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ESTABLISHING A SURROGATE CONDITIONED MOTIVATING OPERATION EFFECT WITHOUT (UNCONDITIONED) MOTIVATING OPERATIONS: A PILOT INVESTIGATION

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The surrogate conditioned motivating operation (CMO-S) is not extensively studied and therefore lacks a wide empirical base. We sought to test whether CMO-S effects could be produced when no unconditioned motivation operation (UMO) was explicitly programmed. Four undergraduate students played a dot-clicking game on a computer. Game-related stimuli (background color or sound) changed throughout each session, which coincided with changes to earned points for dot clicking (a distractor variable). During training sessions, some stimulus changes were reliably correlated with particular edible deliveries and consumption. Pre-training, mid-training, and post-training probe sessions tested for general (any edible) and specific (particular edibles coordinated with particular stimuli) CMO-S effects when stimuli were presented without programmed UMOs. Two of the four participants provided evidence of CMO-S effects, while the other two did not. Limitations around interfering motivating operations and future directions (e.g., preparedness) are discussed.

Keywords: motivation; behavior analysis; simulation

Successful demonstrations and replications that establish the surrogate conditioned motivating operation (CMO-S) 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). A common definition of a CMO-S effect requires an unconditioned motivating operation (UMO) be paired with a neutral stimulus (NS), resulting in a relation where the once NS will influence behavior similarly or identically to the UMO's effect (Ormandy, 2018). The prototypical example of this concept is eating lunch at noon because noon (i.e., the NS) and eating (i.e., the UMO of hunger) are historically paired. In an applied example, Lanovaz et al. (2014) paired colored poster boards (NS) with items known to evoke stereotypy (UMO). After pairing, the presence of the posterboards alone increased stereotypy, in comparison to baseline. Like its umbrella concept, the motivating operation (MO), CMO-S effects are measured in two ways. One being value-altering effects that are determined by rate of acquisition and the other behavior-altering effects determined by a relative increase in behavior historically related to the CMO-S (see Malott, 2007).

Failure to produce a CMO-S effect might be less dependent on the NS or competing stimuli, but on whether the MO occurred variably or at all in their presence. Without testing for behavior and value-altering effects, one cannot ensure pairing actually occurred and thus it is impossible to rule out MO presence as a confound. However, it is currently unclear how researchers could effectively test for MO relations during pairing sessions without disrupting the procedure or what behaviors satisfy the MO. MOs are transient (Ormandy, 2018) and can be satisfied by myriad responses. It might be beneficial to consider response classes over individual responses unless the study permits finer-grained analyses. For example, when cold, putting on a sweater, turning up the thermostat, or closing a window can satisfy the MO. Metabolic processes also accomplish this, but might be undetectable.

In designing a study to establish the CMO-S effect, the first step is to identify a NS (i.e., produces no UMO effect) and a UMO (or perhaps just an MO) to pair. Some UMOs might work better than others, though what UMO-NS pairings make for more efficient conditions are not yet documented. For example, for some species, food deprivation or satiation might

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take long periods to establish (Ormandy, 2018; see 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. Second, testing requires a NS presentation in the absence of the UMO. A CMO-S is said to develop when tests show increased UMO-related behaviors above pre-experimental levels. Due to limited successful demonstrations, it is unclear how the pairing procedure between the UMO and NS should be arranged (e.g., simultaneously [Ormandy, 2018], sequentially [Lanovaz et al., 2014]). Other considerations, such as time between and number of pairings, also lack empirical basis. Much of the confusion of the CMO-S concept might be owed to the lack of clarity over essential conditions.

With such ambiguity, we might question the necessary role of UMOs in the development of a CMO-S effect; does any response related to any MO lead to the same outcome? To test the assumption that the UMO might not need to be present, we conducted the following study in which probes provided free operant access to a UMO-related stimulus (i.e., food) that had been paired with a stimulus event (i.e., sound or color) with no programmed UMO for food consumption. If multiple stimuli are individually paired with certain edibles and other stimuli are paired with no edibles to serve as control stimuli, 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 stimulus is presented. If general food consumption is higher in the presence, but not the absence, of these stimuli after pairing, a moderate case for a CMO-S effect can be made.

METHOD

Participants

Four undergraduates with no identified sensory impairments from a mid-sized Midwestern university participated. Course credit was offered for participating and all students consented to data sharing. Participants will be referred to as P1, P2, P3, and P4.

Setting and Materials

Sessions were held in a 9′ x 19.5′ office. Participants were seated in front of a computer monitor at a desk facing a blank wall. The researcher sat at a desk behind the participants. Each session was recorded by a hidden camera located on top of a cabinet situated between the participant and researcher; video footage was reviewed for IOA and procedural integrity methods.

Various necessary items (e.g., computer, mouse, edibles, plates) were included. Six PsychoPy3 (Peirce et al., 2019) computer programmed games, referred to as G1-S (i.e., Game 1, Sound), G2-S, G3-S, G1-C (i.e., Game 1, Color), G2-C, G3-C were programmed to randomly present either three supplemental sounds (i.e., S1, S2, S3) or three alternative colors (i.e., C1, C2, C3). The computer used was set to the same volume for all trials.

PsychoPy3 Game Details

A white circle, 1/20th the height of the monitor's size, moved around the screen when clicked. Points were earned for each click on the circle and appeared at the top of the screen. Clicks were worth one point during intervals with the default color/sound, and worth 3, 4, or 5 points during C1/S1, C2/S2, or C3/S3 intervals, respectively. Circle clicks and point values served only to provide participants the opportunity to invent a reason for the color or sound changes or edible delivery, which the researcher alluded to in session instructions.

For sound games (i.e., G1-S, G2-S, and G3-S), the screen remained gray throughout play. A repetitious instrumental jazz-like soundtrack (i.e., default sound) played throughout. Fifteen s sound clips were used; S1 was bongo drums, S2 was 'cosmic bubbles', and S3 consisted of 'industrial sounds' (e.g., machines working).

Color games had no programmed audio; rather, the screen remained gray (i.e., default color) until an alternative color replaced the default color for 15 s. Alternative colors were assigned as follows: C1 was green, C2 was blue, and C3 was orange.

A random number generator determined when each stimulus change occurred, with two caveats: (1) Changes could not occur during the first and last 15 s of the game and (2) at least 15 s transpired between each presentation. Stimuli and default changes were timed identically across sound and color games for G1, G2, and G3.

Design

This study used a multiple probe design. Conditioning sessions occurred between probes.

Procedure

Participant Screening. Participants started by completing allergy and food restriction screening, as well as three preference assessments of edible items. Three different classes of edibles (i.e., chocolate, candy, salty) were presented as a list of twenty edible options. Participants divided edibles into two categories: those they would eat and those they would not, for each of the three classes. The "would eat" pile was then subdivided in three: most preferred (two edibles max), least preferred (two edibles max), and the remaining into a "moderately preferred" pile ranked from most to least. The three middle-most ranked edibles were chosen for each participant as they were deemed the most likely to be neutral. Edibles were randomly assigned as E1, E2, and E3 for each participant.

Participant Assignments. Participants were randomly assigned to either color or sound games; P1 and P4 had color games, P2 and P3 had sound. Each participant had pairings of E1 to C/S1 and E2 to C/S2. E3 and C/S3 were never presented together or with other stimuli as they served as controls. The order of the three games was assigned to each session using a random number generator, and that order was shared across all participants.

General Procedure. Sessions 1, 5, and 10 were probes and sessions 2-4 and 6-9 were conditioning. Participants had no restrictions on their food or water consumption prior to sessions and each session lasted about 20 minutes. The primary researcher presented instructions, collected data, and, on conditioning sessions, delivered edibles.

Probes. During probes, participants had access to water and three plates of four edibles each, ordered E1, E2, and E3. 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 contacting the edible, followed by the edible's removal from the plate. Before beginning, the researcher presented the following instructions:

> "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. Please keep your mask up at all times and only lower it when eating or drinking. Do not touch anything else in the room, other than the snacks, water, and your mouse."

Conditioning. During conditioning sessions, participants had free access to water and their computer mouse and the researcher presented edibles according to their programmed time. Twelve edibles were delivered (i.e., 4 of each 3 types) to ensure the number of edibles were constant across training and probe trials. During the instructions, participants were told that edibles were delivered when they met a predetermined goal (i.e., a deception) and to consume edibles as soon as they were delivered. The instructions were read as follows:

> "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 mouse."

If the game malfunctioned (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. The researcher then loaded the next game to play for the remainder of the fifteen min session. This scenario occurred once for P4 only.

Dependent Variables and Measurement. Data were only collected during probe sessions, given that participants had no opportunity to independently select edibles (i.e., the DV) during conditioning trials. and consisted of recording the time each edible was chosen. Data were analyzed on two levels: stimulus class (i.e., any edible) and individual stimulus (i.e., particular edibles), and both in terms of overlapping with a stimulus change.

Procedural Integrity and Interobserver Agreement. A random number generator was used to determine which sessions a second observer would take interobserver agreement (IOA; 50% of probe sessions) and procedural integrity (35% of all sessions) data across all participants. Both IOA and procedural integrity for probe sessions were completed via video recordings after all participants had given consent for their videos to be reviewed.

Procedural integrity as scored by the secondary researcher was 169/170 or 99.41%. Due to video recording limitations, some items could not be verified (e.g., door being closed, personal devices being turned off). For IOA, 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. IOA was 100%.

Post-Study Assessments. Participants conducted a sensory discrimination test, matched to their assignment (i.e., either sounds or colors). Two sounds/colors were presented sequentially, and the participant indicated if the two sounds were the same. Each sound/color used in the study was presented with itself and with each other sound/color at least once. This test was completed at the end of the study to decrease reactivity and priming effects. Both color-assignment participants (i.e., P1 and P4) scored 100%, whereas the two sound-assignment participants (i.e., P2 and P3) scored 10/12 and 7/12, respectively. These latter results could have altered the effectiveness of conditioning sessions.

Debrief and Exit Survey. Following the discrimination test, the researcher debriefed with each of the participants. Participants had been told during sessions they would receive edibles when they met a specific point goal; the researcher clarified there was no goal and edibles were presented according to predetermined times. 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 to provide more information on their experience. While subjective, some responses suggested limitations to the study. For example, all participants reported choosing certain edibles due to preference, and P1 and P3 both claimed they knew stimulus changes and edibles were paired together. What is most notable is 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 there were multiple competing MOs. Similarly, P2 claimed 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.

RESULTS

Figure 1 depicts the analyses for P1 and P4; P2 and P3 are described only in text for clarification purposes (see supplemental files for copies of these graphs). Matches refer to a participant selecting an edible during the stimulus change event it was paired with during training (e.g., an E1 select during a C/S1 event). Overlaps refer to selections during non-paired stimulus change events (e.g., an E1 select during a C/S2 or C/S3 event). Bar graphs represent the timing and duration of stimulus changes. Circles, squares, and diamonds represent timing of edible selection anchored to the *x*-axis and order of edible selection anchored to the *y*-axis. Circles represent edible selection outside of events, squares represent edible selections that overlap any stimulus change event, and diamonds represent edible selections that match the stimulus change event it was paired with during training. Blue, green, and orange bars represent C1, C2, and C3 (control) presentations, respectively. Blue, green, and red shapes represent E1, E2, and E3 (control) selections, respectively.

P1 consumed 12 edibles in the first probe; of those twelve, one was overlapped and two were matched. After training, on the second probe, they consumed 12 edibles (4 overlapped; 0 matched). On the third probe, they consumed 12 edibles (3 overlapped; 1 matched). P4 consumed 10 edibles in the first probe (1 overlapped; 0 matched). They consumed 9 edibles in the second probe (0 overlapped; 0 matched) and 10 edibles in the third (2 overlapped; 2 matched [1 of each of the stimulus-edible pairings from training]). P2 and P3 experienced sound changes during training and probes. P2 consumed 2 edibles in the first probe, 4 in the second, and 2 in the third; no overlaps or matches occurred. P3 consumed 4 edibles in the first probe (1 overlapped; 0 matched), 6 edibles in the second probe (1

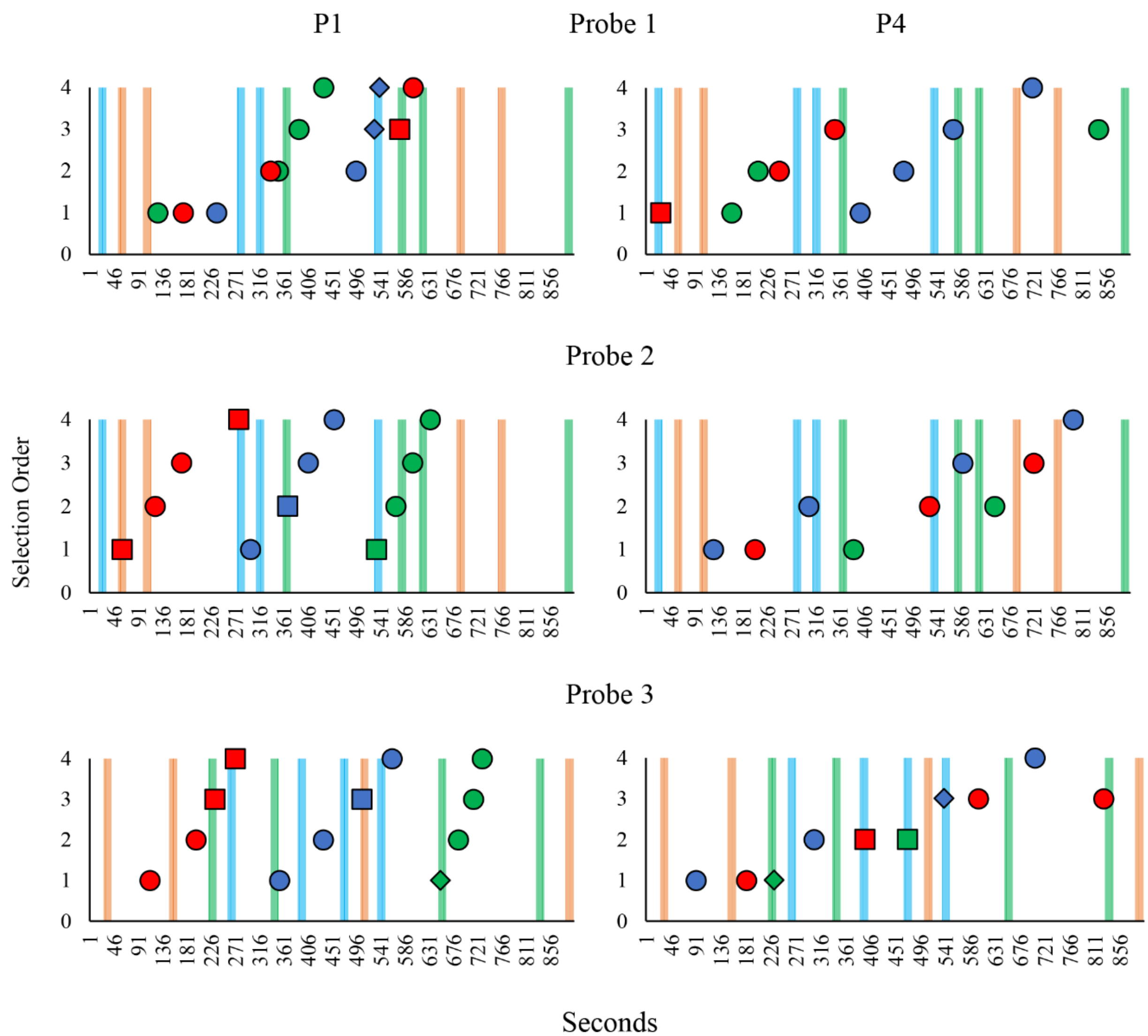

Figure 1. Stimulus change timing, edible selection timing, and selection order on probe sessions for P1 and P4.

overlapped; 1 matched) and 4 edibles in the third probe (0 overlapped).

DISCUSSION

P1 and P4's data suggest moderate evidence of a CMO-S. For these two participants, edible consumption in the presence of any alternative color during probes increased over the course of the study. While an increase was observed, neither participant reached consistent or high levels of overlapped or matched selections (e.g., 6-12) by the final probe, suggesting moderate, rather than strong, evidence of an observable effect. While both participants mentioned in their exit survey that they chose edibles in the order of their preferences, the timing of those choices is most important. As more training trials occurred, they made more selections during stimulus change events; suggesting edibles were more valuable at those times and a general CMO-S effect may have occurred. The development of at least a general CMO-S effect is further supported by noting both P1 and P4 scored 100% on their sensory discrimination tests, suggesting that pairing opportunities were salient and thus more likely to produce an effect during probe trials. Contrastingly, P2 and P3 both failed their sensory discrimination tests and did not produce an effect during probe trials, suggesting salient pairings are needed to produce an effect. Further, consider that P1 and P4 had color-changing sessions with salty snacks and P2 and P3 had chocolate snacks with sound-changing sessions. Perhaps particular combinations of stimuli and MOs 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 MO subtype.

A few limitations are worth exploring. The exit survey results suggest the preference assessment was not successful in identifying equally neutral, or neither highly nor non-preferred edibles. For example, during probe sessions, P1 typically ate all of the 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 intervals. Additionally, competing MOs might have influenced participant responding. Consider that exit surveys suggested some participants were more thirsty than hungry or did not want the snacks during the session. Future research would do well to explore more effective methods of establishing neutral stimuli for pairing purposes, either by using better assessments (e.g., progressive ratio assessments) or by using arbitrary stimuli, perhaps tokens.

Points were worth more during supplemental or alternative stimulus conditions and edible consumption during these times might have interfered with the participant's ability to earn points. If this was indeed an interfering MO, it would be interesting, as point accumulation was meaningless; participants were told points were used to determine when edibles would be delivered during training (a deception), and edibles were provided in a free operant format during probes.

P2 and P3 both failed their sensory discrimination test. It is unclear why failures occurred, as the sounds are arguably distinct (see supplemental files for a sample of each sound). Speculatively, participants were not motivated to respond correctly during this task, instructions did not acknowledge they could ask for sounds to be repeated, and the interstimulus interval between sounds each could have contributed to the failed discrimination test.

Due to scheduling conflicts, P2 and P3 played the same game twice in the same day, each game separated by just a few minutes. 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 could interfere with the CMO-S procedure. Additionally, spacing out sessions could 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.

The results of this study suggest the CMO-S is worth pursuing; however, researchers may need to adapt different methods when designing their studies to create successful demonstrations and improved data analysis methods (e.g., conditional probability analyses to account for chance responding). For example, this study demonstrated an effect could occur despite no active creation of an MO, which differs from previous research on this concept. Researchers must control for AO effects, which were likely present in this study. Researchers should also consider preparedness to find the most effective combinations to create a specific or general CMO-S effect.

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