University of Nevada, Reno

Valuation of objects versus images: The extent to which real object displays influence consumer decision making

A thesis submitted in partial fulfillment
of the requirements for the degree of

BACHELOR OF SCIENCE, NEUROSCIENCE

by

MENKA WEBSTER

Jacqueline Snow, Ph.D., Thesis Advisor

December, 2014

UNIVERSITY OF NEVADA RENO

THE HONORS PROGRAM

We recommend that the thesis
prepared under our supervision by

MENKA WEBSTER

entitled

Valuation of objects versus images: The extent to which real object displays influence consumer decision making

be accepted in partial fulfillment of the
requirements for the degree of

BACHELOR OF SCIENCE, NEUROSCIENCE

____
Dr. Jacqueline Snow, Ph.D., Thesis Advisor

____
Tamara Valentine, Ph.D., Director, Honors Program

December, 2014

Abstract

Recent research has shown that behavioral and brain responses are different for real objects versus pictures of the same items. This project tests whether the display format (real objects versus images) in which foods are viewed influences consumer decision making. After bidding on items, participants viewed the same items, with a subset replaced by real objects. They then had to choose between several pairs of images that had equal initial value, but were previously presented as different display types. Real food objects were hypothesized to elicit higher value as measured by monetary bids because they present the observer with the potential for physical interaction (whereas images do not). However, the results did not reveal a significant effect of presentation format: real objects and images did not differ for high-valued items, and objects were surprisingly chosen less than images for low-valued items. The factors contributing to these effects and their implications are discussed. For the conditions tested, the results suggest that real world objects may primarily bias consumer choices against items – by adversely affecting choices for items that are not highly valued while not promoting choices for items that are valued.

Acknowledgement

I would like to thank Dr. Jacquie Snow for serving as my mentor. Under her guidance, this has been both an enjoyable and educational experience. Furthermore, I would like to thank Mike Gomez, a graduate student in Dr. Snow's lab, who ran the study with me. I would also like to thank Dr. Tamara Valentine for her guidance, comments, and feedback on my thesis throughout the year. Finally, I would like to thank all of the participants in my study who helped me with my research by patiently staring at delicious food items while on an empty stomach!

Table of Contents

List of Figures

INTRODUCTION

Much of what we know about how people perceive and respond to visual stimuli is based on the study of two-dimensional (2D) images. Although images allow observers to recognize objects and scenes, these display formats are not equivalent to real world objects in real-world settings, and the question of whether “reality” matters has for the most part been overlooked. Specifically, the ways in which observers perceive tangible real-world three-dimensional (3D) objects, in comparison to 2D images of objects, is a largely unexplored area of empirical research. Yet in the few cases where differences of display types have been examined (Holmes and Heath, 2013; Kwok and Braddick, 2003; Humphreys and Riddoch, 1987; Mischel and Moore, 1973; Bushong et al., 2010) important differences between real objects and image displays have emerged.

In this thesis I examine whether previous exposure to real world snack foods (versus 2D color photographs of snack foods) influences consumer decision making- i.e. how people make choices when selecting items. The current hypothesis is that the physical presence of a real snack food can trigger automatic motoric consummatory processes (such as intention or preparation to grasp) that when executed, lead to contact with the appetitive food – actions that cannot be performed with 2D pictures of foods. Specifically, real foods might be associated with rewards, and thus with the actions that lead to those rewards (eg. reaching to obtain the food). Here I examine whether the potential for interaction with real snack foods is sufficient to bias decision making in a subsequent two-alternative forced choice situation. I hypothesize that snacks viewed in the form of tangible real world objects will be selected more often than chance at the time of consumer choice, whereas foods that are viewed as 2D photographs (although initially rated as equally desirable) will be selected comparably less frequently.

Preliminary research in the field of economic decision-making suggests that real objects may be valued more than images - as measured by the amount in dollars that observers are willing to pay for a food item (Bushong et al., 2010). Aside from the question of the underlying mechanism that drives the ‘real object advantage’ reported by Bushong et al., (2010), the question remains as to whether consumer *decision-making* is affected by real object displays (over and above ‘valuation’ as measured simply by willingness-to-pay, as in Bushong et al’s 2010 study). Bushong et al. (2010) investigated willingness-to-pay for real objects versus visual images of the same items, by presenting participants with food stimuli in the form of text displays, colored photos, or real objects. The possible influence of display format on decision-making is important from an economic perspective because in a purchasing situation consumers are typically faced with making a choice between two or more competing but equally desirable options. If display format can increase the competitive advantage of one item over another, this advantage could have a powerful influence not only on consumer behavior, but on marketing strategies. For example, would it be better to encourage the consumer to come into the store, or to purchase online?

With respect to consumer decision-making behavior, a recent study by Schonberg et al., (2014) investigated the factors that influenced consumer choice and found that decisions between items were influenced by whether or not participants were required to learn to make a speeded motor response to the item prior to the time of choice. In the study by Schonberg et al., (2014), however, the food stimuli were only presented as computerized 2D color photographs, and the motor response involved a button-press on a keyboard – a task that had no specific relevance to the food item displayed (and clearly would not lead to physical interaction with the depicted food item). Critically, however, the study by Schonberg et al., (2014) suggests that there may be an important causal relationship between the preparation of a physical motor response towards a stimulus, and the subsequent effect on consumer choice.

In this study I extend upon the previous research of Bushong et al., 2010 and Schonberg et al., 2014 by examining whether decision-making behavior is influenced by prior exposure to a stimulus that affords the *potential for physical* interaction, but for which no overt motor response is required. In other words, I examine whether or not *potential* for action is sufficient to bias decision-making behavior. Using an analogous experimental 'training' paradigm to that of Schonberg et al., (2014), I investigate whether the format in which a snack food is displayed (real object versus image) during training has an influence on participants' subsequent food choice preferences.

Based on the results of Schonberg et al. (2014), and previous research involving real world objects (Holmes and Heath, 2013; Kwok and Braddick, 2003; Humphreys and Riddoch, 1987; Mischel and Moore, 1973; Bushong et al., 2010), I predict that when faced with a decision between two equally desirable food items, participants will be more likely to select items to which they previously had exposure to as real foods than as color photographs of foods.

LITERATURE REVIEW

Object perception is the perceptual process in which the visual system extracts the shape and identity of objects through analysis of the 2D image projected on the retina. (Kourtzi et al., 2003). This process occurs in the ventral visual pathway (Goodale and Milner, 1992; Riesenhuber and Poggio, 1999), a pathway in the brain that starts in the primary visual cortex and progresses anteriorly and ventrally along the temporal lobe to ‘higher-order’ object-selective areas in the lateral occipital complex (LOC) and ventral occipito-temporal cortex (vOT).

Importantly, however, there are a number of fundamental differences between real objects and images that may influence how the two stimulus types are processed in object-selective areas. When we look at real objects with both eyes, we perceive them in depth (due to stereopsis), unlike 2D images, which we perceive as being flat. As a result, viewing real objects provides additional 3D shape information than 2D images. Furthermore, monocular depth cues, which require one eye to provide information about depth, size, and texture, and binocular depth cues, which provide information about depth when both eyes are used, are consistent with each other for real objects. Conversely, for images, monocular depth cues (such as shadows) indicate depth, but binocular cues indicate flatness – thereby leading to ‘cue conflicts’ for 2D images, but not real objects (Ban et al., 2012). Perhaps most importantly, real objects offer the potential for physical interaction. Indeed, *some* types of real objects, namely foods, may be viewed as being particularly important for the participant in that they offer not only the opportunity for touch, manipulation and usage, but for taste and consumption –factors that arguably could further bolster perceived value in terms of enjoyment, nutrition, health, and ongoing survival.

Yet despite these and other fundamental differences between viewing real objects and pictures, there is not an extensive amount of research that explicitly compares the effects of these two types of stimuli on cognition. Although this seems surprising, there are a number of pragmatic reasons for using 2D images in place of real objects in the context of laboratory research. In particular, real objects are difficult to work with, in terms of ensuring their accurate presentation, sequencing, and timing. As is outlined in more detail below, however, recently emerging data suggest that 2D images are *not* appropriate proxies for real objects in experimental settings (Humphreys and Riddoch, 1987; Mischel and Moore, 1973; Bushong et al., 2010). The desire to conduct easily executable, controlled experiments in the lab may thus have been prioritized at the expense of the generalizability of the data to real world stimuli and contexts.

There are a number of lines of evidence to suggest that 2D images are not appropriate proxies for real world objects, from neuropsychological studies in human patients, to behavioral psychology and economics, to neuroimaging. First, evidence from case-studies in patients with brain damage suggests that display format can have a profound impact on object recognition. Patients with damage to brain areas responsible for object recognition (i.e., LOC) have difficulty recognizing objects – a neurological condition known as visual object agnosia (Chainay and Humphreys, 2001). Interestingly, however, patients suffering from agnosia are better at recognizing objects when they are displayed as real 3D exemplars, compared to when they are 2D photos (Chainay and Humphreys, 2001; Servos et al., 1994). The ability of these patients to identify more accurately real objects as opposed to images suggests that display format has a significant influence on object perception and recognition, though the mechanism for this effect is currently unknown. These results are important because they suggest that there may be different neural mechanisms that are engaged in the processing and / or representation of real objects versus images.

Second, evidence from behavioral psychology indicates that there are important differences between real objects versus 2D images on cognition. In a recent study of human memory, Snow et al., (2014) examined whether the format in which objects were displayed influenced learning and recall. In this study participants were asked to remember a large set (n= 44) of everyday household objects. Critically, the objects were presented either as colored images, black and white line drawings, or real world exemplars. The results indicated that real objects were freely recalled and recognized significantly better than objects that were presented as matched black and white line drawings or colored photographs. The same effects were replicated in a follow-up experiment. Taken together, these results indicate that real objects have qualities that make them more memorable than images. Although the Snow lab is currently investigating the mechanism for this effect, their results provide further evidence that objects and images are processed differently in the brain – effects that could potentially influence how observers *value* objects shown in different display formats.

Third, neuroimaging evidence suggests that there may be important differences in the way real objects and images are stored or represented in the human brain. Functional magnetic resonance imaging (fMRI) is a technique used to monitor noninvasively neural activity by measuring changes in blood flow in the brain while observers perform different tasks. In fMRI, the repetition of an image of a given stimulus results in a characteristic reduction in the blood-oxygen-level dependent (BOLD) response, compared to when a series of different object images are presented (Krekelberg et al., 2006; Grill-Spector et al., 2001). This so-called ‘fMRI repetition effect’ has been observed many times using images of objects (Grill-Spector et al., 2001). Surprisingly, the same effect is weak if not absent for real objects (Snow et al, 2011). This study suggests there might be important qualitative differences in how real objects versus images are encoded in the brain - a result that has also been suggested by other researchers (Vuilleumier et al., 2002). However, few fMRI studies have incorporated real objects, and fewer still have directly compared fMRI responses to real world objects versus 2D images, and thus little more is known about the differences in neural processing between the two stimulus types.

A further line of research that demonstrates potentially important differences between real objects versus images comes from behavioral studies in the field of economics, which suggest that observers may place more value upon real objects than images (Mischel and Moore, 1973). For example, the early ‘Stanford marshmallow experiments’ conducted by Mischel and colleagues (1973) examined the ability of young children to exert self-control when presented with appetitive real foods. The children were presented with a food item, such as a marshmallow or pretzel, and were told that they could either eat the food item immediately, or wait 15 minutes for the experimenter to return, at which time they would be rewarded with a treat which was of greater value than the single initial object presented. The researchers found that when children were presented with real food objects, their tolerance for delay was minimal (i.e., the children showed little capacity for delayed gratification). Interestingly, however, a follow-up study conducted by the same authors a year later found that children *did not* show the same failure of delayed gratification when they were presented with *images* of foods in the same type of task (Mischel, 1974). The authors speculated that images of appetitive foods are perceived by children as being less valuable than the real food items themselves, which affected their ability to wait for potentially more desirable outcomes. It is currently unclear, however, whether real food displays might have a similar influence on delayed gratification in adults because the study was only conducted in young children, and levels of impulsive behavior (and thus the ability to delay gratification) may vary between adults and children. To the extent that these effects transfer to adults, the results of Michel and colleagues suggest that the form in which food objects are displayed influences how they are processed and the subsequent behavioral responses they elicit (Mischel and Moore, 1973). Further, it is tantalizing to speculate as to whether the fact that the real food items were always within reach and could be consumed influenced the level of delayed gratification behavior shown by the children– although, again, this possibility has never been explicitly tested.

Adults have, however, been tested in a recent economic study by Bushong et al., (2010) that examined willingness-to-pay for real objects versus visual images of the same items. Bushong et al. (2010) presented college-aged students with food stimuli in the form of text displays, colored photos, or real objects and examined whether the value of items changed depending on the ways in which they were presented (despite the fact that each display type yielded a similar end reward – consumption of the real food item at the end of the study) – as shown in **Figure 1**. In this study, 'value' was operationalized in terms of the amount that the students were willing to bid for the food item from an allowance of $3.00, given to them at the start of the experiment. Bushong et al., (2010) found that students were willing to pay between 40-60% more for the real food items over the same stimuli displayed in the form of colored photos or text displays – even though the students were informed that they would receive the same (real food) reward at the end of the experiment. Specifically, the average bid when the stimulus was presented as text was 68 cents (SD=0.52), which is almost equivalent to the average bid when the stimulus was presented as a picture (71 cents, SD=0.53). Yet when the stimulus was instead presented as a real object, the average bid was significantly larger (113 cents, SD=0.61). A follow-up study by the same authors found that the beneficial effect of real objects on willingness-to-pay disappeared when a transparent barrier was placed between the participant and the food item.

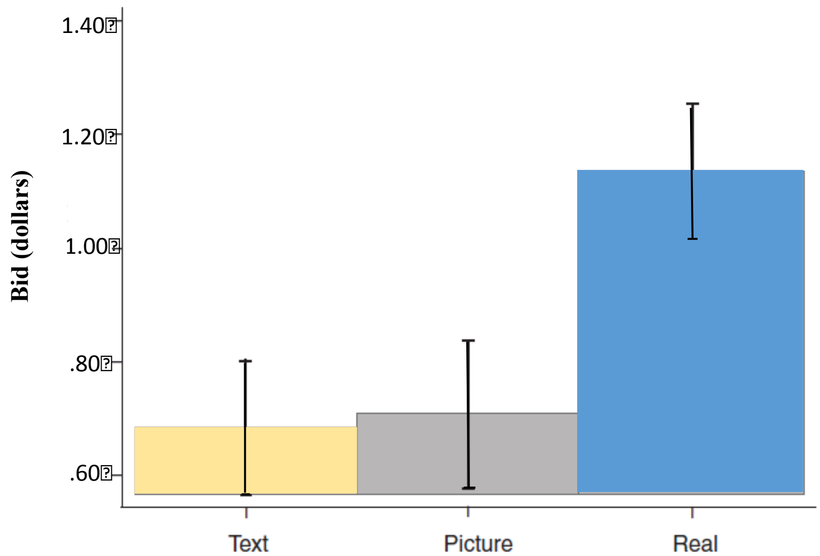

Figure 1.**The amount of money (in dollars) that participants bid on food items presented as text, pictures, and real objects.** The y-axis shows the amount that participants bid (in dollars) and the x-axis shows the ways in which the food item was displayed for the participant (text, picture, or real object) (Bushong et al., 2010).

Bushong et al., (2010) interpreted their participants' overall higher bid values for real snack foods as reflecting the automatic triggering of 'Pavlovian consummatory processes' (Balleine, 2005; Balleine et al., 2008). The argument is that animals learn to associate the presence of particular stimuli (i.e., edible foods) with a reward response (i.e., eating behavior); over time, the mere physical presence of the same stimulus (an appetitive food item) is sufficient to automatically elicit a behavioral response (i.e., approach behavior towards the rewarding food item). However, one potential difficulty with the above explanation is that the authors found a 'real object advantage' for both edible food stimuli *and* non-edible trinkets (such as mugs) – which presumably do not elicit a consummatory response but may, nevertheless, elicit a motor approach response relating to the physical use that the item affords the participant. A potentially more parsimonious explanation for the difference in value that Bushong et al's (2010) participants showed for real objects versus pictures is that real objects simply present the participant with the *potential for interaction* whereas pictures do not – that is, real objects *afford action* (Gibson, 1979; Norman, 2002). For example, observers are capable of grasping an apple or a mug, whereas an image of either item does not afford physical interaction.

The question of whether the potential for motoric interaction with real objects is a critical factor in driving the effects reported by Bushong et al., (2010) could be examined directly, for example, by manipulating the distance with which objects were placed in front of the participant, or by manipulating whether they were placed within reach of the dominant versus non-dominant hand (Gallivan et al., 2009; Gallivan et al., 2011). Unfortunately, recent attempts to *replicate* the results of Bushong et al., (2010) in the Snow lab at the University of Nevada, Reno (UNR) have not been successful. This could, in part, be due to a fundamental problem with the design of the original experiment. Bushong et al., (2010) tested participants in the photo and text conditions in groups, whereas participants in the real food condition were tested individually. It is possible that the one-on-one testing environment with the experimenter, as opposed to the group based environment, may have confounded the effect of stimulus valuation during the study. Although researchers have to date been unable to replicate the findings of Bushong et al., (2010) with snack foods – particularly when the design flaws are remediated by testing all participants in an individual context, this may not necessarily mean that adults do not value real objects more than images (cf: Mischel and Moore, 1973). It is possible, for example, that the task used by Bushong et al., (2010)- the Becker-DeGroot auction paradigm, is not *sensitive* enough to reveal potential differences between real objects and images on consumer responses. It is also possible that there are critical *participant* variables that are influencing the willingness to pay at the different study venues (i.e., students at Caltech vs. Reno NV). In any event, the basis and potential for differences in valuation of real and imaged objects remain unknown.

Despite the problems with the study by Bushong et al., (2010), other behavioral and imaging data (Snow, Rangel & Culham, in preparation) suggest that there are effects of real objects on the frequency with which food items are selected. Specifically, when participants were asked to rate (in the fMRI scanner) how much they wanted to eat foods at the end of the experiment, clear differences emerged between the frequency with which participants used strong versus weak preference ratings for the real snack foods versus matched images of the same items. Specifically, on a rating-scale of preference strength, strong preferences were provided significantly more often for real foods than for images of foods (which tended to elicit a greater number of weaker preferences). Moreover, in the study by Snow, Rangel & Culham, (in preparation) real objects amplified fMRI responses in the ventromedial prefrontal cortex (vmPFC)- a brain area linked with stimulus valuation (Rangel, 2013).

Another approach to testing the influence of display format on consumer decision-making is the ‘approach-training’ task recently described by Schonberg and colleagues (Schonberg et al, 2014) – as shown in **Figure 2**. In this task, participants were required to bid how much they would be willing to pay to receive different snack foods.

In particular, participants were presented with 60 food items (one at a time) that they bid anywhere from $0 to $3 on. They had the opportunity to win one of these snacks at the end of the study if their bids were higher than a randomly generated price for a randomly chosen item. After the Auction phase, participants were presented with a subset of these items: a quarter of the items were presented with a corresponding auditory tone, which required a simple motor response (button-press). Each item was presented 8 times in 8 repeating blocks, and each individual trial was separated by a jittered intertrial interval, which lasted 3 seconds on average. In a subsequent two-alternative forced-choice (2AFC) preference test, the authors asked participants to make a choice between a food item that was paired with the motor response, versus an item that was equally valued (initially) but was not previously paired with a motor response in the previous phase. The authors found that participants tended to choose the food item that was paired with the motor response significantly more frequently than those that were not (**Figure 3**). In a similar vein to previous studies (Bushong et al., 2010; Balleine, 2005; Balleine et al., 2008) the authors argued that the elicitation of a motor response was critical in biasing the decision that participants made in response to a given pair of food items (Schonberg et al, 2014).

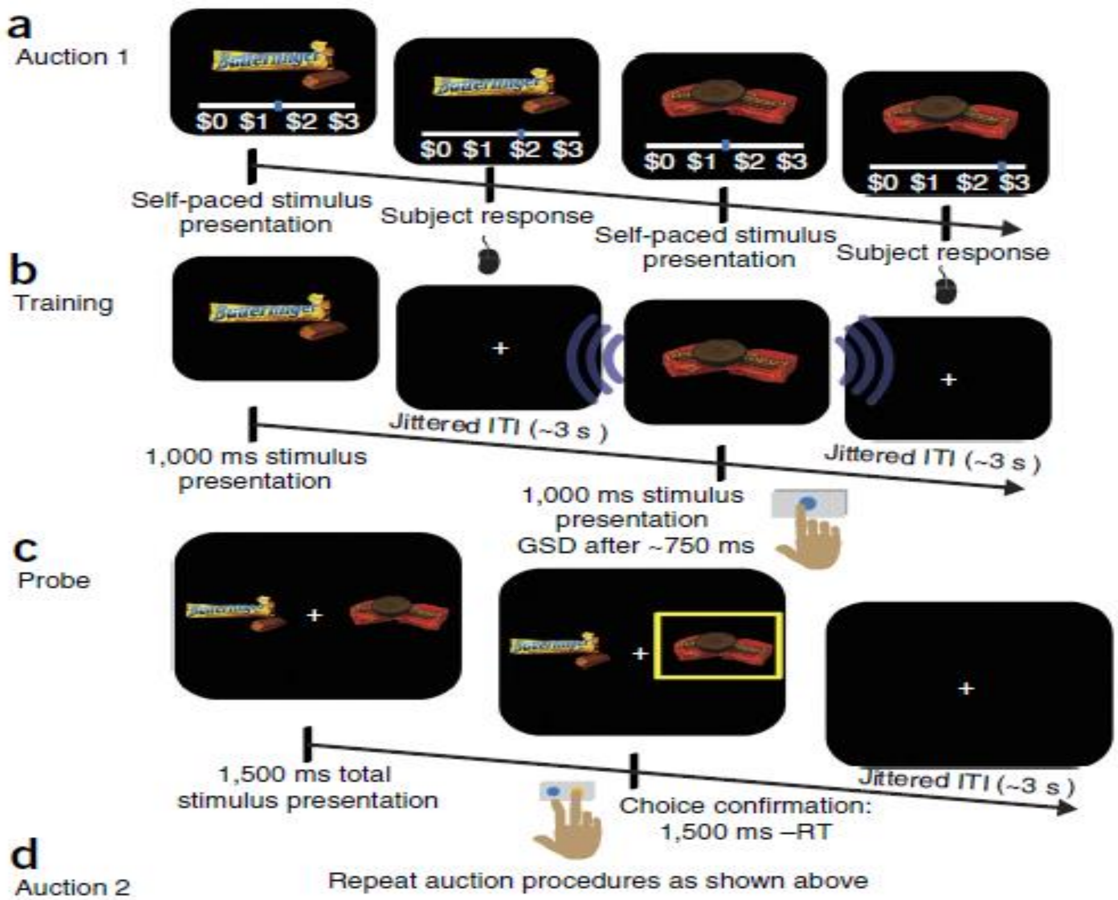

Figure 2. Tasks for cue-approach training study. Participants were required to complete 4 tasks (Auction 1, Training, Probe, and Auction 2). See text for details (Schonberg et al, 2014).

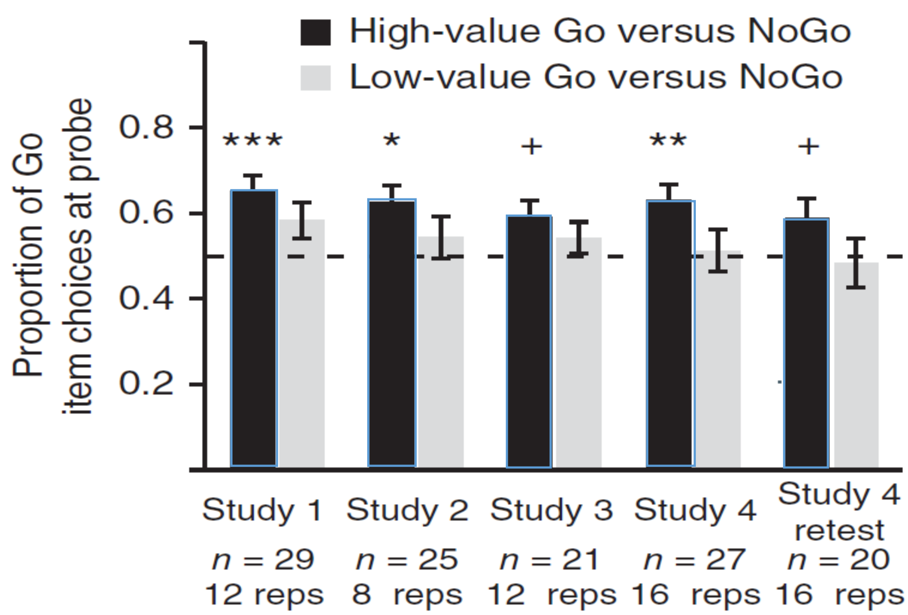

Figure 3. Behavioral results for cue-approach training study. The y-axis contains the proportion of choices for the items associated with a motor task during the Probe task. The x-axis shows the results for the various studies completed by Schonberg. "N" is the number of participants in each study and "reps" is the repetitions of each stimulus during the training. Across all studies, participants tended to chose items that had been associated with an auditory cue and motor response (Schonberg et al, 2014).

The aim of the current study is to determine whether the *potential* for motoric interaction with real objects (versus images) is sufficient to produce a similar bias in consumer choice as that reported by Schonberg et al., (2014) when participants were asked to actually perform a physical (but stimulus irrelevant) motoric action. We used a variant of the Schonberg et al. task, in which we eliminated the explicit motor response to images of food items, and replaced these trials with a display of a real snack food (for which a grasping response was possible, but not physically executed). Thus in the current study participants were not required to make a motor response to the stimulus, but could *potentially* interact with the food items. If real food displays automatically elicit motoric approach routines, and if the elicitation of approach routines can influence simple choice, then we should expect to see that two-alternative forced choices are influenced by the prior exposure to real object displays. This manipulation is used to determine whether the potential for action (with real foods) is sufficient to influence consumer choice, or whether a physical motor response is necessary to drive effects on decision-making. In turn, this will shed important new light on the underlying mechanism that drives the previously observed effects that real objects have on behavior and neural responses.

METHODS

Materials

This experiment tested human participants' preference for food items that were presented in one of two display types (real food vs. picture). As in Schonberg et al., (2014) there were three phases to this experiment: Auction phase, Training phase, and Probe task, as illustrated in **Figure 4.** The computer code that was used to execute the experiment was written in Python, and executed via a linux command window. Within the main Python code framework, separate sub-routines were run in Pygame, Matlab and R programming language. Additional Python and Matlab codes were developed for the Training phase of the experiment, where real objects replaced the images that were paired with auditory cues in the Schonberg et al. (2014) experiment, and PLATO (Portable Liquid-Crystal Apparatus for Tachistoscopic Occlusion) spectacles included to control viewing time for the stimuli (which in our case involved real food objects). Sixty common snack foods (e.g., Twix, Cheezits, Kit Kat, Pringles), and high-resolution color images of the same items, were used as stimuli. The stimuli included sweet, salty, and sour snacks - but all were items that were appetitive, based upon the stimuli used in previous studies of food preference outlined above. All snack foods were displayed with part of the contents removed from the packaging (as in previous food-based economic bidding studies), on a paper plate on the turntable (or as color photographs). A complete list of stimuli is provided in **Appendix A**. Each snack food was photographed on the turntable (described below) using a Canon Rebel T2i DSLR camera with constant F-stop and shutter speed. Image size was adjusted using Adobe Photoshop and the resulting photograph stimuli were presented on the monitor at a size that matched the real snack foods.

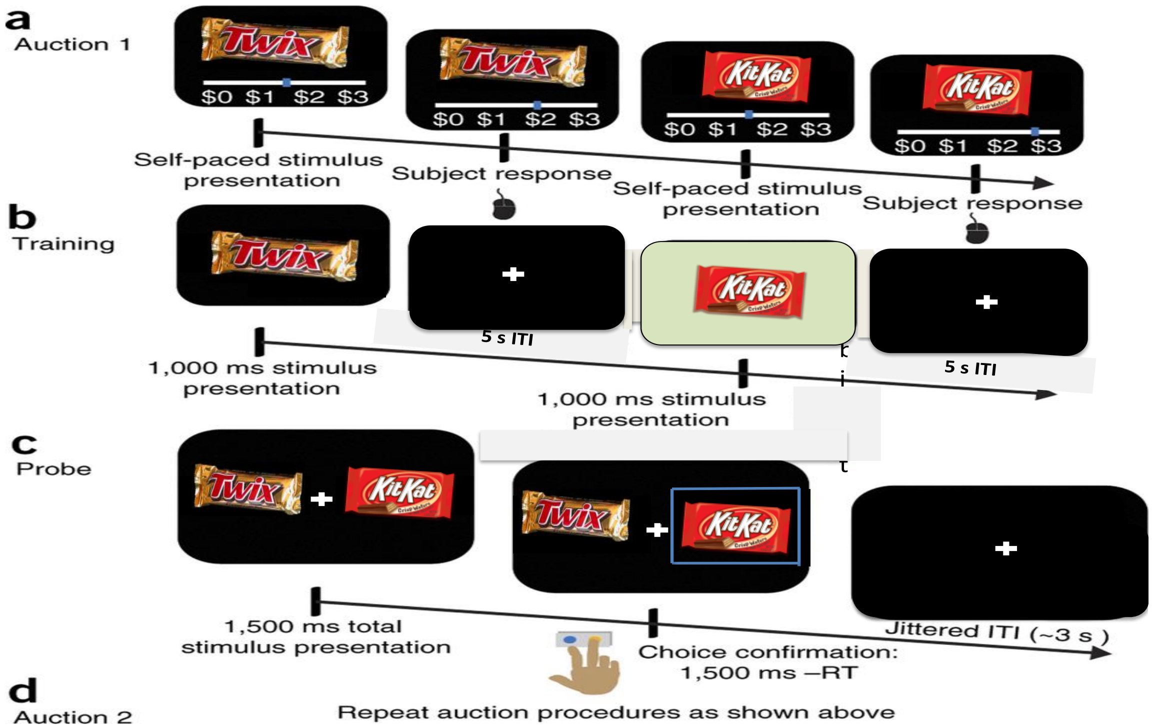

Figure 4. The three tasks of the experiment. (**a**) Auction phase- 60 food item images were presented to the participants, one at a time, and they were given the task of bidding $0 to $3, depending on how appealing these items were to them. The participants used the mouse cursor along a scale ranging from 0 to 3 to place their bids. **(b)** Training phase- participants passively viewed each of the snack foods from the Auction phase. The foods were displayed either as an image (75% of trials – shown in black box in the Figure), or a real food item (25% of trials – as indicated by the green box in the Figure). On each trial, the food stimulus was viewed for 1,000 milliseconds. Viewing time was controlled using PLATO LCD goggles controlled by a computer. Trials were separated by a 5 sec ITI. Real and pictorial stimuli were presented in random order, and the same order was used in each repetition of the Training phase. **(c)** In the Probe task participants had 1,500 milliseconds to choose between one of two items displayed on the computer screen. Trials were separated by jittered intertrial intervals, with an average ITI duration of 3 seconds.

Stimulus Presentation

PLATO goggles were used to control viewing time (see **Figure 5**). In order to present participants with a large set of snack foods that were shown in the form of real objects or 2D photographs, a rotating turntable was developed (**Figure 6**). The turntable, constructed of wood, was 335 cm in diameter and was divided into twenty cells. The radius of the turntable was 62 cm, with each cell subtending an angle of 18 degrees. The cells were separated by vertical dividers of height 61 cm. Each cell in the turntable was used to display individual food items. In front of the turntable was a vertical viewing aperture (51x58 cm when fully opened, otherwise 6x58 cm) through which participants could view the stimuli. To display images of snack foods on randomly interleaved trials, a 27-inch LCD monitor was positioned behind the viewing aperture.

Figure 5. The PLATO goggles worn by participants during the Training phase. The goggles include computer-controlled LCD panels within a plastic frame. The goggles were used to control the exposure duration of the stimuli during each trial. Participants wore these goggles during the Training phase of the experiment (which involved the presentation of real food items).

a b

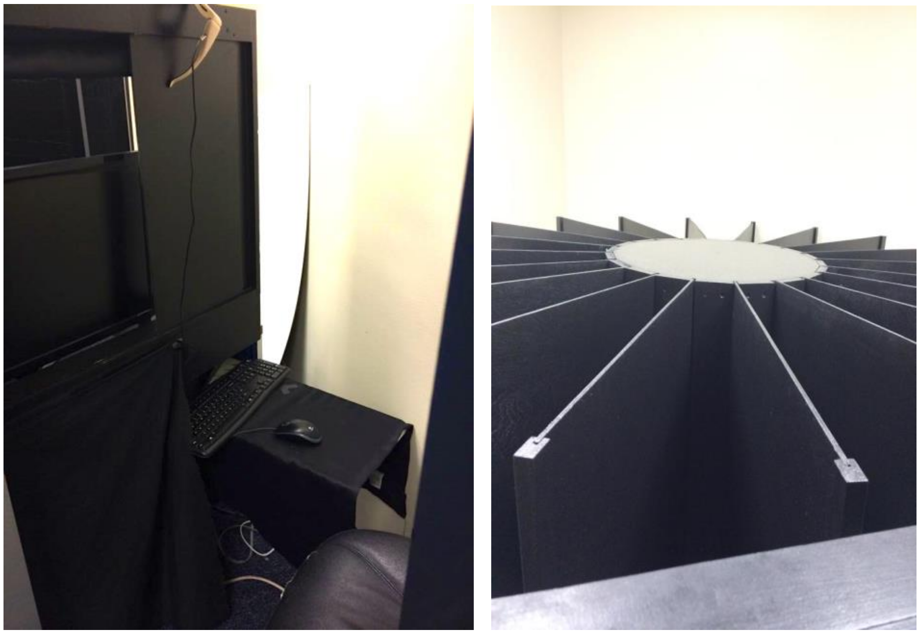

Figure 6. The experimental display. a) Experimental booth. Participants sat on the chair facing the computer monitor, which was either present or absent (to reveal the turntable that was directly behind the monitor) -- depending on whether or not participants were looking at an image or real object, respectively on each trial. The monitor was moved into/out of view by sliding it across the table behind the viewing aperture. **b) Turntable for displaying the items** A view of the turntable from above, showing the 20 display cells into which the food stimuli were positioned.

Participants

After the setup of the experiment, 16 college students (12 females) were recruited through the UNR Psychology participant pool (SONA system). Data from one participant were excluded from the group results due to incorrect performance during the Probe task. The first minute of data for the Probe task for one other participant was lost because the participant failed to complete the task correctly. Before signing up for the study, participants were informed via SONA that they would be shown various food items and would have to make monetary judgments about each item. The eligibility requirements were that the participants must have normal/corrected-to-normal vision, be at least 18 years old, must be able to provide informed consent, and have no clinical or psychiatric diagnoses. As in previous studies (Bushong et al., 2010) to incentivize food choices, participants were required to fast (excluding water) for *at least four hours* prior to participating in the experiment. All participants provided written informed consent in accordance with the experimental protocol approved by the university HSREB.

Procedure

Participants were tested between the hours of 1:00pm – 7:00pm; this ensured that all participants had sufficient time to fast and were making food choices at the time of day that they would normally consume snack foods. The study lasted approximately one and a half hours. Participants were first required to complete a questionnaire providing information about the time of their last meal, their level of hunger at the present moment (on a scale of 1-10, 1 being “not hungry at all” and 10 being “starving”), and the extent to which they liked to consume snack foods (on a scale of 1-10, 1 being “not at all” and 10 being “totally”) (**see survey in Appendix B**). After participants finished filling out the surveys, they were given the first set of written instructions for the experiment (**see instructions (taken from Schonberg et al. (2014) and modified) in Appendix C**). Participants were told that the goal of the experiment was to examine their snack food preferences. The participants were informed that they would be required to remain in the laboratory for an additional 30 minutes after completion of the experiment (as in previous studies using similar bidding procedures; Bushong et al., 2010; Hare et al., 2009). Participants were also told that they would be provided with the opportunity to acquire a snack during the first part of the experiment and this would be the only food item that they would be able to consume while they waited in the laboratory **(see instructions in Appendix C)**. Participants were paid $15 for participating in the experiment, and received three course credits (plus the remainder of their $3.00 allowance to spend on snacks during the study). As outlined above, the experiment consisted of three main experimental phases: Auction, Training, and Probe, followed by a final ‘Lotto’-like procedure in which the Auction was implemented. In the final part of the experiment, a single food item was selected for purchase.

Auction Phase:

Participants were led to the testing room that contained the turntable and computer screen. There was a small table in front of the computer screen on top of which was a keyboard, mouse, and $3 at the right-hand corner. Participants were seated in front of the table and monitor and the instructions were briefly reiterated. During each trial of the Auction phase (**Figure 4**), a single food item appeared on the computer screen, one at a time. Below the item was an analogue bid-bar anchored at each end with a value of $0 (min) to $3 (max). Participants entered a bid between $0 and $3 by clicking with a mouse (held in the right hand) on the analogue bid bar. There was no time limit on this part of the experiment and the following trial would not start until participants placed a bid on the current item.

Participants were advised that the $3 was theirs to keep, but that they could use that money in this part of the experiment to place a bid on each of the 60 food items that would be shown on the computer screen. They would be shown these items one at a time, and for each item, they would be able to bid from $0 to $3, depending on *how much they wanted that item at the moment*, rather than how much they thought the item would be worth in a convenience store. Importantly, participants were instructed that, based on their bids and decisions during the experiment, they would have the chance to receive one (real) unopened food item (out of the 60 items shown during the Auction phase) at the end of the study. Participants were told that they would be able to eat this single food item during their waiting period, but would not be allowed to eat any other food. Before beginning the Auction phase, participants completed three practice trials with the experimenters in the room. The practice trials involved food items that were not part of the set that the participants could purchase. After the practice trials were complete, the experimenters left the room and participants placed their bids on the 60 food items.

Upon completion of the Auction phase, a computer program was used to identify the eight highest and eight lowest valued items. These items would in turn be shown as real objects during the following Training phase. The program first placed the 60 food items in order (from highest to lowest value), based on the monetary bids of each participant. This list was then cut in half (the first half being the high item subset (numbers 1-30) and the second half being the low item subset (numbers 31-60). Within the high and low subsets, the first seven items and last seven items were excluded from being used as a real food item. Thus, these excluded items were shown as images during the next phase of the experiment. For the remaining items, there were two orders that could be selected (order one or order two). If order one was selected then numbers 8, 11, 12, 15, 16, 19, 20, and 23 (in terms of the ranking number) were chosen to be the high-valued real objects, and numbers 38, 41, 42, 45, 46, 49, 50, and 53 were chosen to be the

Low-valued real objects shown during the following phase. The other 22 items (in both the high and low subset of items) were shown as images. If order two was selected, then numbers 9, 10, 13, 14, 17, 18, 21, and 22 were chosen to be the high-valued real objects, and numbers 39, 40, 43, 44, 47, 48, 51, and 52 were chosen to be the low-valued real objects shown during the Training phase. Again, the remaining 22 items in each subset (in total 44 items) were presented to the participants as images, while the 16 high/low-valued items were shown as the actual food items.

Training Phase:

Participants were given the next set of instructions to read while waiting in a different room (**see instructions in Appendix C**). During this time the experimenters placed unwrapped real food items (Bushong et al., 2010) on a paper plate on a sector of the turntable. Once all 16 real food items were placed on the turntable, the participant returned to the testing room and again seated in front of the computer screen (**Figure 6**). The experimenters were separated from the participant by a curtain.

Participants were told that they would see the same 60 items that they just bid on, but some would be in the form of an image while others would be the actual item. Their only task for this part of the experiment was to passively view each item. The participant was once again asked if he or she had any questions and the instructions **(in Appendix C)** were briefly reiterated.

The experimenters were able to prepare the stimulus (real food versus photo) that would be presented to the viewer on the upcoming trial via a visual cue on a laptop connected to the computer screen. The exact image (or text) of a food item that participants would see appeared on a laptop for the experimenters five seconds before the actual trial. If the visual cue on the experimenters' laptop was an image, then the participant would see the item as an image and the experimenters would leave the monitor in front of the participant. However, if the item was a real object, this item would appear on the experimenters' laptop as text and the monitor would be slid back to reveal the object on the turntable. For example, if the item was meant to be a 'real' snickers bar, the text on the laptop would read "snickers bar" and the monitor would be moved to reveal this item on the turntable. The 16 real objects were placed in the order specified by the computer program (**Figure 7**).

While the experimenters moved the monitor and the turntable, the participants passively viewed each item. On each trial, participants were required to wear the PLATO goggles. The goggles became transparent for one second, thereby displaying the stimulus. This was followed by a 5 sec ITI during which the goggles became opaque, thereby preventing participants from seeing the experimenters preparing the following trial, or the rotating turntable. A sound masker (a speaker that emits white noise) was turned on during the ITI to block out any extraneous noise generated during stimulus changeover. After five seconds, the goggles would open again, revealing the stimulus for the following trial - either an image or object.

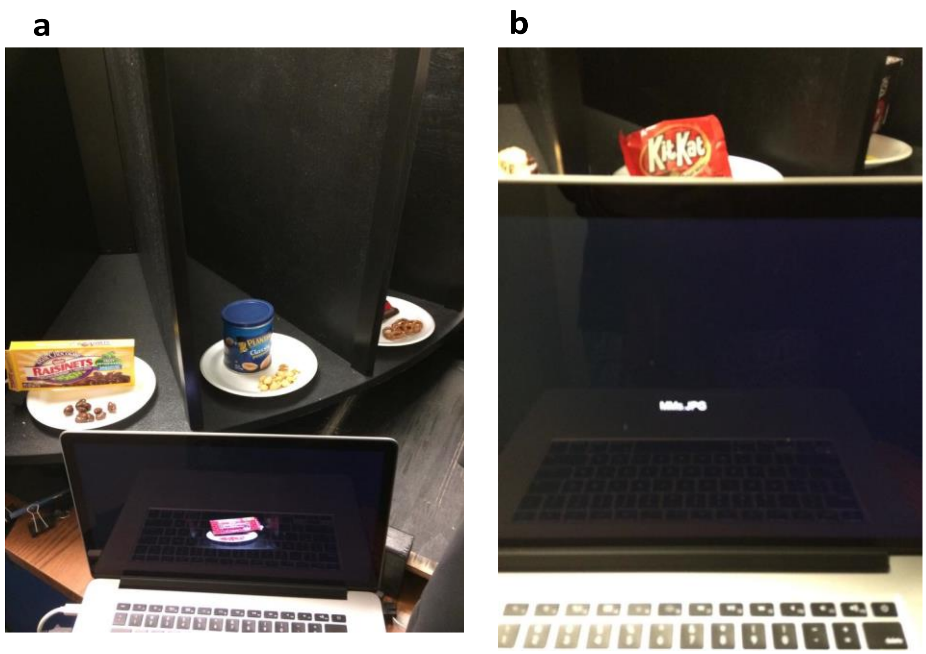

Figure 7. The experimenters' view during the Training phase. (a) An image of a food item appeared on the laptop screen for 5 seconds before the participant viewed the same image on the monitor in front of them. **(b)** The written text of the real food item that the participant would see appeared on the laptop's screen 5 seconds before the participant viewed the actual food item. This gave the experimenter's enough time to move the turn table and slide the monitor back before the PLATO goggles opened so that the participant could see the display.

The presentation of all 60 items (44 images and 16 real objects) constituted a single block for this part of the experiment. There were a total of eight blocks in the Training phase (designed to match the eight training blocks used in the Schonberg et al., 2014 study) and the order and presentation of the stimuli (as a real object or an image) remained the same throughout each block.

Probe Task:

This final phase of the experiment tested whether participants' two alternative forced choice decisions between foods that were previously valued equally (as measured by willingness to pay during the Auction phase), would be influenced by the display format in which the snacks were presented during the previous Training phase. On each trial of this task, participants were shown *pairs* of images of snacks of equal value (as established during the Auction phase), and were asked to choose which of the two items they would prefer to eat. The pairings of the items were determined using a computer program, using the same bidding list generated after the Auction phase. Again, there was a 'high'-item subset and 'low'-item subset, with the first and last seven items in each subset excluded from being used as a real object. For the Probe task, items 8 to 15 (from the high-item subset) were selected as the 'high-value' items (four of these items had been shown as real objects and four had been shown as images during the Training phase) and items 38 to 45 (from the low-item subset) were used for the 'low-value' items (again, four of these items had been shown as real objects and the other four had been shown as images during the Training phase). Each item in the high-value subset that was shown as an image during the Training phase was paired randomly, one at a time, with each of the four images that were shown as real objects. The same process was repeated for images in the low-value subset of items. In total there were 128 trials (pairs of images) in the Probe task.

In the Probe task all pairs of items were presented to participants on the computer screen (as images). Participants pressed either the "u" or "i" keys on the keyboard with the right hand to indicate a preference for the left or right image on the display, respectively. Participants had 1.5 seconds to make a food choice decision. Again, participants were given written instructions to read before participating in the task. The experimenters were not in the room with the participants during this part of the study.

Auction Implementation:

After completion of the three main Experimental Phases, the computer program selected a random item and value to determine whether participants would spend any of their $3.00 allowance on one of the snack foods. This involved the automated selection of a single item from the set of 60 food stimuli that participants bid on during the Auction phase, along with a price for the item that was randomly chosen between $0.00 and $3.00. If the participants' previous bid on he item was *greater than* the randomly generated price, then the participants would purchase the item (paid using their $3 allowance). However, if the bid of the participants was lower than the randomly generated price, the participants could not obtain this item, and would keep their $3 allowance.

RESULTS

SPSS was used to run all analyses. First, we examined participants' behavioral responses on the initial rating scales. Next, we checked whether Probe task choices for items in the 'high-value' stimulus subset were more common than the 'low-value' subset (which we should expect to see based on the differences in willingness to pay from the Auction phase). Finally, we examined whether there was any effect of display type (real objects versus images) in the Training phase on the frequency of selection of items in the Probe task.

1. **Behavioral Ratings**

Participants each completed a questionnaire at the beginning of the experiment. The questionnaire was designed to confirm that participants enjoyed eating snack foods **(Figure 8a),** to determine how often snack foods were consumed per week **(Figure 8b.),** and self-rated hunger level **(Figure 9).** Specifically, participants were asked "on a scale of 1 to 10, how much do you like to eat snacks/junk food?" (1 being "not at all" and 10 being "totally"); "how many snack/junk food items (example: cookies, chips, candy, etc.) do you consume in a typical week?"; and "on a scale of 1 to 10, how hungry would you say you are at this moment?" (1 being "not hungry at all" and 10 being "starving"). The distribution of responses to these questions are shown in **Figures 8 and 9.**Participant number 4 was absent from the group results as he or she did not fill out the questionnaire.

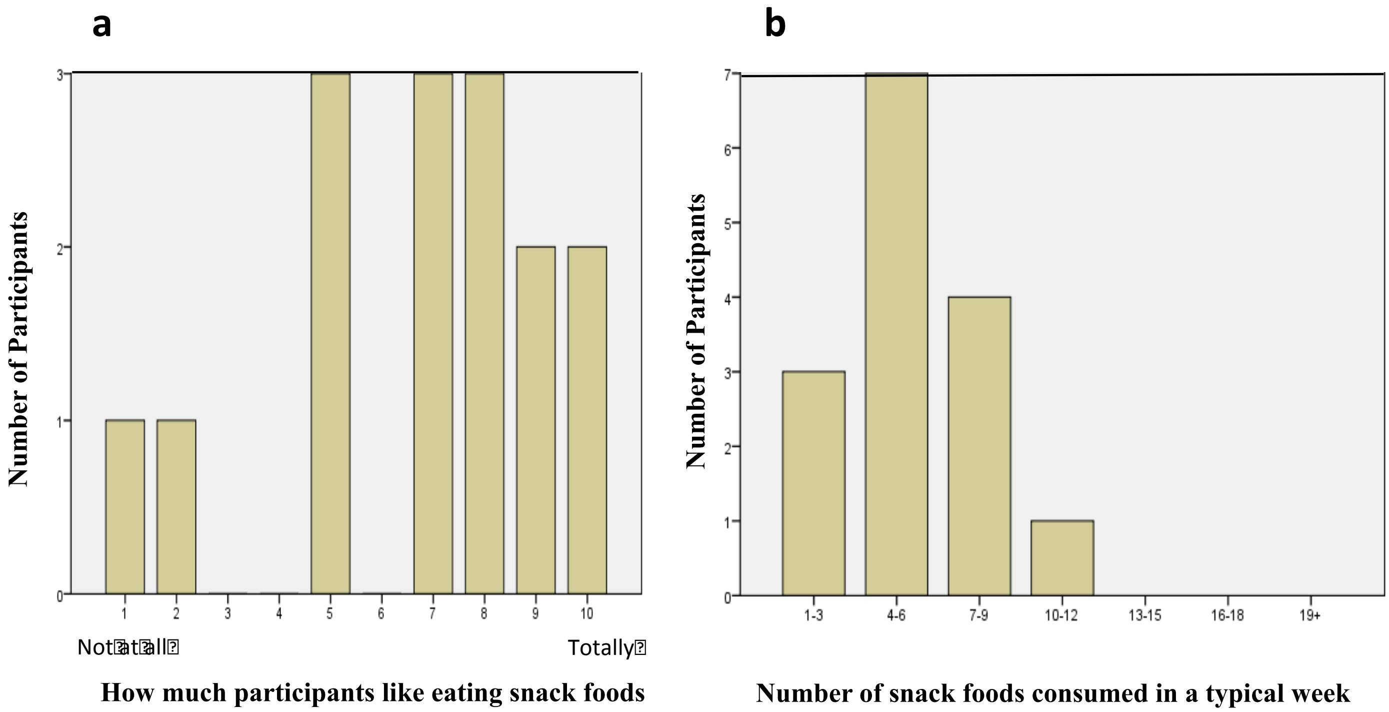

Figure 8. Frequency histograms showing participants' self-rated enjoyment, and frequency of consumption, of snack foods. (a) Participants (n=15) first rated how much they liked to eat snack foods, on a scale of 1 to 10 (1=not at all, 10=totally). From the 15 participants who filled out the survey, 13 participants used a rating of 5 or higher on the enjoyment scale. **(b)** Participants next rated how frequently they consumed snack foods in a typical week. Most participants rated themselves as eating from 4 to 9 snack food items per week.

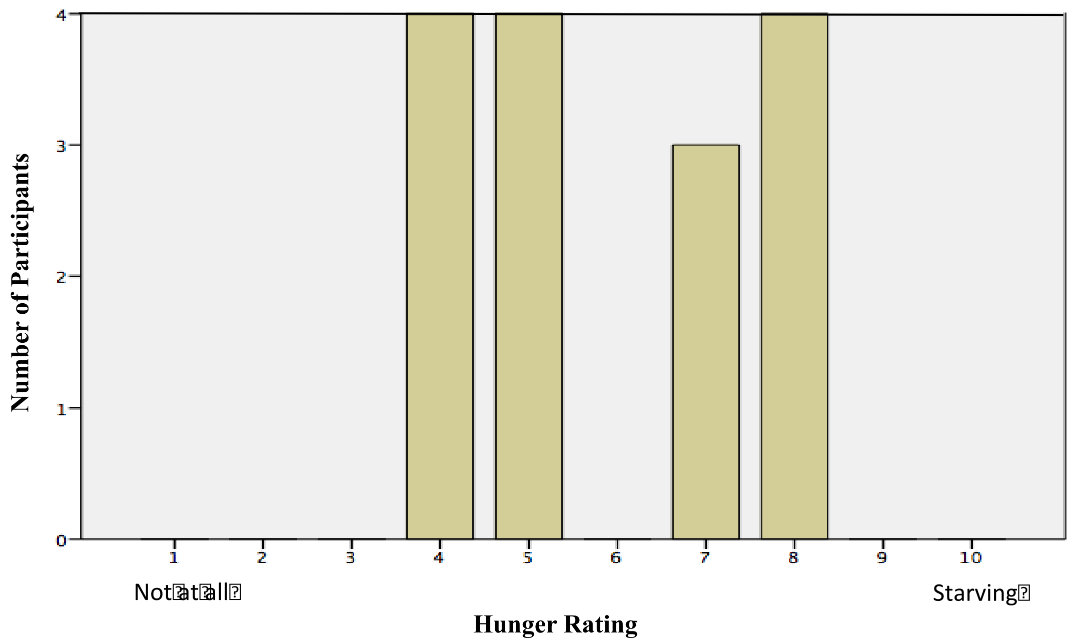

Figure 9. Frequency histogram showing participant hunger ratings prior to commencing the experiment. Participants (n=15 rated themselves as being not hungry at all to very hungry at the beginning of the study (1=not hungry at all, 10=starving).

The behavioral rating data confirmed that participants enjoyed eating the types of snack food items used in the study, and that these items were consumed on a weekly basis **(Figure 8).** Consistent with the instructions to fast prior to the study, more than half of the participants (11 out of 15) were relatively hungry before participating in the experiment **(Figure 9).**

2. **Correspondence Between 'Willingness to Pay' at Auction and Food Choice at Probe for High-value versus Low-value stimulus subsets.**

At the end of the Auction phase we ranked each of the snack foods according to the monetary bid that each participant placed on each food item. These rankings were used to select a subset of stimuli and assign them to either the ‘high value’ or ‘low value’ stimulus sets, and from there to divide further the items into two Display Type groups: real foods versus pictures. This process was repeated individually for each participant. Dividing the stimuli into groups based on rankings in the Auction phase ensured that the stimuli in each group (high / low value; real / picture) were matched in terms of ‘willingness to pay’ – a common metric for stimulus value. As a ‘sanity-check’, we first sought to confirm that our method of dividing the stimuli into high vs low value groups based on *willingness to pay* was indeed effective in driving *consumer choice*. In other words, this analysis was designed to check whether the initial rankings of food items transferred to the two-alternative forced-choice (2AFC) preference test. To do this, we examined the frequency with which high value vs. low value items were selected at Probe. We anticipated that items that participants were willing to pay more for in the Auction phase (items with higher rankings) should be selected more often at Probe than items for which participants were willing to pay less for (items with lower rankings).

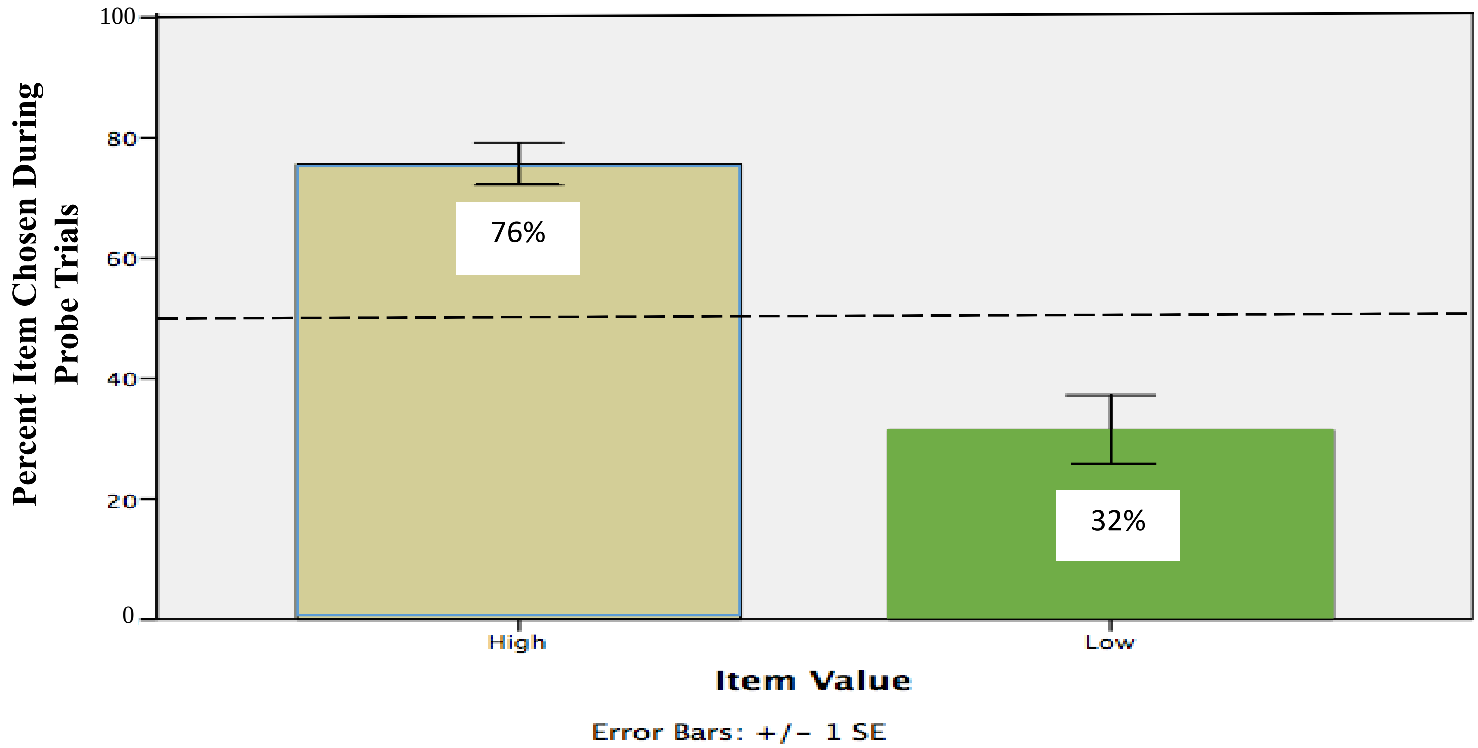

Figure 10. The percent of items chosen by participants during the Probe task for the High-value versus Low-value stimulus subsets. The dashed line at 50% corresponds to the expected choice frequency if item value did not differ from chance between the high- and low-value subsets. Examination of the Figure shows that items of higher value are, as expected, chosen more frequently (76% of trials) than items of lower value (32% of trials). These percentages were based on a total of 128 choices per subject. N=15.

Examination of **Figure 10** shows that participants selected high-value items during the Probe task more frequently than low-value items (Mean high=76%, SD = 13%; Mean low=32%, SD=22%) **(Figure 10).** A repeated measures t-test confirmed that high-value items were indeed selected significantly more frequently than expected by chance alone ($t(14) = 6.68$, $p<0.001$) during the Probe task, showing that the initial rankings of food items during the Auction phase transferred to the 2AFC preference test. In other words, items that the participants bid more on during the Auction phase were chosen more frequently during the Probe task.

3. The Influence of Display Type (Real vs. Picture) during Probe

Finally we examined whether participants chose items that were displayed as real foods during the Training phase more frequently than those that were displayed as images during the Probe task. **Figure 11** shows the percentage of real food stimuli that were selected during the Probe by *each participant*. The chance selection rate (50% real vs. picture) is indicated by the horizontal dashed line. Examination of the individual participant data showed that the % of real object choices ranged from less than 40% to greater than 80%**.** Note that qualitatively there was a wide range of variability in individual participant's choices between real vs pictured stimuli. Critically, **Figure 12** shows the percentage of trials in which participants selected the real food stimuli (versus picture exemplars) at Probe, separately for the high-value and low-value stimulus subsets.

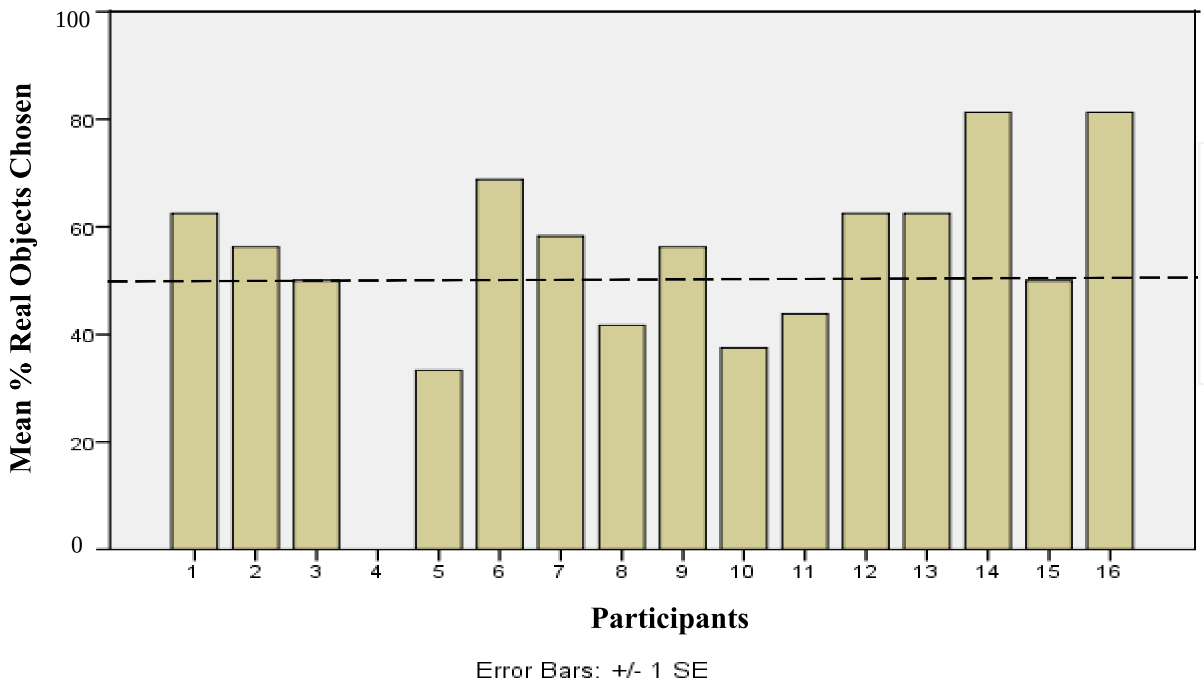

Figure 11. Percent of real objects chosen by each participant during the Probe task. The x-axis shows the individual participants (n=15) and the y-axis shows the percentage of trials in which the participants chose items from the real object displays during the Probe task. The dashed line represents chance performance (when choices do not differ from chance (50%) levels). Nine of the fifteen participants who participated in the Probe task chose real objects more than 50% of the time. These percentages were based on a total of 128 choices per subject.

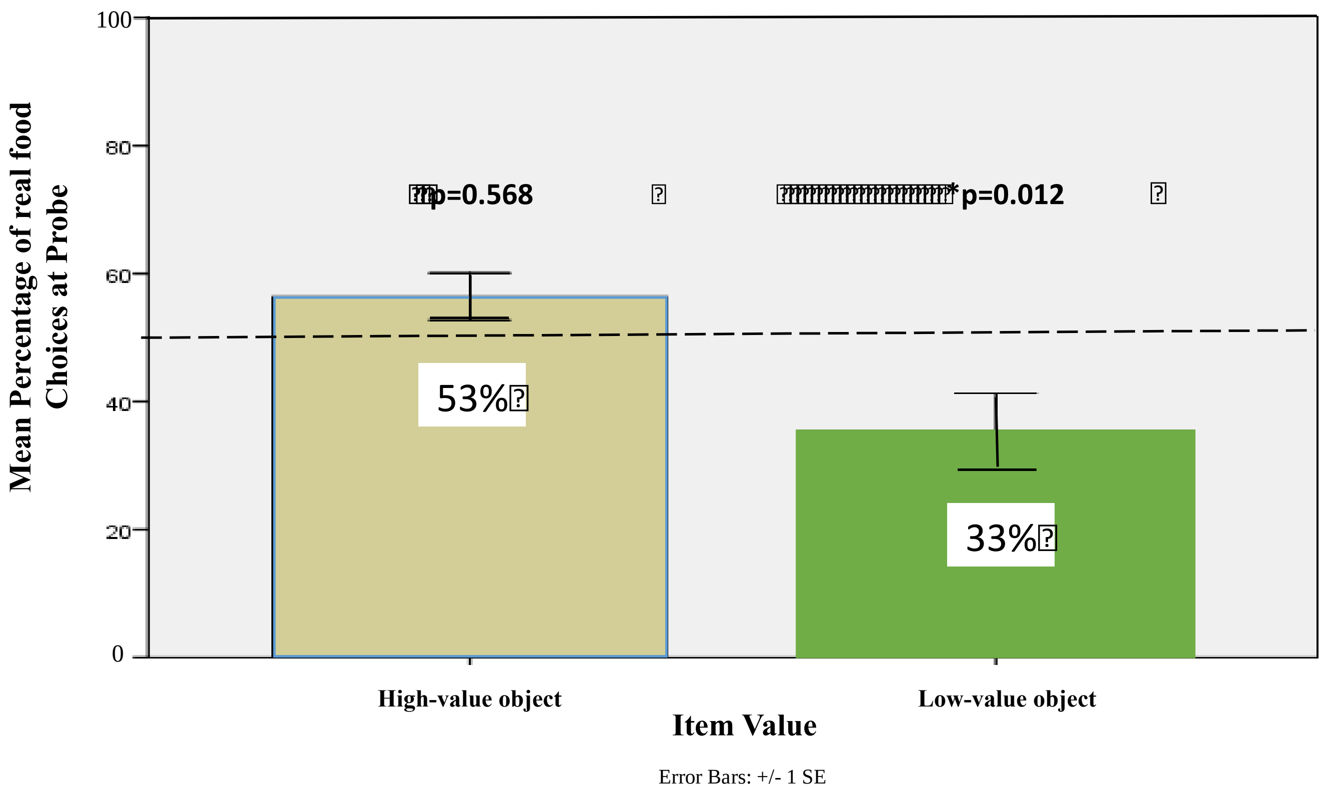

Figure 12. Mean percentage of trials in which participants chose Real Food stimuli at Probe, shown separately for High Value and Low Value stimulus sets. The x-axis shows the type of item (high-value or low-value item) for real object stimuli and the y-axis shows the mean percentage of trials that participants (n=15) chose these real objects during the Probe task. The dashed line represents 50% chance (corresponding to no difference between the real object vs. its image). For the high-value stimulus set, participants chose items that were displayed as real foods during the Training phase on 53% of trials. Conversely, for the low-value set, participants chose real objects only 33% of the time. These percentages were based on a total of 128 choices per subject.

Qualitatively, examination of **Figure 11** shows that participants chose high-value items that had been displayed as real foods during the Training phase more frequently than those that were shown as 2D photos (Mean real =52.9%, SD = 19.7%; Mean picture=33.2%, SD= 23.6%) **(Figure 11).** A one sample t-test was conducted to assess whether real food stimuli were selected at a frequency greater than would be expected by chance (i.e., 50%). In other words, if there was no effect of Display Type during the Training phase, then the expected frequency of real versus picture food choices would be 50%. The t-test showed that the high-valued objects were not selected more frequently than would be expected by chance (t (15) =0.584, p=0.568). Surprisingly, however, real food stimuli in the low value set were selected significantly *less* frequently than would be expected by chance alone (t (15) =2.84, p=0.012). In other words, although there was no difference in the frequency of selection of real foods vs. pictures of foods for the high-value subset of items, participants tended to choose images more frequently than real objects in the low-value stimulus set.

DISCUSSION

The purpose of this study was to examine the extent to which real object displays influence consumer decision making. In part this was assessed by creating a replication of the Schonberg et al. (2014) experiment, with the critical manipulation that real objects were used in place of a motor response. However, discrepancies were found between my results and the results of Schonberg et al., (2014). Again, Schonberg et al., (2014) found that participants tended to choose the images that were associated with a motor task (high-valued food items paired with a motor task were chosen on 60-65% of trials), In contrast, in this study, this bias was not found when the motor task was replaced by only viewing real objects (53% of trials). Although the effect found for high-value real objects was qualitatively in the predicted direction (participants chose high-value real objects over 50% of the time), this difference did not reach statistical significance. In line with the group results, examination of the single participant data confirmed that there was indeed a large amount of variability in participants' preferences for stimuli that were displayed as real snack foods. Conversely, Schonberg et al. (2014) found that there was no effect of the cue-approach training on items of low value. In contrast, I found that training with real foods significantly *diminished* the frequency with which these same food items were selected during the Probe task.

Analysis

As part of the study, hungry participants who enjoyed eating snack food items on a regular basis (as was seen by the results) were recruited. The questionnaire that was provided to participants at the beginning of the experiment confirmed that the majority of people participating in this study enjoyed eating snack foods, and ate them on a regular basis. These measures were taken in order to try to motivate realistic decision, and thus it was advantageous that the participants came into the experiment with an empty stomach and with a love for snack foods.

The critical prediction for my study (based on the hypothesis that real objects provide affordances for interaction) was that training with real food displays would elicit activation of automatic motor routines, which would in turn influence consumer choice. To examine this prediction, I first looked at whether or not there was a connection between the items that were ranked high/ low in the Auction phase and the choices made during the Probe task. In other words, I was curious to see if the initial rankings of items were transferred to the two-alternative forced-choice (2AFC) preference test. It was found that the high-valued items were indeed selected more frequently than the low-valued items. This finding supported the assumption that bid value (as measured by willingness to pay) was reflected also in consumer choices during the two alternative decisions during the Probe task. In other words, as expected, there was good agreement between how much they valued items and which items they selected.

When I looked at the effect of display type (real versus images) for high-valued and low-valued items, I found that participants chose high-value items that had been shown as real objects during the Training phase more often than high-value items that had been displayed as images during the Training phase. However, a statistically significant effect of selection frequency for real foods versus images for high-value stimuli was not found. This was therefore not similar to Schonberg et al.'s (2014) finding in that participants tended to choose images that were associated with a motor response significantly more than images that were not. However, when I looked at how often participants chose low-value objects in comparison to low-value images of items, I found an opposite, and very surprising, result in comparison to Schonberg et al.'s (2014) findings. Participants tended to choose images over real objects for items that were of lower value to them. This did not match my prediction that the objects would be valued more than images, for both high and low-valued items. However, this effect could potentially be explained by the fact that a participant's *dislike* for an item of low value may have been *amplified* if he/she has the chance of physically interacting with that item.

Overall, the results of the current study suggest that viewing an appetitive real food object is not sufficient to influence consumer decision making – at least for 'liked' foods. In other words, solely having the potential for interaction for items that are preferred does not appear to have an effect on whether or not that item is chosen after exposure to the real object. However, for less liked (or even 'disliked' items), having the potential for interaction could elicit the opposite effect: participants may prefer the item that does not have the possibility for consumption. In addition, it may also be possible that the potential for interaction with real food stimuli is not sufficient to influence consumer choice. This study is about the difference between real objects versus images. However, the critical manipulation tested here was whether the *potential* for interaction with the (food) stimuli influenced consumer choice. That is, in contrast to the study by Schonberg et al. (2014) participants were not explicitly making a physical motor response to the stimuli, but the stimuli offered the implicit affordance for interaction. This may have been a critical factor affecting whether the real objects in fact were valued differently.

Limitations

Although the findings in this study did not reveal the expected effect of both high-valued and low-valued real objects being significantly preferable to high-valued and low-valued images, these results could be due to a large number of factors that varied from the Schonberg et al. (2014) experiment. For example, the PLATO goggles, which were not used in the Schonberg et al., (2014) experiment, were too tight and uncomfortable. All 16 participants commented on the fact that the goggles were difficult to wear for a long period of time (the Training phase lasted, on average, 45 minutes). The uncomfortable goggles and the length of the Training phase could have potentially caused the participants to lose interest or become tired, distracted, or frustrated before the Probe task, which was the most critical part of the experiment. Further, due to the need to wear the PLATO goggles (while displaying real food stimuli in our study), participants were in complete darkness for most of the Training phase. This could have also induced sleepiness or distractibility. In addition, the fact that the goggles opened only briefly and thus participants were in darkness most of the time, meant that the viewing conditions were highly unnatural. Although this was necessary to control exposure duration and presentations of the real food objects, it meant that I was testing natural behaviors in a non-natural environment. Despite these disadvantages, the goggles were necessary in order to be consistent in terms of how often the participant viewed an item.

Another factor that could have affected the results was the motivation of the participants. If participants had not truly fasted for 4 hours, then they may have been less hungry and thus less interested in the items. Furthermore, it became clear over the course of testing that all of the participants ended up keeping their three dollars at the end of the study (none of the participants bid higher than the randomly generated value during the Auction implementation. This raises the question of whether or not the participants were truly bidding on how much the item was actually *worth* to them, or if they were trying to bid low on all of the items so that they would be able to keep the maximum amount of money possible. Further evidence in support of this possibility can be seen in an attempted replication of the study by Bushong et al., (2010) that is currently being conducted in the Snow Lab at UNR. Students at UNR who have been participating in this study have also opted to keep their three dollars the majority of the time (rather than use that money to bid reasonable amounts on the snack foods) – which could again be because they might place more importance on the money than the actual food items. If the Schonberg et al., (2014) study were perhaps to be replicated in another context (e.g.

when participants were more motivated or were drawn from a different population), then a different effect may have been found (one that would be closer to our prediction that students would choose the real objects more often than images of objects).

If the participants were predominantly thinking about obtaining the money (rather than the foods), a potential way to get around this would be to tell the participants that they will not be able to keep the money at the end of the study, unless their bid is higher than the number generated by the computer and then they would be able to use this money to pay for the item and keep the remaining money. However, this might cause the opposite problem- participants may actually bid higher than what the item is worth to them in order to increase their chances of making more money. Another way to get around the 'money problem' would be to tell the participants that they will not actually be able to keep that money (however, this would eliminate the 'willingness to pay' component of the study). It would be worth trying various ways with the population at UNR to determine whether or not the possibility of earning more money played a large role in decision making.

Implications and Future Directions

If I were to repeat this experiment in the future, I would change several aspects of the methodology. First, I would use four, rather than eight blocks during the Training phase. Although this would differ from the Schonberg et al., (2014) experiment, it is likely that the long Training phase had a negative effect on the vigilance of the participants and thus on performance in the following Probe task. This negative effect can be deduced by the fact that participants found the PLATO goggles to be uncomfortable and each participant questioned the length of the Training phase. Eight blocks would be more appropriate if the testing conditions were less taxing. Furthermore, having shorter Training phases would allow for a larger sample size in a shorter period of time.

It would also be interesting to do a follow up experiment incorporating the motor training used in the Schonberg et al. (2014) study (i.e., a direct replication of the Schonberg et al., (2014) result). However, instead of solely images, the participants would be required to reach out towards both images AND real objects and then participate in the Probe task to see if the new training methods would have an influence on the participants' decisions. This would further establish whether or not having a motor response is necessary for changing valuation.

Another interesting follow-up study could be done on the main, and unexpected, effect found in this study for foods of low value. It was surprising that participants tended to prefer the image as opposed to the real objects when dealing with food items that they found less appealing. The participants as a whole chose the real objects with low value (the low-valued real food items) 33% of the time, as opposed to the images of objects with low value (the low-valued images of items), which were chosen an average of 67% of the time. A possible explanation to this is that viewing real objects of items that are already disliked (i.e., foods that are truly 'aversive') could cause the opposite effect of what was predicted if having the potential for interaction could be a negative. For example, if a participant was presented with a food item, such as 'Hostess Cupcakes', that was of low value to the participant (or disliked) during the Auction phase, then seeing this food item as a real object, and having the potential to reach out and grab it, could make the item even more undesirable than it was before.

Although this study did not produce the predicted results, it opens up new questions for understanding how real objects are processed by the brain. Moreover, there are many related applied questions in marketing and advertising since these are cases where the display format is highly important for understanding the most effective means of influencing consumer behavior. The present study suggests that the differences between objects and images may sometimes be subtle, and suggests that these subtleties may have important consequences for how observers behave. With regard to how we interact with the world, it also suggests that while real objects differ from images, real actions may also differ from affordances; that is, the potential to reach may be less effective than an actual movement. Thus, there is a possibility that passive viewing of real objects (versus images) has little effect on decision-making, and that executing a physical motor response might be *necessary* to influence decision-making. Further attempts to answer these questions are worth pursuing because the way we perceive and value objects affects many aspects of our lives, and in particular how we behave as value-driven consumers.

References

Balleine, B.W. (2005). Neural bases of food-seeking: affect, arousal and reward in corticostriatolimbic circuits. *Physiology & Behavior*, 86, 717-730. doi:10.1016/j.physbeh.2005.08.061

Balleine, B.W., Daw, N.D., & Doherty, J.O. (2008). Multiple forms of value learning and the function of dopamine. *Neuroeconomics: Decision-Making and the Brain*, 367-389.

Ban, H., Preston, T.J., Meeson, A., & Welchman, A.E. (2012). The integration of motion and disparity cue to depth in dorsal visual cortex. *Nature Neuroscience*, 15, 636-643. doi:10.1038/nn.3046

Bushong, B., King, L.M., Camerer, C.F., & Rangel, A. (2010). Pavlovian processes in consumer choice: the physical presence of a good increases willingness-to-pay. *American Economic Review*, 100, 1-18. doi:10.1257/aer.100.4.1556

Chainay, H. & Humphreys, G.W. (2001). The real object advantage in agnosia: Evidence of a role for shading and depth in object recognition. *Cognitive Neuropsychology*, 18, 175-191. doi:10.1080/02643290042000062

Gallivan, J.P. & Wood, D.K. (2009). Simultaneous encoding of potential grasping movements in macaque anterior intraparietal area. *The Journal of Neuroscience*, 29, 12031-12032. doi:10.1523/JNEUROSCI.3245-09.2009

Gallivan, J.P., McLean A., & Culham, J.C. (2011). Neuroimaging reveals enhanced activation in a reach-selective brain area for objects located within participants' typical hand workspaces. *Neuropsychologia*, 49, 3710-3721. doi:10.1016/j.neuropsychologia.2011.09.027

Gibson, J.J. (1979). *The ecological approach to perception*. Hillsdale, NJ: Lawrence Eribaum Associates.

Goodale, M.A. & Milner, D.A. (1992). Separate visual pathways for perception and action. *Trends in Neurosciences*, 15, 20-25. doi:10.1016/0166-2236(92)90344-8

Grill-Spector, K., Kourtzi, Z., & Kanwisher, N. (2001). The lateral occipital complex and its role in object recognition. *Vision Research*, 41, 1409-1422. doi:10.1016/S0042-6989(01)00073-6

Hare, T.A., Camerer, C.F., & Rangel, A. (2009). Self-control in decision-making involves modulation of the of the vmPFC valuation system. *Science*, 324, 646-648. doi:10.1126/science.1168450

Holmes, S.A., & Heath, M. (2013). Goal-directed grasping: the dimensional properties of an object influence the nature of the visual information mediating aperture shaping. *Brain and Cognition*, 82, 18-24. doi:10.1016/j.bandc.2013.02.005

Humphreys, G.W. & Riddoch, J.M. (1987). A case of integrative visual agnosia. *Oxford Journals*, 110, 1431-1462. doi:10.1093/brain/110.6.1431

Kourtzi, Z., Erb, M., Grodd, W., & Bulthoff, H.H. (2003). Representation of the perceived 3-D object shape in the human lateral occipital complex. *Cerebral Cortex*, 13, 911-920. doi:10.1093/cercor/13.9.911

Krekelberg, B., Boynton, G.M., & Van Wezel, R.J. (2006). Adaptation: from single cells to BOLD signals. *Trends in Neurosciences*, 29, 250-256. doi:10.1016/j.tins.2006.02.008

Kwok, R.M. & Braddick, O.J. (2003). When does the Titchener Circles illusion exert an effect on grasping? Two- and three- dimensional targets. *Neuropsychologia*, 41, 932-940. doi:10.1016/S0028-3932(02)00324-X

Mischel, W. (1974). Processes in delay of gratification. *Advances in Experimental Social Psychology*, 7, 249-292. New York: Academic Press.

Mischel, W. & Moore, B. (1973). Effects of attention to symbolically presented rewards on self control. *Journal of Personality and Social Psychology*, 28, 172-9. doi:10.1037/h0035716

Norman, J. (2002). Two visual systems and two theories of perception: an attempt to reconcile the constructivist and ecological approaches. *Behavioural and Brain Sciences*, 24, 1-62. doi:10.1017/S0140525X0200002X

Rangel, A. (2013). Regulation of dietary choice by the decision-making circuitry. *Nature Neuroscience*, 16, 1717-1724. doi:10.1038/nn.3561

Riesenhuber, M., & Poggio, T. Hierarchical models of object recognition in cortex. (1999). *Nature America*, 2, 1019-1025. doi:10.1038/14819

Schonberg, T., Bakkour, A., Hover, A.M., Mumford, J.A., Nagar, L., Perez, J., & Poldrack, R.A. (2014). Changing value through cued approach: an automatic mechanism of behavior change. *Nature Neuroscience*, 17, 625-629. doi:10.1038/nn.3673

Servos, P., Jakobson, L.S., Goodale, M.A., & Humphrey, G.K. (1994). The role of surface information in object recognition: studies of a visual form agnostic and normal subjects. *Perception*, 23, 1457-1481. doi:10.1068/p231457

Snow, J.C., Pettypiece, C.E., McAdam, T.D., McLean, A.D., Stroman, P.W., Goodale, M.A., & Culham, J.C. (2011). Bringing the real world into the fMRI scanner: repetition effects for pictures versus real objects. *Scientific Reports*, 1, 1-10. doi:10.1038/srep00130

Snow, Rangel & Culham, in preparation. Bringing the real world into the fMRI scanner: Real objects amplify the neural correlates of valuation compared to photos.

Snow, J.C., Skiba, R.M., Coleman, T.C., & Berryhill, M.E. (2014). Real-world objects are more memorable than photographs of objects. *Frontiers in Human Neuroscience.* doi:10.3389/fnhum.2014.00837

Vuilleumier, P., Henson, R.N., Driver, J., & Dolan, R.J. (2002). Multiple levels of visual object constancy revealed by event-related fMRI of repetition priming. *Nature Neuroscience*, 5, 491-499. doi:10.1038/nn839

Appendix A

List of Snack Food Items:

1. Kit Kat
2. Twix
3. Kellogs Fruity Snacks
4. Nestle Crunch
5. Orange Slices
6. Dots
7. Oreo Minis
8. Keebler Fudge Stripe Cookies
9. Hershey's Milk Chocolate
10. Juicy Oozers (Wild Gummy Bears)
11. Rice Krispie Treats
12. Fruit Roll Ups
13. Peach Rings
14. Trolli Crawlers (Sour Gummy Worms)
15. Sour Patch Kids
16. Starbursts
17. Heath Chocolate
18. Mini Pretzels
19. Beef Jerky
20. Nature Valley
21. Quaker Granola
22. Famous Amos (Chocolate Chip)
23. Lifesavers Gummies
24. Jolly Ranchers
25. Snickers
26. M&M's
27. Skittles
28. Animal Crackers
29. Mini Chips Ahoy Cookies
30. Peanut M&M's
31. Grandma's Chocolate Chip Cookies
32. Hot Tamales
33. Milkduds
34. Good and Plenty
35. Nabisco Newtons
36. Reese's Pieces
37. Ritz Cheese Crackers
38. Sun-maid Raisins
39. Cheetos
40. Cheez-its
41. Hostess Cupcakes

42. Fruit Pie
43. Nutter Butter
44. Pringle Stix
45. Coconut Tips
46. Goldfish Crackers
47. Mike and Ike
48. Pringles Chips (original)
49. Boston Baked Beans
50. Reese's Peanut Butter Cups
51. Red licorice
52. Toblerone
53. Baby Ruth
54. Nerd
55. Planter's Peanuts
56. Raisinets
57. Runts
58. Sweetarts
59. Junior Mints
60. Red Hots

Appendix B

Snack Foods and Money Study: Questionnaire

EXPERIMENTER: Participant#:______ Date:___/___/___ Time:___:___am/pm

1.) When was the last **time** you ingested anything but water today? _____:_____am/pm

2.) On a scale of 1 to 10, how hungry would you say you are at this moment?

Not hungry at all | 1 2 3 4 5 6 7 8 9 10 | Starving

3.) Have you ever been involved with the running of a research experiment?

Yes No

4.) Have you ever worked (research assistant, etc.) in a research lab?

Yes No

5.) On a scale of 1 to 10, how interested are you in experimental research?

Not at all | 1 2 3 4 5 6 7 8 9 10 | Totally

6.) On a scale of 1 to 10, how involved are you in experimental research?

Not at all | 1 2 3 4 5 6 7 8 9 10 | Totally

7.) How many snacks/junk food items (example: cookies, chips, candy, etc.) do you consume in a typical week?

1-3 4-6 7-9 10-12 13-15 16-18 19+

8.) On a scale of 1 to 10, how much do you like to eat snacks/junk foods?

Not at all | 1 2 3 4 5 6 7 8 9 10 | Totally

9.) Have you dieted in the past?

Yes No

10.) Are you dieting now?

Yes No

Appendix C

Study instructions:

The goal of the experiment is to study your food preferences. We will now provide detailed instructions about the experiment.

At the end of the experiment, about 60 minutes from now, we will ask you to sit in an adjacent room for another 30 minutes. During this time you will be given the opportunity to have a snack. You will be able to read a magazine or any other materials that you might have brought with you but **the only food** that you will be allowed to eat is whatever snack you obtain from us.

Next to your computer station are three dollars. This money is now yours and with this money you will be allowed to buy food from us as if we are your own personal convenience store. Whatever money you do not spend is yours to keep.

There are several parts to today's experiment. We will give you detailed instructions before each part starts. The instructions will appear on the screen and you will have as much time as you need to read them. We will also have a short demo trial for each part. If you don't understand the instructions before any part of the experiment feel free to approach the experimenter and ask him/her any questions you might have.

Part 1: *Auction (~6 minutes)*

We will hold an auction of food items. We will show you pictures of 60 different snacks, each one on a separate trial. During each presentation you will be allowed to bid a dollar amount by using the mouse to select any amount between $0 and $3.
Although you will bid on all 60 items, you will be allowed to buy only one of them.
At the end of the experiment we will select one trial at random and that will be the only trial that will count. Since you don't know which trial it will be, you should treat every trial as if it were the only one that will count.
Because only one trial will be chosen, you do not have to worry about spreading your $3 budget over the different items. Think of it as if you have $3 for every individual trial and ask yourself how much of the $3 you want to spend on the food displayed on that trial since it may be the only one that you are given a chance to buy.

Auction Rules:

In every auction there is a rule that determines the price at which the items are sold. This auction is no different.
The rule is a bit unusual, but its implications are straightforward. There is no way of gaming the auction, the BEST thing that you can do in every trial is to ask yourself how much you would be willing to pay to eat THAT item at the end of the experiment, and then bid the amount closest to that value.

What is the rule? At the end of the experiment, after the trial that counts has been selected, the computer will choose a sum ranging from $0 to $3 in $0.25 increments.
If your bid is less than or equal to the number chosen by the computer, you will NOT get the snack, and will not have to pay anything. If your bid is greater than the number chosen by the computer, you may purchase the item at the (computer's) lower price.

Why is it in your own interest to bid the actual price you would pay to eat the item at the end of the experiment?
You might think that your best strategy is to bid less than the item is worth to you. This is INCORRECT.
The price that you pay is determined by the sum chosen by the computer, NOT by your bid. Thus, if you lower your bid you would not be able to affect the price that you pay, but you might end up losing the opportunity to buy the item at a "good" price.

For example, suppose that having the chance to eat the snack at the end of the experiment is worth $2 for you. If you bid your true value ($2), you will get the item only if the computer choses a number less than $2 (for example $1.50), and you pay the reduced price of $1.50. You will not get the item if the computer chooses a number $2 or more. It follows that by bidding your true value you make a "profit" since you always end up paying less than what the item is worth to you.
Clearly, you should never bid more than what the value of the snack is worth to you because you run the risk of paying more than your true value for an item.

We ask you to please turn off your cell phone now as to not be distracted during the experiment.

We will now present a demo trial of the auction – please place your bid to get acquainted with the process. The choices are not limited by time but please try to make them as fast as you can.

Part 2: *Viewing food items (~45 minutes)*

During this task you will see some of 60 different snacks you previously bid on. Except that, instead of just images on a computer screen, the actual snack food items will be placed in front of you. Each item will only be displayed for a few moments. Then the goggles will be shut to block your view. Be ready, because after a moment or two the goggles will open again and a different snack food item will be in front of you. Your task is to focus your complete attention on each snack food item for the brief period that each is shown.

Part 3: *Choice between two pictures (~10 minutes)*

Now that you have completed View Real Snacks task, two pictures of food items will come up on the screen. For each trial, we ask you to choose one of these items using the "u" or "i" keys on the keyboard for the left or right item, respectively. You will have 1.5 seconds to make your choice on each trial, so please try and make your choice quickly. At the end of the experiment, we will select one trial at random and give you the food item you chose.