worth 3, 4, or 5 points during C1/S1, C2/S2, or C3/S3 intervals, respectively. This element was added to distract participants from the true meaning of the stimulus change by providing a ‘reasoning’ for such changes.

For sound games (i.e., G1-S, G2-S, and G3-S), the screen remained grey the entire fifteen minutes, whereas the audio changed throughout. For a majority of the session, a repetitious instrumental soundtrack (i.e., default sound) played; when sound changes occurred, the respective fifteen-second supplemental sound clip would play overtop of this soundtrack. For example, one supplemental sound was a chainsaw; this chainsaw sound played overtop of the default sound, such that the default sound was barely audible.

Color games had no programmed audio (i.e., the game itself was silent); rather, the screen remained grey (i.e., default color) until an alternative color was presented. Alternative colors were assigned as follows: C1 was green, C2 was blue, and C3 was orange.

A random number generator was used to assign the timestamped location of each stimulus change by having the generator choose twelve numbers between 15 and 885 (i.e., 900 seconds are in 15 minutes, but stimuli could not be presented in the first or last 15 seconds). This process was also used to determine the times where the control edible (i.e., E3) was delivered. As a reminder, C/S3 was a control and was never paired with an edible during conditioning sessions. Similarly, E3 was a control and was presented four times throughout each conditioning session in the absence of any color/sound change.

Each stimulus change (i.e., change from an interval with the default color/sound to an interval with the alternative/supplemental color/sound) was separated by at least fifteen seconds from another, and no stimulus change occurred in the first or last fifteen seconds of the game; this was to ensure the researcher could accurately deliver instructions and edibles and to avoid two sounds/colors from being presented too close together that it interfered with responding (e.g., AOs for edible consumption could be created due to habituation effects). Timestamps were the same for color and sound session to serve as a control; meaning that all participants would experience stimulus changes at the same time of the game, regardless of if their game had alternative color intervals or supplemental sound intervals. See Appendix D for a copy of each video's stimulus change/E3 assignments.

It is important to mention that the researcher conducted calibration tests with each of the six games to verify that stimuli changes occurred at the exact time they were programmed to. Because of this calibration, there was no need to take data on when each stimulus change occurred during any sessions with participants as they were programmed and thus there was no room for human integrity errors.

Design

This study used a multiple probe design with conditioning sessions occurring between probes. The first probe was used to assess for the expected CMO-S effect prior to conditioning and to provide a comparison measure for future probes (i.e., baseline responding prior to conditioning). Two additional probes were conducted: one after three conditioning sessions and one after four additional conditioning sessions. This process was used to document any changes in responding to assess if increased conditioning sessions influenced the development of the CMO-S effect. Due to time limitations, a reversal was not conducted.

Procedure

Participant Screening

Each participant conducted a pre-assessment consisting of three preference assessments of edible items (see Appendix E). For three different classes of edibles, participants were provided with a list twenty edibles. They divided these edibles into two categories: those they would eat and those they would not. From the "would eat" pile, participants sorted the remaining items into three options. The first and third options, "Most preferred" and "Least preferred" had room for two items each. The remaining items were put in a fourth column and ranked from most to least preferred. So long as at least three items were placed in this fourth column for one of the edible classes, the participant could continue with the study. When the participant had completed all three preference assessments, the researcher reviewed the results to determine which edible class would be used for that participant. In the chance that a participant had more than one edible class with enough edibles listed in the remaining column, the researcher used a random generator to select which class would be used. For example, P2 had enough edibles in the remaining column for all three preference assessments, so a randomizer was used to select the edible type, whereas P1 only had one preference assessment with enough edibles in the remaining column, so no randomizer was needed.

The edible assessment also included questions pertaining allergies and food restrictions to ensure participants were not consuming hazardous items and that sessions were occurring outside of any fasting periods that would inhibit food consumption. After passing the screening phase, participants completed consent forms, and were briefed on the study's parameters (i.e., playing a computer, some sessions of which will have food available; see also Appendix B and Appendix C for session instructions).

Participant Assignments

The three items determined by the preference assessment were then randomly assigned as E1, E2, and E3 for each participant (see Appendix F). These items were chosen for the study given that they should be the most neutral among the presented options and thus were least likely to severely disrupt or impair responding due to preference. There were two possible stimulus-pairing arrangements for both color changing and sound changing groups: Grouping 1 (C/S1-E1, C/S2-E2, C/S3-Control, E3-Control) or Grouping 2 (C/S1-E2, C/S2-E1, C/S3-Control, E3-Control). Participants were assigned their grouping in the order they passed screening, such that the first identified participant was Participant 1 (P1), and so on. The same method was used to assign participants to either sound or color changing sessions (see Appendix G).

The same game number was used for all participants for their respective session number to serve as a control (e.g., all participants played Game 2 for their first probe session and Game 1 for their first conditioning session). The order of the three videos was assigned to each session using a random number generator (see Appendix H).

General Procedure

Participants were scheduled to complete sessions in a specific order, consisting of sessions 1, 5, and 10 being probe sessions and sessions 2-4 and 6-9 being conditioning sessions. Participants had no restrictions on their food or water consumption prior to sessions and each session lasted about 20 minutes. During each session, the primary researcher was available to present instructions, collect data, and/or deliver edibles. Prior to sessions, the researcher used a checklist to ensure the computer was set correctly: the computer was turned on, PsychoPy3 was open in full screen and set to the starting page for the correct game, the mouse was connected and working, and the computer was set to the correct volume. The researcher also ensured that the rest of the room was prepared accordingly (e.g., lights were on, door was closed, other computers and devices were turned off, edibles were present during free operant sessions).

Probes

During probe sessions, participants were sat at the computer with the prescribed game ready to play. They had access to water, their computer mouse, and three plates of edibles. To keep the number of edibles consistent with conditioning sessions, twelve edibles (i.e., four of each type) were provided separately on three small plates beneath the participant’s computer screen, ordered E1, E2, and E3 for all probe sessions. The researcher presented the instruction listed on the procedural integrity checklist but did not provide any other instructions or prompts throughout the session.

During these sessions, the researcher watched from the live video footage of the participant and recorded when and what edibles were chosen. Choice was defined as any part of the participant's hand making contact with an edible item, followed by the edible's removal from the plate (see Appendix I to reference the data sheet).

Conditioning

During conditioning sessions, participants were sat at the computer with the prescribed game ready to play. They had access to water and their computer mouse. The researcher presented the instruction listed on the procedural integrity checklist but did not provide any other instructions or prompts throughout the session. If the game malfunctioned during the fifteen-minute session (e.g., the dot they must click on to gain points disappeared), the researcher recorded the time, and instructed the participant to take an intermission away from the game while the researcher loaded the next numerical game to play for the remainder of the fifteen minute session (i.e., if Game 2 malfunctioned at the five minute mark, Game 3 would be played for the remaining 10 minutes). This scenario only occurred once throughout the entire experiment and is discussed further in the limitations section.

During conditioning sessions, the researcher was responsible for starting a timer as soon as the participant started their game to ensure they would deliver edibles at the time they were assigned based on the methods previously described. Edibles were prepared and stored out of the participant's sight to avoid reactivity. When the researcher presented an edible to the participant, the participant was required to consume the edible immediately. If a participant refused to eat the item, the session would have been discarded; however, this never happened. This process continued until the game was over and all twelve edibles were delivered (i.e., four of each E1, E2, and E3).

During these sessions, the researcher would hold up one, two, or three fingers behind the participants back to signal if they delivered E1, E2, and E3, respectively. This coding system was used to increase the accuracy of treatment integrity, given that the video recording could not accurately depict what edible was delivered and thus a second observer would only be able to see that an edible was delivered, without knowing which edible it was.

Dependent Variables and Measurement

As mentioned above, data were only collected during probe sessions and consisted of recording the exact time each edible was chosen. No data were collected during conditioning sessions as these sessions were designed to create pairing opportunities and would not provide data to suggest a CMO-S effect has occurred, given that there was no chance for free operant choice.

Data were analyzed in two different ways: conditional probability analyses and number of edible choices during certain intervals (e.g., number of edibles chosen during default intervals versus intervals with supplemental/alternative sounds/colors). Data were calculated to assess responding on two levels: response class and individual responding. First, the researcher identified the base probability for both of these levels (i.e., what is chance responding?) by assessing the number of edibles available and the number of intervals they could be consumed in. Then, the researcher calculated the actual percent of choice based on each participant's data. Then, these two percentages were compared to assess if actual responding was better or worse than chance responding and if there was any trend in responding as conditioning sessions increased. If actual responding increased compared to chance responding, this would suggest that an effect had occurred. To clarify, chances and actual results of choices during and outside of general and specific stimuli change events were assessed for each participant on each of their probes.

To complete the probability analyses, a few things must be made clear. Sessions were 900 seconds long, of which C/S changes 1, 2, and 3 all were each present for 60 seconds total (i.e., each change happened for 15 second intervals, four times in the session). This means that for response class analyses, 20% of sessions had a stimulus change present. This percentage was calculated by adding the 60 seconds of each of the three paired stimulus, for a total of 180 seconds, divided by the total of 900 seconds. Similarly for individual response class analyses, 6.67% if sessions had an individual stimulus change present. This percentage was calculated by dividing the 60 seconds the individual stimulus change was present by the total of 900 seconds. So, in general, a participant's chance of choosing an edible, all things being equal, during any stimulus change event was 20% and the chance of them choosing an edible during its paired time was 6.67%.

A few adjustments were made for analyses, given that some participants chose all four of a specific edible before all of its paired stimuli changes occurred or before the end of the game (e.g., on Probe1, P1 chose all of E2 before the fourth C2 stimulus change occurred). Because of this, the researcher adjusted the calculations for chance to better reflect the participant's opportunity of choice; for the session mentioned above, 45 seconds was divided by 729 seconds to calculate the percent of correct responding for E2. This was because there were only 45 seconds where C2 played while E2 was also available and all E2s were gone by 729 seconds. Therefore, any additional time in the session would not be representative of chance responding, for this edible was no longer an option and thus there was no chance. Similar adjustments were made across participants when all edibles were chosen before the 900 seconds or when a specific edible was exhausted before the end of the session. See Appendix J for a copy of all analyses for all participants. See also Appendix K for a secondary method used to visually analyze data.

Procedural Integrity and Interobserver Agreement

A random generator was used to determine which sessions a second observer would take interobserver agreement data (IOA) and procedural integrity (see Appendix L) across all participants. For reference, each participant had 10 sessions, meaning there were 40 total sessions in this study. Both IOA and procedural integrity were completed via video recordings after all participants had given consent. For procedural integrity, a task list was created to identify all steps needed to correctly perform probe and conditioning sessions (see Appendix B and Appendix C). The primary researcher used this checklist during sessions and scored themselves accordingly and then a secondary researcher reviewed fourteen (i.e., 35%) of these sessions to take secondary data on the primary researcher's performance.

Calculations consisted of totaling correct responses, dividing this number by the total number of opportunities, and then multiplying by 100. Procedural integrity as scored by the secondary researcher was 169/170 or 99.41% and is broken down as follows: Session 5 (12/13), Session 6 (12/12), Session 10 (13/13), Session 12 (13/13), Session 13 (11/11), Session 15 (12/12), Session 19 (11/11), Session 21 (12/12), Session 27 (11/11), Session 33 (13/13), Session 34 (12/12), Session 37 (13/13), Session 39 (12/12), Session 40 (12/12). Due to video recording limitations, some items were not able to be verified (e.g., door being closed, personal devices being turned off).

Given that data were only collected during probe sessions, no IOA was collected during conditioning sessions. The secondary researcher reviewed 50% of probe sessions and scored when edibles were chosen. These data were then compared to the primary researcher's data and agreement was scored by comparing recorded times. If both researchers listed a time within 3 seconds of the other, or if both researchers listed an item as not selected during the session, an agreement was scored. Total agreements for each session were divided by the 12 (i.e., total number of edibles that could be chosen) and multiplied by 100. IOA was 100% and is broken down as follows: Session 1 (12/12), Session 4 (12/12), Session 13 (12/12), Session 19 (12/12), Session 22 (12/12), Session 39 (12/12).

Post-Study Assessments

Once the last participant had finished their final probe session, participants met with the researcher to conduct a sensory discrimination test (see Appendix M). Depending on each participant's assignment to either color or sound changing sessions, two sounds/colors were presented sequentially, and the participant was asked if the first sound/color was the same or different from the second. Each sound/color was presented with itself and with each other sound/color at least once to assess if participants could distinguish each sound from all the others. The sounds and colors used in this assessment were the four colors (i.e., grey, blue, green, orange) and four sounds used in the experiment.

While this test was completed at the end of the study to decrease reactivity effects, it may have been worthwhile to do so before-hand to ensure there were no conflicting variables. Results of this assessment showed that both participants who had color changing sessions (i.e., P1 and P4) scored 100%, whereas the two participants who had sound changing sessions (i.e., P2 and

P3) scored 10/12 and 7/12, respectively. This suggests that P2 and P3 were unable to accurately discriminate sound changes from each other, which could have altered the effectiveness of conditioning sessions and thus responding during free operant conditioning.

Exit Survey

Following the discrimination test, the researcher debriefed with each of the participants to reveal the true purpose of the study and inform the participants of how they had been deceived throughout the study. These deceptions included hiding the true title of the study, which was done to decrease the chance that participants would look up the concept of the CMO-S and then become reactive during sessions. Participants had also been told during sessions that they would receive edibles when they met a specific goal; the researcher clarified that there was no goal and edibles were presented according to predetermined times. Finally, participants were told of the hidden camera and were given an opportunity to either delete their footage or give consent to this footage being used for research purposes. All four participants consented.

Finally, participants completed an exit survey (see Appendix N) to provide more information on their experience. While this measurement is subjective, there were some responses that suggested limitations of the study. For example, all participants claimed they chose certain edibles over others due to preference and P3 and P1 both claimed they knew stimulus changes and edibles were paired together. What is most notable is that P3 claimed they typically do not eat at the time most of their sessions were ran, they were sick of the snack options, and were often more thirsty than hungry; this response suggests that there were multiple competing motivating operations that could have affected the CMO-S effect from being produced. Similarly, P2 claimed that they were full and did not want to eat candy for two of their three probe sessions. This suggests another AO for snack consumption that could have altered responding.

Chapter 3: Results

Participant 1

In the first of three probe sessions (i.e., before any conditioning occurred), P1 chose all twelve edibles: three edibles during an alternative color interval, two of which were during the to-be-conditioned alternative color interval (i.e., two selects of E1 during a C1 interval, which were to be conditioned after the first probe), and nine edibles during default color intervals (i.e., grey screen). On the second probe, they again chose all 12 edibles: four edibles during an alternative color interval, one of which was the control edible during the control color interval, and eight edibles during default color intervals. On the final probe, they chose all twelve edibles: five edibles during an alternative color interval, one of which was during its conditioned color interval (i.e., selection of E2 during C2 interval), and six edibles during default color intervals.

Figures 1 and 2 depict the following analysis for P1. The chance probability of consuming any edible when any alternative color was present ranged from 19.97% to 21.33%; P1's actual percentages of edibles consumed during alternative color, in order of probe trials, was 25.00%, 33.33%, and 41.67%. The increasing trend suggests that P1 outperformed chance as sessions progressed and provides evidence of a developing general CMO-S effect. An analysis of P1's choice of edibles during intervals of their conditioned alternative color does not yield consistent data, suggesting that a specific CMO-S effect had not developed.

Figure 1

Chance and Actual Percent of Edible Choice During Intervals with an Alternative Color (i.e., C1, C2, or C3) Across Probe Sessions for Participant 1

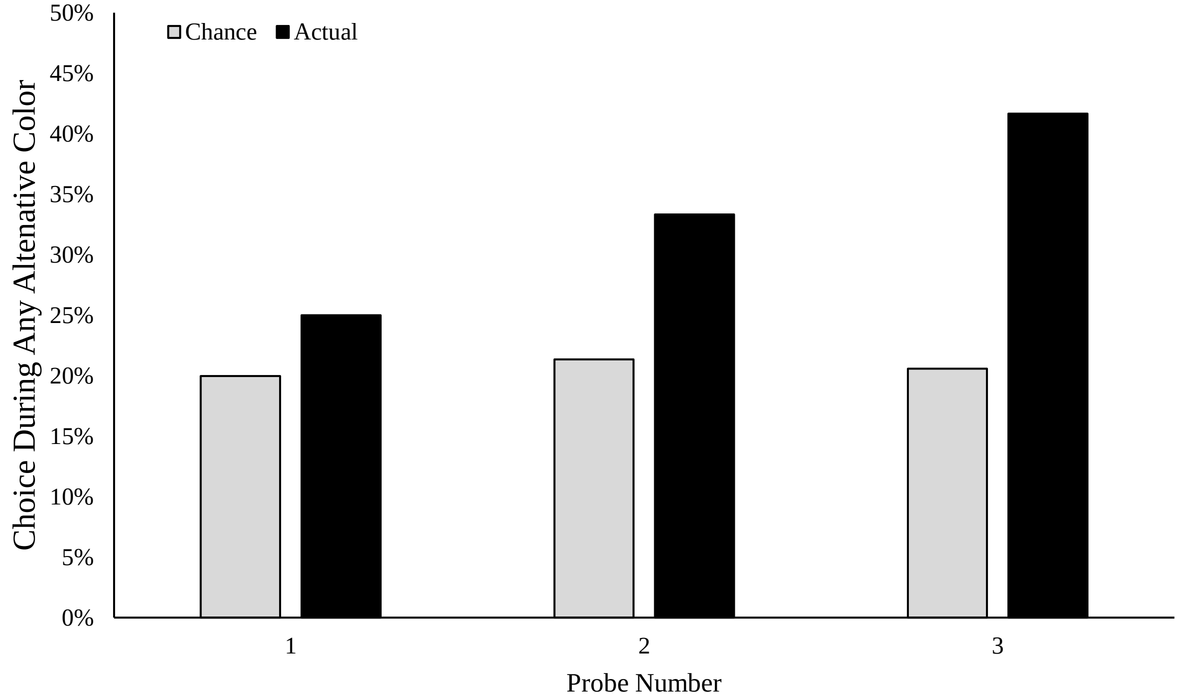
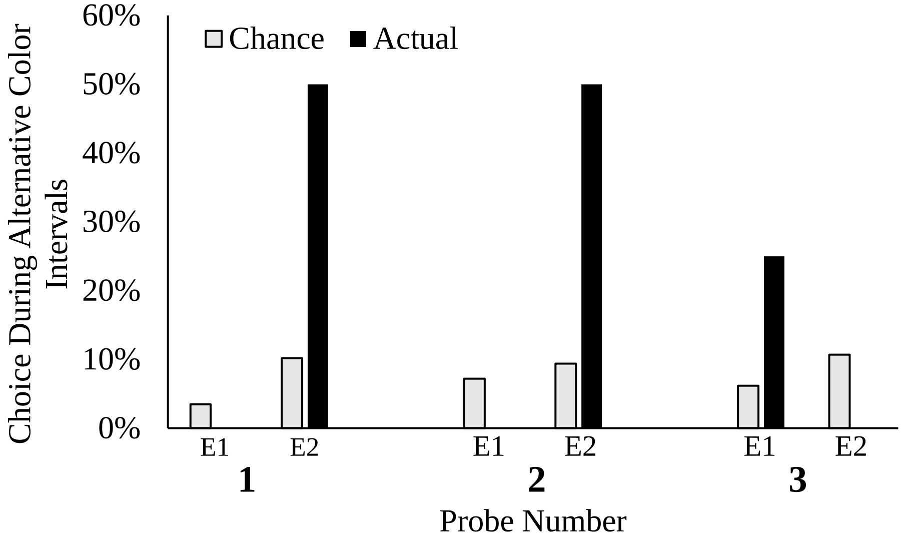


Figure 2

Chance and Actual Percent of E1 Choice During C1 Intervals and E2 Choice During C2 Intervals Across Probe Sessions for Participant 1



Note. P1 did not choose any E1 during C1 intervals on Probe 1 or Probe 2, and also did not choose any E2 during C2 intervals on Probe 3.

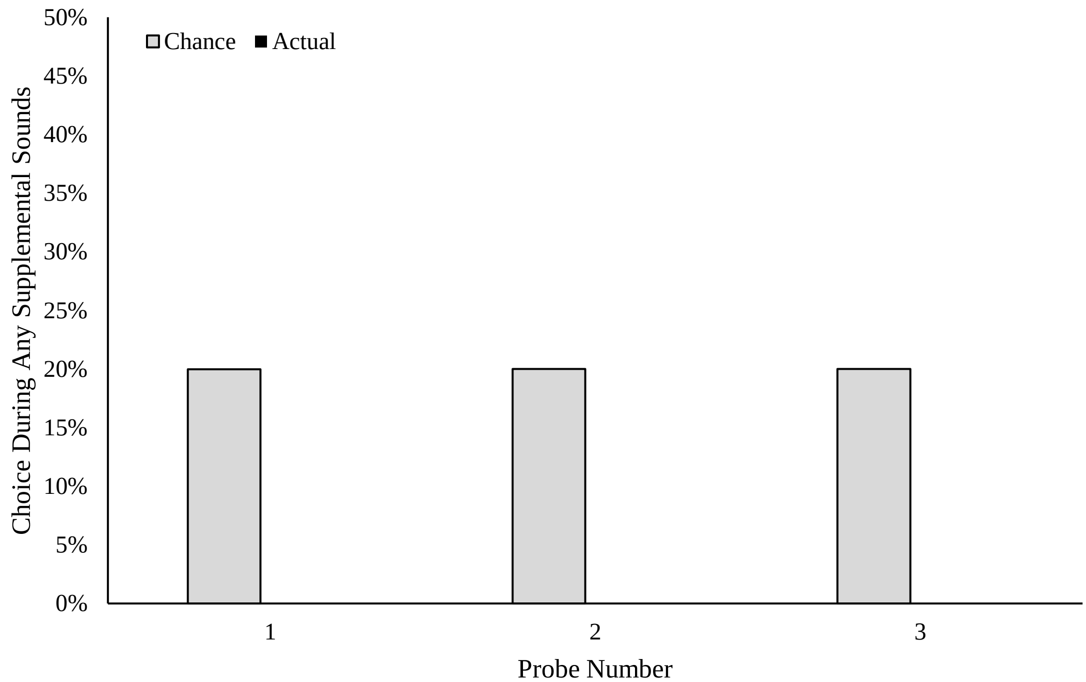
Participant 2

On Probe 1, P2 chose no edibles during intervals with supplemental sounds, but consumed two edibles during intervals with the default sound. On Probe 2 they chose no edibles during intervals with supplemental sounds but consumed four edibles during intervals with the default sound. On the final probe, they chose no edibles during intervals with supplemental sounds and, like Probe 1, consumed two edibles during intervals with the default sound.

For P2, consumption during intervals with supplemental sounds remained at 0.00% and chance responding remained at 20.00% across all probes. These data provide no evidence for the development of either a general or specific CMO-S effect. See Figures 3 and 4 for details.

Figure 3

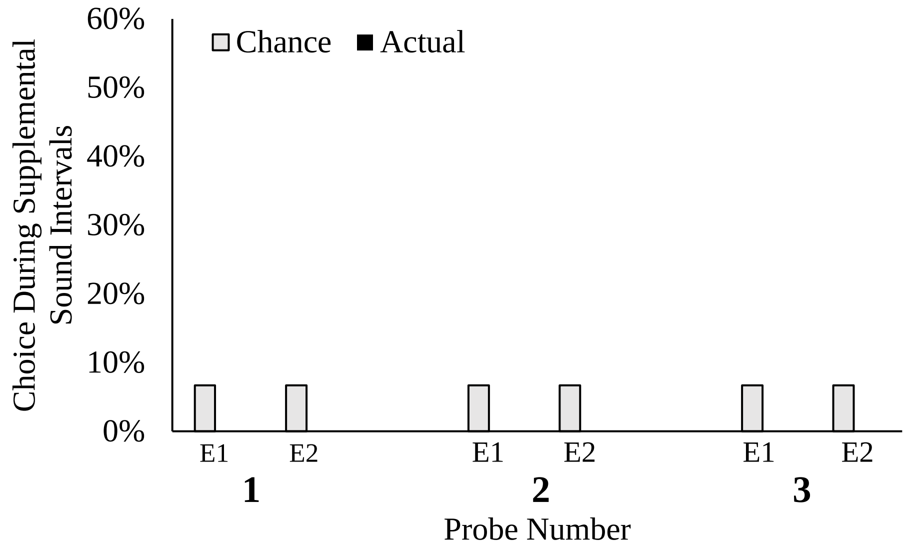
Chance and Actual Percent of Edible Choice During Intervals with an Alternative Sound (i.e., S1, S2, or S3) Across Probe Sessions for Participant 2



Note. P2 did not choose any edibles during any interval with supplemental sounds on any probe.

Figure 4

Chance and Actual Percent of E1 Choice During S1 Intervals and E2 Choice During S2 Intervals Across Probe Sessions for Participant 2



Note. P2 did not choose any E1 edibles during C1 intervals, or any E2 edibles during C2 intervals on any of the three probes.

Participant 3

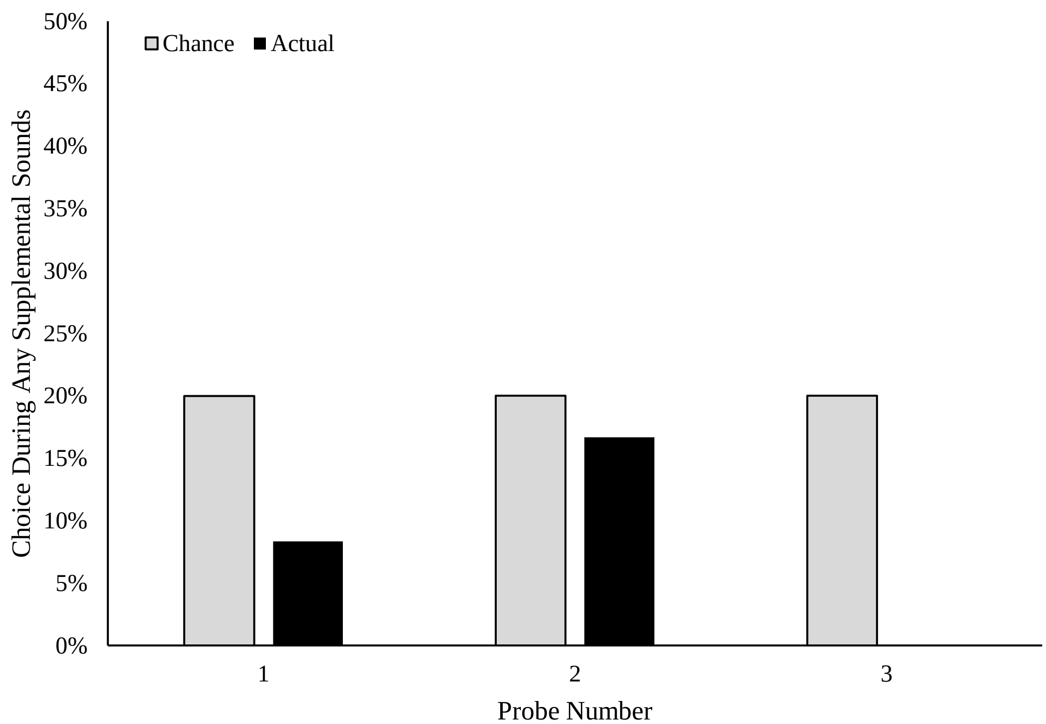
On Probe 1, P3 chose one edible during intervals with supplemental sounds, but no edibles during intervals with the to-be-conditioned supplemental sound, and three edibles during intervals with the default sound. On Probe 2, P3 chose two edibles during intervals with supplemental sounds, one of which was during an interval with the conditioned supplemental sound, and four edibles during default sound intervals. On Probe 3, they chose no edibles during intervals with supplemental sounds and four edibles during intervals with the default sound.

Based on these data and Figures 5 and 6, choice during intervals with supplemental sounds did not consistently increase, nor outperform chance, as data varied from 8.33% to

16.67% to 0.00%, while chance responding remained at 20.00%. This suggests that no CMO-S effect occurred on an individual or general level given that responding was almost always lower than chance, outside of Probe 2 where eating E2 during S2 was higher than chance (i.e., 25.00% compared to 6.67%). These data provide no evidence of either a general or specific CMO-S effect.

Figure 5

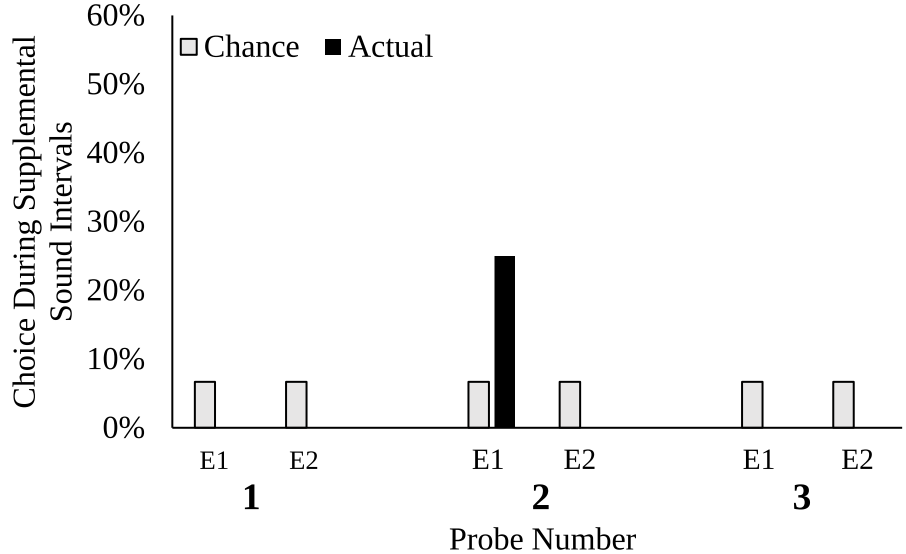
Chance and Actual Percent of Edible Choice During Intervals with an Alternative Sound (i.e., S1, S2, or S3) Across Probe Sessions for Participant 3



Note. P3 did not choose any edibles during an interval with a supplemental sound on Probe 3.

Figure 6

Chance and Actual Percent of E1 Choice During S1 Intervals and E2 Choice During S2 Intervals Across Probe Sessions for Participant 3



Note. P3 did not choose any E1 edibles during S1 intervals on Probe 1 or 3; P3 also did not choose E2 edibles during S2 intervals on any of the three probes.

Participant 4

On Probe 1, P4 chose one edible during an interval with an alternative color, no edibles during an interval with the to-be-conditioned alternative color, and ten edibles intervals with the default color. On Probe 2, they chose one edible during an interval with an alternative color, no edibles during an interval with the conditioned alternative color, and nine edibles during intervals with the default color. On Probe 3, they chose four edibles during intervals with an alternative color, two of which were during intervals of the conditioned color, and six edibles during intervals with the default color.

Figures 7 and 8 depict the following analysis for P4. The chance probability of consuming any edible when any alternative color was present remained at 20.00% for all probes; P4's actual percentages of edibles consumed during alternative colors, in order of probe trials, was 8.33%, 8.33%, and 33.33%. The increasing trend suggests that P4 outperformed chance as sessions progressed and provides evidence of a developing general CMO-S effect. Similarly, chance probability of consuming an edible during its conditioned color interval ranged from 5.35% to 9.28%; P4's performance of choosing E1 during C1 intervals and E2 during C2 intervals both increased across Probes 1, 2, and 3, from 0.00% to 0.00% to 25.00%, respectively. The increasing trend suggests P4 outperformed chance as sessions progressed and provides evidence of a developing specific CMO-S effect.

Figure 7

Chance and Actual Percent of Edible Choice During Intervals with an Alternative Color (i.e., C1, C2, or C3) Across Probe Sessions for Participant 4

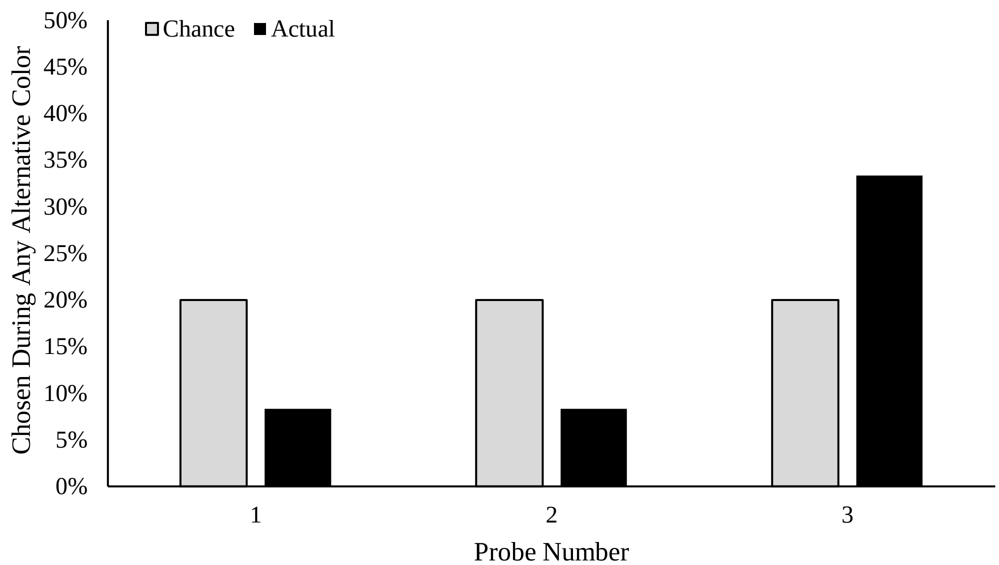
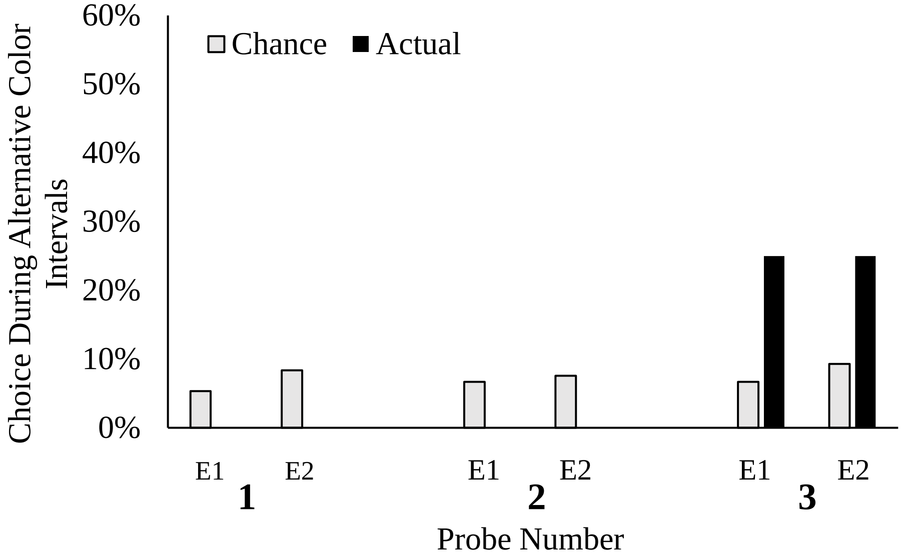


Figure 8

Chance and Actual Percent of E1 Choice During C1 Intervals and E2 Choice During C2 Intervals Across Probe Sessions for Participant 4



Note. P4 did not choose any E1 edibles during C1 intervals or E2 edibles during C2 intervals on either Probe 1 or 2.

Chapter 4: Discussion

These data, particularly P1 and P4, suggest that some sort of CMO-S effect was developing. Specifically, for these two participants, edible consumption in the presence of any alternative color during probes increased over the course of the study, often exceeding chance responding levels (most importantly after Probe 1, when conditioning trials occurred). Interestingly, P4's third probe found evidence of a specific CMO-S effect developing as increased E1 and E2 consumption occurred in the presence of C1 and C2, respectively. The development of at least a general CMO-S effect is further supported by noting that both P1 and P4 scored 100% on their sensory differentiation tests.

While P2 and P3 both did not demonstrate an effect, the results of their exit survey suggests that there were a number of AOs for snack consumption during probe sessions and discrimination deficits that could have interfered with responding. Given that both participants did not score 100% on their sensory discrimination test, it can be inferred that they were unable to recognize stimuli change events during sessions and thus conditioning sessions could have been ineffective given that stimuli changes and their edible pairings may not have been noticed. This limitation may highlight why previous CMO-S studies have failed, given that if a contrived MO (i.e., stimulus change event) was not active at the time of a paired stimulus, no effect could be created. In this study, there was no contrived MO to avoid this limitation, but discrimination errors may have served a similar function that inhibited responding.

Finally, consider that the two participants whose data suggested the development of a general CMO-S effect had color changing sessions and salty snacks, whereas the two participants who did not demonstrate an effect had sound changing sessions and chocolate snacks. While the difference in pairings was not purposeful, given that color and sound change trials were chosen at random and edibles were chosen based off which preference assessment provided the widest range of neutral edibles, this assignment may have provided another avenue of research worth exploring. Specifically, particular combinations of stimuli and reinforcers might more readily be conditioned; a phenomenon known as preparedness (see Seligman, 1970). The idea of preparedness in CMO-S development has not yet been explored in the literature, but this area seems like a logical next step in the study of this motivating operation subtype.

Chapter 5: Limitations

The exit survey results suggest that the preference assessment was not successful in identifying equally neutral, or neither highly preferred nor non-preferred, edibles. For example, during probe sessions, P1 typically ate all of E3, then E1, then E2, suggesting the presence of an interfering MO from the edibles themselves. Here, consuming E3 edibles might have blocked consumption of E1 edibles during C1 stimuli had E3 edibles not all been consumed. One possible explanation for the preference hierarchy could be due to the edibles, irrespective of other characteristics (e.g., size), while another explanation could be that edible sizes varied, though arguably not in a significant manner.

An additional interfering MO, in this case an AO, might exist in the point system built into the program. Consider that points were worth more during supplemental or alternative stimulus conditions. Edible consumption during these times might reduce the participant's ability to earn points, as they need to stop momentarily to obtain and insert the edible into their mouth. If this was indeed an interfering MO, it would be interesting, as point accumulation during probes are meaningless; participants were told that points were used to determine when edibles would be delivered (a deception), but edibles are provided in a free operant format during probes. Any interfering MO from the points during probes would be a product of generalization from training conditions.

Due to scheduling conflicts, some participants played the same game twice in the same day. Scheduling sessions at least one day apart provides safeguards against two possible extraneous variables. First, sessions occurring in rapid succession could increase the likelihood of the participant identifying the experimental manipulation (coordinating stimulus conditions with edibles). Second, habituation or satiation effects are mitigated, which can help reduce the possibility of the second session being aversive if they are no longer interested in the edibles or they are no longer hungry (if it is a conditioning session) or producing no consumption (if it is a probe session). An additional benefit of spacing out sessions is to potentially capitalize on MO effects; behavior altering effects are more likely to occur when an EO is in place, and the hungrier (or less habituated) organism will be more readily conditioned. Interestingly, it was P2 and P3, the two participants who did not produce any CMO-S effects, that repeated sessions within a single day occurred (sessions 3-4 and 6-7 for P2 and sessions 6-7 and 8-9 for P3; note that these sessions were conditioning, not probe, sessions).

Another limitation is that sometimes the game system would glitch; on P4's second session, the game glitched and the dot needed to earn points disappeared from the screen. The researcher followed the protocol mentioned in the method section, but this disturbance did differentiate pairing opportunities from what was intended (i.e., there were five pairings of E1/C1 and E3 and only one pairing of E2/C2 during this session).

Due to time constraints, reverse conditioning was not possible. Had time allowed, the sound and edible pairings would have been reassigned for participants that showed an effect, meaning that each edible would have a new sound/color stimulus pairing. Alternating conditioning and probe trials would continue until the researcher could conclude if the reversal was successful or unsuccessful. If the CMO-S effect could be reversed, participants should alter responding to choose the newly paired edible when the sound/color is played, rather than the edible it was previously paired with.

Relatively minor issues arose that might be worth considering. For example, during the study, the university's COVID policies changed and the mask mandate was lifted. Thus, sometimes the researcher's instructions were not said exactly as written, given that some parts were non-applicable (e.g., "please keep you mask up"). This lack in procedural integrity explains the missing point in the researcher's procedural integrity score on session 5. Sounds coming from a nearby classroom were present during some sessions. The video system would stop recording every five minutes and require the researcher to click a continue button before continuing to record, which would sometimes create a multiple second delay in the recording, which sometimes occurred during edible delivery. The lag in videos did present a barrier during IOA measures, given that the researcher would have to recalibrate their timer throughout the video to adjust for these lags (e.g., the researcher would use stimulus changes to identify what their timer should be set at).

Chapter 6: Next Steps

The CMO-S effect has little empirical evidence to support its existence, and this study serves to expand on those data supporting a potential CMO-S effect. In this study, half of the participants demonstrated than an effect was likely developing, of which, both participants showed strong results. Based on these results, there are two ideas researchers should consider when pursuing CMO-S research: preparedness and interfering MOs.

As mentioned above, the two participants who demonstrated an effect had salty snacks and color changing screens, whereas the two participants who did not demonstrate an effect had sweet snacks and intervals of sound change. These results suggest that certain stimuli pairings may be more readily conditioned to create an effect. In this case, edible-visual pairings may be more effectively conditioned when compared to edible-auditory pairings. This may not be surprising, given that prior research has demonstrated that events cannot be considered equal, given that each organism may be more or less prepared to learn a relation between events and thus this level determines the rate of acquisition or extinction of such relations (Seligman, 1970). Given that little is known about what paired events have higher or lower preparedness levels, future research should explore which pairings are the most effective at producing or diminishing the CMO-S. This study justifies preparedness research over longer periods; consider that researchers were able to identify a classes of stimuli pairings that were most effective at creating an effect (e.g., edible-visual). This would inform what stimuli practitioners should use to either reverse existing CMO-S effects that serve a disadvantageous function to the individual (e.g., a CEO-S for stereotypy during instructional times) or to create advantageous CMO-S effects (e.g., a CEO-S for exercise).

A secondary consideration is avoiding interfering MOs. In this study, the two participants who did not produce an effect had back-to-back conditioning sessions, two times each. There is a chance that the extended duration and increased presentation of the same edibles produced habituation or satiation effects. These effects could have created an aversion to these edibles and thus when free operant probes were conducted, this learning history created an AO for edible consumption that interfered with CMO-S creation.

The results of this study suggest that the CMO-S is worth pursuing; however, researchers may need to adapt different methods when designing their studies to create successful demonstrations. For example, this study demonstrated an effect could occur despite no active creation of a MO, which differs from previous research on this concept. Perhaps it is the creation of the MO that interferes with the effectiveness of these studies, and it is worthwhile to continue contriving CMO-S relations without this measure. Similarly, researchers must program against AOs and most importantly, researchers should consider what stimuli they are pairing to find the most effective combinations.

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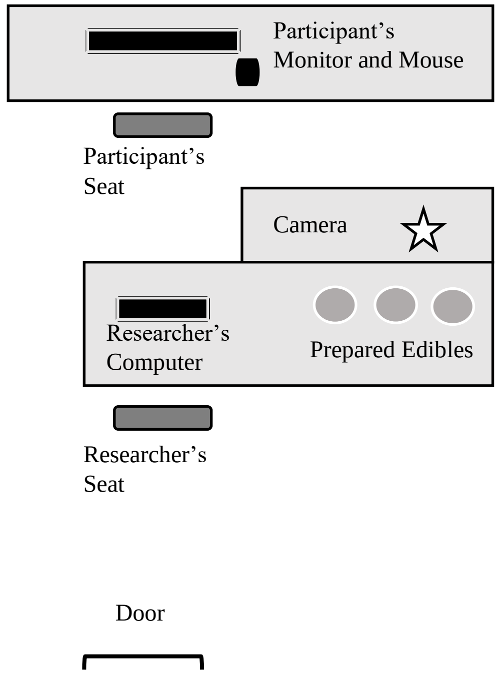
Appendix A: Diagram of Lab



Appendix B: Test Probe Session Instructions and Checklist

TEST PROBE INTEGRITY CHECKLIST

Before each session, complete the checklist to ensure all components are accounted for.

Primary Researcher:	**Date:**
Secondary Observer:	**Participant:**

The primary researcher will use the corresponding checklist to ensure the room, participant, and researcher themselves are prepared for the session. Steps 1-12 must be completed *before* the participant enters the room.

When steps 1-15 have been completed, the researcher will present the following instructions to the participant. This statement will be read *exactly* as written.

You will have 15 minutes to play a game. Help yourself to the snacks provided. I will let you know when the time is up. If you need more water or want to withdraw, please let me know, but otherwise refrain from asking any questions. Do not touch anything else in the room, other than the snacks, water, and your mouse"

Throughout the session, the researcher will not provide any prompts or deliver any edibles. The researcher will inform the participant when the session is over and they may collect their items and leave.

When the participant has left, the researcher will restore the room to its previous state by following steps 18-23.

	Checklist Items	**Step Completed?** *(circle)*	
1.	Room lights are on	Yes	No
2.	Door is closed and active research sign is on door	Yes	No
3.	All computers and personal devices are turned off	Yes	No
4.	Camera is recording (Blink app is pulled up on Live View)	Yes	No
5.	Computer is turned on	Yes	No
6.	Mouse is connected and working	Yes	No
7.	PsychoPy is open to starting page of correct video (i.e., page says 'Click Mouse to Start')	Yes	No
8.	Keyboard, printer, and other items are removed from table	Yes	No
9.	Computer volume is on level 60	Yes	No
10.	Each plate has four of one type of edible (for three total plates)	Yes	No
11.	Plates are placed on table in front of participant of equal distance	Yes	No
12.	Water bottle is set on the desk	Yes	No
13.	Participant is seated	Yes	No
14.	Participant's personal devices are muted and put away	Yes	No
15.	Participant signs check in sheet	Yes	No
16.	Researcher states the instructions as written	Yes	No
17.	Researcher alerts participant the session is over when screen says "The Study is Done…"	Yes	No
18.	Researcher turns off camera	Yes	No
19.	Researcher uploads data from Blink onto Dropbox	Yes	No
20.	Researcher closes computer program, ejects hard drive, turns off computer	Yes	No
21.	Researcher removes bowls and returns them and any leftover edibles to storage box	Yes	No
22.	Researcher uploads data sheet to protected folder and shreds document	Yes	No
23.	Researcher turns off light and locks door before leaving	Yes	No
Score out of 23 *(yes=1, no=0):*			

Appendix C: Conditioning Session Instructions and Checklist

CONDITIONING INTEGRITY CHECKLIST

Before each session, complete the checklist to ensure all components are accounted for.

Primary Researcher:	**Date:**
Secondary Observer:	**Participant:**

The primary researcher will use the corresponding checklist to ensure the room, participant, and researcher themself are prepared for the session. Steps 1-10 must be completed *before* the participant enters the room.

When steps 1-14 have been completed, the researcher will present the following instructions to the participant.
"You will have fifteen minutes to play a game. While you work, you will be presented a food reward when you've met our predetermined goal. You will not be informed of what this goal is. When food is presented, pause your game, immediately eat the item, then resume working. I will let you know when the time is up. Do not touch anything else in the room, other than the snacks, water, and your mouse"
Once the participant has pressed 'Play', the researcher will start the respective video. Throughout the session, the researcher will deliver edibles according to the video schedule. When the video has finished playing, the researcher will inform the participant that the session is over, and they may collect their items and leave. When the participant has left, the researcher will restore the room to its previous state by following steps 19-22.

	Checklist Items	**Step Completed?** *(circle)*	
1.	Room lights are on	Yes	No
2.	Door is closed and active research sign is on door	Yes	No
3.	All computers and personal devices are turned off	Yes	No
4.	Camera is working (Blink is turned to Live View)	Yes	No
5.	Computer is turned on	Yes	No
6.	Mouse is connected and working	Yes	No
7.	PsychoPy3 open to correct video and on (i.e., page says 'Click Mouse to Start')	Yes	No
8.	Keyboard, printer, and other items are removed from table	Yes	No
9.	Computer volume is on level 60	Yes	No
10.	Researcher has four of each edible prepared and out of the participant's sight	Yes	No
11.	Water is set out on desk	Yes	No
12.	Participant is seated	Yes	No
13.	Participant's personal devices are muted and put away	Yes	No
14.	Participant signs check in sheet	Yes	No
15.	Researcher states the instructions as written	Yes	No
16.	Researcher delivers E1 within 3 seconds, each time its paired sound/color occurs	Yes	No
17.	Researcher delivers E2 within 3 seconds, each time its paired sound/color occurs	Yes	No
18.	Researcher delivers E3 within 3 seconds each time its assigned time passes	Yes	No
19.	Researcher alerts participant session is over when screen says "The Study is done…"	Yes	No
20.	Researcher turns off camera	Yes	No
21.	Researcher uploads video from Blink to Dropbox	Yes	No
22.	Researcher closes computer program, ejects harddrive, and turns off computer	Yes	No
23.	Researcher turns off light and locks door before leaving	Yes	No

Score out of 23 *(yes=1, no=0):*

Appendix D: Game Components

Table 1

Game Components

G1		G2		G3	
Time (s)	**Stimuli**	**Time (s)**	**Stimuli**	**Time (s)**	**Stimuli**
54	C/S3	17	C/S1	26	C/S3
95	C/S3	53	C/S3	92	E3
134	E3	100	C/S3	148	C/S3
204	C/S3	170	E3	221	C/S2
240	E3	207	E3	257	C/S1
271	C/S1	274	C/S1	337	C/S2
324	C/S1	310	C/S1	387	C/S1
386	C/S2	359	C/S2	419	E3
457	E3	486	E3	466	C/S1
518	C/S2	529	C/S1	503	C/S3
553	C/S2	573	C/S2	535	C/S1
621	C/S1	612	C/S2	600	E3
723	C/S3	682	C/S3	648	C/S2
768	C/S2	758	C/S3	693	E3
801	E3	822	E3	830	C/S2
875	C/S1	883	C/S2	884	C/S3

Note. S=Sound, C=Color, E=Edible, G=Game.

Appendix E: Pre-Training Screening: Preference Assessment 1

<table>
<tr><th colspan="4">Preference Assessment</th></tr>
<tr><td colspan="4">Participant: Date Researcher:</td></tr>
<tr><td colspan="4">Record which of the following twenty edibles you would eat. From those items, please record your two most and least favorite items. Rank the remaining items from most (1) to least favorite.
<u>Candies:</u> Milky Way, Milky Way Midnight, Twix, Three Musketeers, Andes, Reese’s Peanut Butter Cups, Hershey’s Kiss, Rolos, Cookies and Cream Hershey’s Kiss, Peppermint Patty, Crunch, Butterfinger, Dove Milk Chocolate, Snickers, 100 Grand, Baby Ruth, KitKat, Almond Joy, Heath Bar, Pay Day</td></tr>
<tr><th>Would Eat</th><th>Most Preferred</th><th>Least Preferred</th><th>Remaining
(ranked from most (1) to least favorite)</th></tr>
<tr><td>1.</td><td>1.</td><td>1.</td><td>1.</td></tr>
<tr><td>2.</td><td>2.</td><td>2.</td><td>2.</td></tr>
<tr><td>3.</td><td></td><td></td><td>3.</td></tr>
<tr><td>4.</td><td></td><td></td><td>4.</td></tr>
<tr><td>5.</td><td></td><td></td><td>5.</td></tr>
<tr><td>6.</td><td></td><td></td><td>6.</td></tr>
<tr><td>7.</td><td></td><td></td><td>7.</td></tr>
<tr><td>8.</td><td></td><td></td><td>8.</td></tr>
<tr><td>9.</td><td></td><td></td><td>9.</td></tr>
<tr><td>10.</td><td></td><td></td><td>10.</td></tr>
<tr><td>11.</td><td></td><td></td><td>11.</td></tr>
<tr><td>12.</td><td></td><td></td><td>12.</td></tr>
<tr><td>13.</td><td></td><td></td><td>13.</td></tr>
<tr><td>14.</td><td></td><td></td><td>14.</td></tr>
<tr><td>15.</td><td></td><td></td><td>15.</td></tr>
<tr><td>16.</td><td></td><td></td><td>16.</td></tr>
<tr><td>17.</td><td></td><td></td><td></td></tr>
<tr><td>18.</td><td></td><td></td><td></td></tr>
<tr><td>19.</td><td></td><td></td><td></td></tr>
<tr><td>20.</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Follow-Up Questions
1. This study will include the consumption of edible food items. To ensure your safety and wellbeing, please list any known food allergies or dietary restrictions (e.g., fasting periods). If you have no known restrictions, please indicate this by writing NA.
2. Please list any sensory deficits or impairments you may have, such as color blindness, deafness, or author visual or auditory limitations. If you have no known impairments, please indicate this by writing NA.</td></tr>
</table>

Pre-Training Screening: Preference Assessment 2

Preference Assessment			
Participant: Researcher:			Date:
Record which of the following twenty edibles you would eat. From those items, please record your two most and least favorite items. Rank the remaining items from most (1) to least favorite. **Candies:** Gushers, Sour Patch Kids, Watermelon Sour Patch, Starburst (pink), Starburst (yellow), Starburst (red), Starburst (orange), gummy worms, sour gummy worms, Mike and Ike, Air Head (blue), Air Head (white), Air Head (orange), Air Head (red), Air Head (green), Laffy Taffy (red), Laffy Taffy (pink), Laffy Taffy (yellow), Laffy Taffy (purple), Laffy Taffy (blue)			
Would Eat	**Most Preferred**	**Least Preferred**	**Remaining** *(ranked from most (1) to least favorite)*
1.	1.	1.	1.
2.	2.	2.	2.
3.			3.
4.			4.
5.			5.
6.			6.
7.			7.
8.			8.
9.			9.
10.			10.
11.			11.
12.			12.
13.			13.
14.			14.
15.			15.
16.			16.
17.			
18.			
19.			
20.			

Pre-Training Screening: Preference Assessment 3

Preference Assessment	
Participant:	Date:
Researcher:	

Record which of the following twenty edibles you would eat. From those items, please record your two most and least favorite items. Rank the remaining items from most (1) to least favorite.

Candies: Nacho Doritos, Cool Ranch Doritos, Dots Pretzels, Original Cheez-Its, White Cheddar Cheez-Its, Original Pringles, BBQ Pringles, Chive and Onion Pringles, Original Sun Chips, Garden Salsa Sun Chips, Chive and Onion Sun Chips, Cheeto Puffs, Original Ruffles, Sour Cream and Onion Ruffles, Veggies Straws, Screamin' Hot Veggies Straws, Garlic Parmesan Pretzel Crisps, Original Pretzel Crisps, Everything but the Bagel Pretzel Crisps, Buffalo Wing Pretzel Crisps

Would Eat	**Most Preferred**	**Least Preferred**	**Remaining** *(ranked from most (1) to least favorite)*
1.	1.	1.	1.
2.	2.	2.	2.
3.			3.
4.			4.
5.			5.
6.			6.
7.			7.
8.			8.
9.			9.
10.			10.
11.			11.
12.			12.
13.			13.
14.			14.
15.			15.
16.			16.
17.			
18.			
19.			
20.			

Appendix F: Edible Assignments

Table 2

Edible Assignments

Phase	Participant 1	Participant 2	Participant 3	Participant 4
Conditioning	E1-3rd ranked E2-1st ranked E3-2nd ranked	E1-2nd ranked E2-1st ranked E3-3rd ranked	E1-3rd ranked E2-1st ranked E3-2nd ranked	E1-3rd ranked E2-2nd ranked E3-1st ranked
Reverse Conditioning	E1-1st ranked E2-2nd ranked E3-3rd ranked	E1-2nd ranked E2-3rd ranked E3-1st ranked	E1-1st ranked E2-2nd ranked E3-3rd ranked	E1-2nd ranked E2-1st ranked E3-3rd ranked

Appendix G: Participant Game Assignment

Table 3

Participant Game Assignment

Participant Number	Color or Sound Sessions
1	Color
2	Sound
3	Sound
4	Color

Appendix H: Game Assignment Across Participants

Table 4

Game Assignment Across Participants

Session	Video
1	G2
2	G1
3	G3
4	G3
5	G2
6	G2
7	G2
8	G1
9	G1
10	G3

Appendix I: Probe Data for All Participants

Table 5

P1 Probe Data

P1 E1=C1, E2=C2, E3=Control, C3=Control				
Probe Number	**Game #**	**Time of E1 Choice (Sour Cream and Onion Ruffle)**	**Time of E2 Choice (Original Ruffle)**	**Time of E3 Choice (Veggie Straws)**
1	2	236	127	174
		495	351	336
		529	389	576
		539	435	601
2	2	299	533	61
		368	569	122
		406	600	171
		454	633	277
3	3	353	652	112
		434	685	198
		506	713	233
		562	729	271

Table 6

P2 Probe Data

P2 E1=S1, E2=S2, E3=Control, S3=Control				
Probe Number	**Game #**	**Time of E1 Choice (Baby Ruth)**	**Time of E2 Choice (3 Musketeers)**	**Time of E3 Choice (Milky Way)**
1	2	#N/A	560	209
		#N/A	#N/A	#N/A
		#N/A	#N/A	#N/A
		#N/A	#N/A	#N/A
2	2	#N/A	#N/A	174
		#N/A	#N/A	357
		#N/A	#N/A	718
		#N/A	#N/A	788
3	3	#N/A	#N/A	375
		#N/A	#N/A	464
		#N/A	#N/A	#N/A
		#N/A	#N/A	#N/A

Table 7

P3 Probe Data

P3 E1=S1, E2=S2, E3=Control, S3=Control				
Probe Number	Game #	Time of E1 Choice (Snicker)	Time of E2 Choice (Almond Joy)	Time of E3 Choice (Twix)
1	2	802	105	186
		#N/A	473	#N/A
		#N/A	#N/A	#N/A
		#N/A	#N/A	#N/A
2	2	163	122	409
		#N/A	282	730
		#N/A	575	#N/A
		#N/A	#N/A	#N/A
3	3	364	183	873
		#N/A	574	#N/A
		#N/A	#N/A	#N/A
		#N/A	#N/A	#N/A

Table 8

P4 Probe Data

P4 E1=C1, E2=C2, E3=Control, C3=Control				
Probe Number	**Game #**	**Time of E1 Choice (Garden Salsa Sun Chips)**	**Time of E2 Choice (Nacho Doritos)**	**Time of E3 Choice (Original Pringles)**
1	2	398	160	28
		479	209	248
		571	841	351
		718	#N/A	#N/A
2	2	126	386	203
		303	648	527
		589	#N/A	721
		794	#N/A	#N/A
3	3	91	232	182
		304	473	396
		539	827	601
		703	#N/A	#N/A

Appendix J: Data Analyses

Table 9

Data Analyses for All Participants Across All Probes

		Participants							
		P1		P2		P3		P4	
Probe Number	**Analysis Type**	**By Chance**	**Actual Responding**	**By Chance**	**Actual Responding**	**By Chance**	**Actual Responding**	**By Chance**	**Actual Responding**
1	Choosing during any alternative/supplemental event	19.97%	25%	20%	0%	20%	8.33%	20%	8.33%
	Choosing during default color/sound intervals	80.03%	75%	80%	100%	80%	25%	80%	75%
	Choosing E1 during C/S1 intervals	10.20%	50%	6.67%	0%	6.67%	0%	8.36%	0%
	Choosing E1 outside of C/S1 intervals	89.90%	50%	93.33%	0%	93.33%	25%	91.64%	100%
	Choosing E2 during C/S2 intervals	3.45%	0%	6.67%	0%	6.67%	0%	5.35%	0%
	Choosing E2 outside of C/S2 intervals	96.55%	100%	93.33%	25%	93.33%	50%	94.65%	100%
2	Choosing during any alternative/supplemental event	21.33%	33.33%	20%	0%	20%	16.67%	20%	8.33%
	Choosing during default color/sound intervals	78.67%	66.67%	80%	33.33%	80%	33.33%	80%	66.67%
	Choosing E1 during C/S1 intervals	9.38%	50%	6.67%	0%	6.67%	0%	7.56%	0%
	Choosing E1 outside of C/S1 intervals	90.62%	50%	93.33%	0%	93.33%	25%	92.44%	100%
	Choosing E2 during C/S2 intervals	7.22%	0%	6.67%	0%	6.67%	25%	6.67%	0%
	Choosing E2 outside of C/S2 intervals	92.78%	100%	93.33%	0%	93.33%	50%	93.33%	50%
3	Choosing during any alternative/su	20.58%	41.67%	20%	0%	20%	0%	20%	33.33%

	pplemental event								
	Choosing during default color/sound intervals	79.42%	58.33%	80%	16.70%	80%	33.33%	80%	50%
	Choosing E1 during C/S1 intervals	10.68%	0%	6.67%	0%	6.67%	0%	9.28%	25%
	Choosing E1 outside of C/S1 intervals	89.32%	100%	93.33%	0%	93.33%	25%	90.72%	75%
	Choosing E2 during C/S2 intervals	6.17%	25%	6.67%	0%	6.67%	0%	6.67%	25%
	Choosing E2 outside of C/S2 intervals	93.83%	75%	93.33%	0%	93.33%	50%	93.33%	50%

Appendix K: Secondary Probe Data Collection Sheet and Visual Analysis

The following spreadsheet was used as a secondary tool to visually analyze data. Stimuli changes are signaled by different colors (i.e., C/S1 is green, C/S2 is blue, C/S3 is red) to represent the 15 seconds they occurred across the 900 second trial. Filled in boxes represent the second an edible was chosen in (i.e., green boxes are E1 choices, blue boxes are E2, and red boxes are E3). The analysis below reflects P3's performance on Probe 3.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
2	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	
3	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	
4	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
5	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	
6	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	
7	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	
8	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	
9	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	
10	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	
11	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	
12	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	
13	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	
14	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	
15	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	
16	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	
17	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	
18	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	
19	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	
20	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	
21	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	
22	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	
23	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	
24	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	
25	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	
26	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	
27	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	
28	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	
29	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	
30	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	
31																															
32	KEY																														
33	Sound/Color 1		E1																												
34	Sound/Color 2		E2																												
35	Sound/Color 3		E3																												

Appendix L: Procedural Integrity and IOA Sessions

Procedural Integrity and IOA Sessions *Below are the session numbers in which the respective data were collected*	
Procedural Integrity	**IOA**
Session 5 Session 6 Session 10 Session 12 Session 13 Session 15 Session 19 Session 21 Session 27 Session 33 Session 34 Session 37 Session 39 Session 40	Session 1 Session 4 Session 13 Session 19 Session 22 Session 39

Appendix M: Sensory Discrimination Test

After the two tones/colors have been played, record whether you believe the two were the same or different by circling the corresponding answer.

1. Same or Different
2. Same or Different
3. Same or Different
4. Same or Different
5. Same or Different
6. Same or Different
7. Same or Different
8. Same or Different
9. Same or Different
10. Same or Different
11. Same or Different
12. Same or Different

Sounds/colors to be played (Researcher keeps this list)

1. C/S1 C/S1
2. C/S4 C/S1
3. C/S2 C/S2
4. C/S4 C/S3
5. C/S1 C/S2
6. C/S2 C/S1
7. C/S3 C/S1
8. C/S3 C/S2
9. C/S4 C/S4
10. C/S3 C/S3
11. C/S2 C/S4
12. C/S1 C/S3

Appendix N: Exit Survey

Post-Study Survey and Debrief

Participant:
Date:

Questionnaire

1. **Were there times in the study where you chose an edible for an 'unknown reason'?** ***Please circle your response below***

   Yes No I Don't Know

2. **Did you choose certain edibles over others because they were more preferred?** ***Please circle your response below***

   Yes No I Don't Know

3. **Did the researcher's presence in the room impact when or if you chose edibles?** ***Please circle your response below***

   Yes No I Don't Know

4. **Were you aware that edibles were paired with sounds/colors?** ***Please circle your response below***

   Yes No I Don't Know

5. **Did you feel unsafe at any time during sessions, related to COVID-19 and/or food contamination?** ***Please circle your response below***

   Yes No I Don't Know

6. **Did any other factors influence your decision to consume/not consume edibles, such as being hungry or full during sessions or worrying about caloric/sugar intake? If so, please list below:**

   ____

   ____

   ____

Appendix O: IRB Approval

ST. CLOUD STATE
UNIVERSITY
EDUCATION FOR LIFE.

Institutional Review Board (IRB)

720 4th Avenue South AS 210, St. Cloud, MN 56301-4498

Name: Cassidy Lehrke

Email: cclehrke@go.stcloudstate.edu

IRB PROTOCOL DETERMINATION:
Exempt Review

Project Title How Snacks Affect Performance on a Computerized Game

The Institutional Review Board has reviewed your protocol to conduct research involving human subjects. Your project has been: **APPROVED**

Please note the following important information concerning IRB projects:

- The principal investigator assumes the responsibilities for the protection of participants in this project. Any adverse events must be reported to the IRB as soon as possible (ex. research related injuries, harmful outcomes, significant withdrawal of subject population, etc.).

- For expedited or full board review, the principal investigator must submit a Continuing Review/Final Report form in advance of the expiration date indicated on this letter to report conclusion of the research or request an extension.

-Exempt review only requires the submission of a Continuing Review/Final Report form in advance of the expiration date indicated in this letter if an extension of time is needed.

- Approved consent forms display the official IRB stamp which documents approval and expiration dates. If a renewal is requested and approved, new consent forms will be officially stamped and reflect the new approval and expiration dates.

- The principal investigator must seek approval for any changes to the study (ex. research design, consent process, survey/interview instruments, funding source, etc.). The IRB reserves the right to review the research at any time.

If we can be of further assistance, feel free to contact the IRB at 320-308-4932 or email ResearchNow@stcloudstate.edu and please reference the SCSU IRB number when corresponding.

IRB Chair:

Dr. Mili Mathew
Chair and Graduate Director
Assistant Professor
Communication Sciences and Disorders

IRB Institutional Official:

María-Claudía Tomany

Dr. Claudia Tomany
Associate Provost for Research
Dean of Graduate Studies

OFFICE USE ONLY

SCSU IRB#: 2074 - 2703	**Type:** Exempt Review	**Today's Date:** 2/1/2022
1st Year Approval Date: 1/31/2022	**2nd Year Approval Date:**	**3rd Year Approval Date:**
1st Year Expiration Date:	**2nd Year Expiration Date:**	**3rd Year Expiration Date:**