



# The effect of the magnitude of the food deprivation motivating operation on free operant preference in mice



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## ABSTRACT

A number of recent studies have demonstrated that organisms prefer stimuli correlated with food under high deprivation conditions over stimuli correlated with food under low deprivation conditions. The purpose of the present study was to extend the literature on this phenomenon by testing for preference under extinction conditions, testing for preference at baseline, employing a free operant preference test, and using mice as subjects. Our results appear to support the existing literature in that most subjects preferred a stimulus correlated with food under high deprivation conditions in the post-training preference test. We provide an analysis of this phenomenon based on the concept of the motivating operation (MO) and discuss how this analysis suggests a number of avenues for further research on this topic.

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## 1. Introduction

In the behavior analytic literature, the term motivating operation (MO) has been advanced to refer to the class of organism–environment interactions that affect organisms' subsequent interactions with their environments by altering the extent to which stimuli function as reinforcing and/or aversive (Laraway et al., 2003; Michael, 1993, 2004). Examples of MOs include various deprivations (e.g., food, water, sleep, or sex deprivation), aversive stimulation, drug intake (Valdovinos and Kennedy, 2004), pain/illness (O'Reilly, 1997; O'Reilly et al., 2000), and events associated with emotions (Lewon and Hayes, 2014). All such events are held to have two functions. First, they alter the value or efficacy of events as reinforcers and/or aversive stimuli. Second, they serve to evoke that part of organisms' repertoires related to the events whose values are altered by the MO. For example, food deprivation is a commonly manipulated MO in laboratory experiments. Food deprivation functions as a MO that increases the value of food as a reinforcer and evokes that class of an organism's responses that has been reinforced with the receipt of food in the past. MOs are distinguished from discriminative stimuli by noting that MOs pertain to the differential effectiveness of outcomes as reinforcers and/or aversive stimuli, while discriminative stimuli are those stimuli that

have been correlated with the differential availability of reinforcers and/or aversive stimuli (Michael, 1982).

A number of basic researchers have begun to examine the relation between MOs and preference for stimuli. Typically this is done in the laboratory by manipulating the food or water deprivation levels of subjects (i.e., imposing either low or high deprivation conditions) prior to training sessions and correlating one stimulus (e.g., stimulus lights, tones, or goal boxes) with food or water delivery under high deprivation conditions and a different stimulus with food or water delivery under low deprivation conditions. Subsequent to this training, subjects are exposed to a preference test procedure whereby one response alternative is either made in the presence of or produces the stimulus correlated with food or water under high deprivation conditions and the other alternative is either made in the presence of or produces the stimulus correlated with food or water under low deprivation conditions. The proportion of responses on the alternative that is either made in the presence of or produces one stimulus relative to the proportion of responses for the other alternative is taken as a measure of preference. In this way, researchers may assess relative preferences for stimuli correlated with reinforcers under different motivational conditions.

While earlier studies failed to demonstrate consistent preference for a stimulus that had been correlated with reinforcers under high deprivation conditions relative to one that had been correlated with reinforcers under low deprivation conditions (Brown, 1956; Capaldi et al., 1983; Hall, 1951; Wike and Farrow, 1962), a number of recent studies have suggested that subjects do indeed appear

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to prefer stimuli correlated with reinforcers under high deprivation conditions. As a representative example, [Marsh et al. \(2004\)](#) demonstrated preference for a stimulus correlated with food reinforcement under high deprivation conditions using 12 wild-caught European starlings as subjects. In high deprivation sessions, subjects pecked a colored key that produced food reinforcement on an FR-1 schedule. In low deprivation sessions, they pecked a key of a different color, which produced food reinforcement on the same schedule. After receiving this training, the birds were then tested for preference between the two colored keys. During the test, the subjects were presented with both of the two colored keys encountered during training. The first peck to either key extinguished both colored keys and produced food reinforcement. Ten trials of this sort were conducted when subjects were under high deprivation, and ten trials were conducted under low deprivation. As measured by the proportion of responses on either alternative during the 20 choice test trials, all twelve subjects significantly preferred to respond to the colored key that had been correlated with food under high deprivation, and this preference was exhibited when tested under both high and low deprivation levels. Similar results have been reported with replications using locusts ([Pompilio et al., 2006](#)), pigeons ([Vasconcelos and Urcuioli, 2008](#)), and fish ([Aw et al., 2009](#)).

While such results demonstrate what seems to be a functional relationship between higher deprivation levels in effect at the time of correlation between a stimulus and a reinforcer and subsequent preference for that stimulus, there are a number of procedural issues that warrant further investigation. First, all but one of the recent studies cited above utilized a preference test procedure in which the delivery of food followed each choice trial. Such procedures have the benefit of avoiding the effects of extinction, since stimuli are never correlated with the absence of food. In so doing, however, they introduce a potential confound in that whichever stimulus the subject chooses in the first discrete trial has then been correlated with more food deliveries than the alternative. These additional correlations of the stimulus with food may ensure that the subjects increasingly prefer a particular stimulus because it has been correlated with food more times than the alternative. Even if this is not the case, subjects may choose to continue to respond on the alternative that they chose first simply because food has been and continues to be delivered following responses on that alternative. [Vasconcelos and Urcuioli \(2008\)](#) attempted to control for this potential confound by arranging it such that food reinforcement during preference tests occurred randomly 50% of the time, regardless of which alternative the subjects chose on each trial. Nevertheless, the potential for confounds remains when the number of stimulus-reinforcer correlations between alternatives is not explicitly controlled throughout the experiment.

The second limitation of the studies published to date is that, as [Meindi \(2012\)](#) has noted, they have not measured baseline preference for the stimuli to be correlated with reinforcers. While it is unlikely that subjects would exhibit a pre-existing preference for particular colored keys, tones, or goal boxes prior to training, the failure to assess preference prior to training does not rule out the possibility of biases for either alternative. Performing a baseline test for preference prior to the correlation of stimuli with reinforcers could explicitly demonstrate that preference for one stimulus relative to the other came about via the training procedures employed in the studies.

Finally, all of the studies cited above utilized discrete trial tests for preference, in which all choice opportunities and inter-trial intervals (ITIs) were determined and scheduled by the experimenter. On each trial, subjects were given one choice between a high and low deprivation stimulus, and each choice response produced a single outcome followed by an ITI. Free operant procedures have the benefit of removing experimenter-imposed constraints

on responding. Subjects may respond at any rate, and such procedures allow them to distribute their responses among available alternatives. Allowing subjects to respond freely and on either alternative concurrently (where they may switch between the two at any time) may reveal more about the extent to which organisms prefer stimuli correlated with reinforcement under higher levels of deprivation.

The purpose of the current study was to expand the literature pertaining to relative preference for stimuli correlated with reinforcers under different MO conditions in several ways. We attempted to address a number of potential limitations in the existing literature by including a baseline test for preference, testing for preference under extinction conditions, and employing a free operant preference test to determine if the results obtained in previous studies which used discrete trial tests may be replicated using a testing procedure in which subjects were able to freely switch between alternatives without constraint. Furthermore, while the studies cited above have demonstrated relative preference for a stimulus correlated with reinforcers under high deprivation conditions with locusts, fish, and birds, this phenomenon has not yet been demonstrated with other species. As such, we performed this study using mice as subjects to evaluate the generality of this phenomenon.

## 2. Materials and methods

### 2.1. Subjects

Twelve experimentally naïve female BALB/c mice served as subjects for this study. Subjects were randomly assigned to one of two groups for the purposes of counterbalancing the order of sessions and the stimuli correlated with food reinforcement under high and low deprivation conditions. All subjects were between 10 and 12 weeks of age at the beginning of training and were housed in clear plastic home cages in groups of three. A temperature- and humidity-controlled colony room in which subjects were housed outside of experimental sessions provided for a 12:12 h light/dark cycle with lights on at 7:00. All experimental sessions were conducted during the light portion of the diurnal cycle. When not deprived of food in preparation for experimental sessions, subjects had free access to water and chow.

### 2.2. Apparatus

All experimental sessions were conducted in Med Associates<sup>®</sup> modular mouse operant chambers. The dimensions inside each chamber were 12.7 cm high × 15.9 cm wide × 14.0 cm deep. From the subject's perspective facing toward the front of the chamber, the left and right walls of the chambers were composed of transparent polycarbonate, while the front and back walls were composed of three modular columns of aluminum panels. Each chamber was housed in a sound attenuating cabinet with a ventilation fan to mask ambient noise. On the front wall of each chamber, a food receptacle (entry port measuring 2.5 cm high × 2.9 cm wide × 1.9 cm deep) was mounted in the center column 0.5 cm above the grid floor. Purina Test Diet 20 mg peanut butter-flavored pellets were delivered into the receptacle as reinforcers. Illuminable nose poke apparatus were mounted 3 cm to either side of the food receptacle. One nose poke apparatus was to the right of the pellet receptacle and the other was to the left of the receptacle from the subjects' perspectives. These two apparatus will heretofore be referred to as the right nose poke and left nose poke, respectively. The access port for each apparatus measured 1.3 cm in diameter by 1 cm deep. Entry of subjects' noses at least 0.64 cm into the apparatus defined a response.

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