

Pavlovian Processes in Consumer Choice: The Physical Presence of a Good Increases Willingness-to-pay

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This paper describes a series of laboratory experiments studying whether the form in which items are displayed at the time of decision affects the dollar value that subjects place on them. Using a Becker-DeGroot auction under three different conditions—(i) text displays, (ii) image displays, and (iii) displays of the actual items—we find that subjects’ willingness-to-pay is 40–61 percent larger in the real than in the image and text displays. Furthermore, follow-up experiments suggest the presence of the real item triggers preprogrammed consummatory Pavlovian processes that promote behaviors that lead to contact with appetitive items whenever they are available. (JEL C91, D03, D12, D84)

A basic principle in many social science models is that choices among objects should not vary with innocuous changes in the procedure by which they are made, or with their description. In this “consequentialist” view, choices should depend only on their likely consequences. Ordering groceries online and shopping in a store should lead to identical contents in the refrigerator at home (holding information about quality and other relevant variables constant).

However, many experiments have shown that the cognitive processes that guide choice appear to violate description invariance and consequentialism. A large research effort in psychology is devoted to studying the ways in which preferences are “constructed” (see Sarah Lichtenstein and Paul Slovic 2006 for a recent compendium of articles). Economists are increasingly interested in what policies make sense if preferences are constructed (e.g., Daniel McFadden 2006). And more recent efforts in neuroeconomics focus on the computational and neurobiological mechanisms used in the computation and comparison of values (for a recent review see Antonio Rangel, Camerer, and P. Read Montague 2008).

Most of the constructed-preferences studies describe goods or services abstractly and alter descriptions without changing consequences. For example, in one classic study medical students were asked to choose between hypothetical surgery and radiation treatment options. Outcomes were described in terms of mortality statistics in one “frame,” and in terms of survival statistics in another frame, while maintaining statistical equivalence (Barbara J. McNeil et al. 1982). Medical students and physicians made different choices when faced with the different frames. In practice, differences in physical displays of goods also appear to be important. For example, marketing firms spend enormous resources creating the packaging of a product (which is typically later discarded), the lighting and location of sales displays, the selection and training of salespeople, and so forth.

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This paper extends the literature on constructed preferences by studying whether the form in which items are displayed affects the value that subjects place on them. We compare three conditions: a text display, a picture display, and putting the actual items in front of subjects. We investigate these three conditions because of their theoretical interest and because they approximate some archetypes of situations in which consumers often find themselves. Consider, for example, choosing a meal in a restaurant by reading a text based menu, looking at a picture based menu (as is common in some countries), or being exposed to a buffet table.

We describe the results of two separate experiments suggesting that, in comparison to a text or high-resolution display, the physical presentation of a food item or a trinket has a sizable effect on its value (as measured by incentive-compatible monetary bids). This presents a puzzle for the behavioral sciences, and especially for the emerging field of neuroeconomics: why do the brain's valuation systems treat these three types of displays so differently?

We propose and test three different explanations of the real-exposure effect based on recent research in psychology and neuroscience. Our results suggest that Pavlovian consummatory mechanisms, which are unfamiliar to economists but have been well established in behavioral neuroscience, might be at work (Bernard W. Balleine, Nathaniel D. Daw, and John P. O'Doherty 2008; Rangel, Camerer, and Montague 2008; Ben Seymour, Tania Singer, and Ray Dolan 2007). The function of these mechanisms is to deploy behaviors that lead to the consumption of appetitive items when those items are physically exposed to them. Furthermore, these types of processes are thought to influence behavior by changing the value that the brain assigns to particular items.

I. Experiment 1: Basic Food Experiment

A. Methods

Fifty-seven Caltech undergraduate and graduate students participated in the experiment. Individuals were excluded if they had a history of eating disorders, had dieted in the past year, were vegetarian, disliked junk food, or were pregnant. The selection criteria were designed to recruit individuals who liked junk food and were not trying to control their diet. Individuals received \$20 for their participation and provided informed consent. Participants were asked to eat and then fast for three hours prior to the experiment. All testing took place in mid-afternoon.

The experiment took approximately 30 minutes. Subjects were told that they would receive \$20 for their participation and might receive additional money and food prizes depending on their decisions in the experiment. During this initial instruction, we emphasized that no deception was used in the experiment. Subjects received their instructions through a computer monitor.

At the beginning of the instruction period participants were informed that they would have to stay in the lab for an additional 30 minutes at the end of the experiment (regardless of its outcome). During this time they were allowed to eat as much as they wanted of the single food item they purchased from us during a bidding task, but no other foods or drinks were allowed. If they did not purchase an item they still had to stay in the lab for 30 minutes at the end of experiment. The foods that they could purchase were 80 different popular snacks such as candy bars (e.g., Snickers bars) and potato chips (e.g., Lay's), which are available at local convenience stores.

Every participant performed three tasks: (i) a liking-rating task, (ii) a familiarity-rating task, and (iii) a bidding task.

During the liking-rating task subjects had to answer the question "How much would you like to eat this item at the end of the experiment?" on a scale of -7 ("not at all") to 7 ("very much"), with 0 denoting indifference. The timeline of the liking-rating trials started with a 1s central fixation cross, followed by a 3s presentation of a high-resolution picture of the item to be rated.

Pictures were 400x300 pixels in size and showed both the package and the food; the name of the food was also displayed above the picture. Afterwards subjects entered their liking rating at their own pace using the keyboard. The items were shown in random order. There was a 1s intertrial interval with an empty screen.

Familiarity-rating trials were similar except that subjects answered the question “How familiar are you with this item?” on a scale of 1 (not much) to 3 (very much). The purpose of these two tasks was twofold: First, the liking and familiarity ratings were used in analyses reported below. Second, both tasks increased the familiarity of the subjects with the foods and their names.

The bidding trials were the core of the experiment. In addition to the participation fee, each subject received an endowment of \$3 that could be used to purchase food from us. At the end of the experiment one of the bidding trials was selected by drawing a ball from an urn. The subject’s bid on this selected trial determined whether he got the item and the price that he had to pay for it.

Items were sold to the subjects on the selected trial by applying the rules of a Becker-DeGroot auction. A random number between \$0 and \$3 (in \$0.25 increments) was selected from an urn. Let n denote the random number that was selected, and let b denote the subject’s bid. If $b \geq n$, the subject got the food item and paid \$ n . If $b < n$, the subject did not get the item but kept the \$3 of bidding money. Note that since the subjects kept whatever funds they did not use, they were de facto spending their own money to purchase the food.

A key feature of the auction procedure is that it satisfies “incentive compatibility”: if a subject’s true value for an item was v , her best response was to bid exactly v . Any deviation from this strategy resulted in a lower expected payoff. Bidding below v does not save money on the price (which is determined by n), it only increases the chance that an item which is liked will not be bought.

Since the rules of the auction are somewhat complicated, we spent significant time training the subjects. In particular, we emphasized that their best strategy was to “go with their gut feeling” about how much each item was worth to them, and then to bid that amount. Debriefing during a pilot experiment confirmed that subjects complied with these instructions. Furthermore, even if there is some bias in bidding relative to true underlying valuation, it should not vary systematically with the display treatments.

The bidding trials were structured as follows: A representation of an item was shown for a certain amount of time, and immediately afterward the subjects entered a bid between \$0 and \$3 by clicking with a mouse on an analog bid bar. There were three between-subjects experimental conditions that differed on how the stimuli were presented in the bidding trials: (i) a text condition ($N = 20$), in which only the text descriptor (the product name) was shown, (ii) an image condition ($N = 17$), in which the high-resolution image of the food was shown, and (iii) a real condition ($N = 20$), in which an open package of the food item was displayed on a tray. In the text and image conditions the item was presented for 3s and there was a 3s intertrial interval. In the real condition, the item was also presented for 3s (although the time was not controlled as precisely), but the intertrial interval varied since it was determined by the amount of time that it took the experimenter to locate the next food and present it to the subject. The real items were displayed in a way that resembled the presentation in the images (including the use of a black cloth on a tray to resemble the black background of the computer screen). In the text and picture conditions data from six to 12 subjects was collected in parallel. Each subject received instructions and performed the task through his own computer terminal. In the real condition only one subject was run at a time.

B. Results

Figure 1 provides a succinct description of the results. There are two main results. First, as can be seen in the top panel, the average bid in the text condition (68 cents, standard deviation = 0.52)

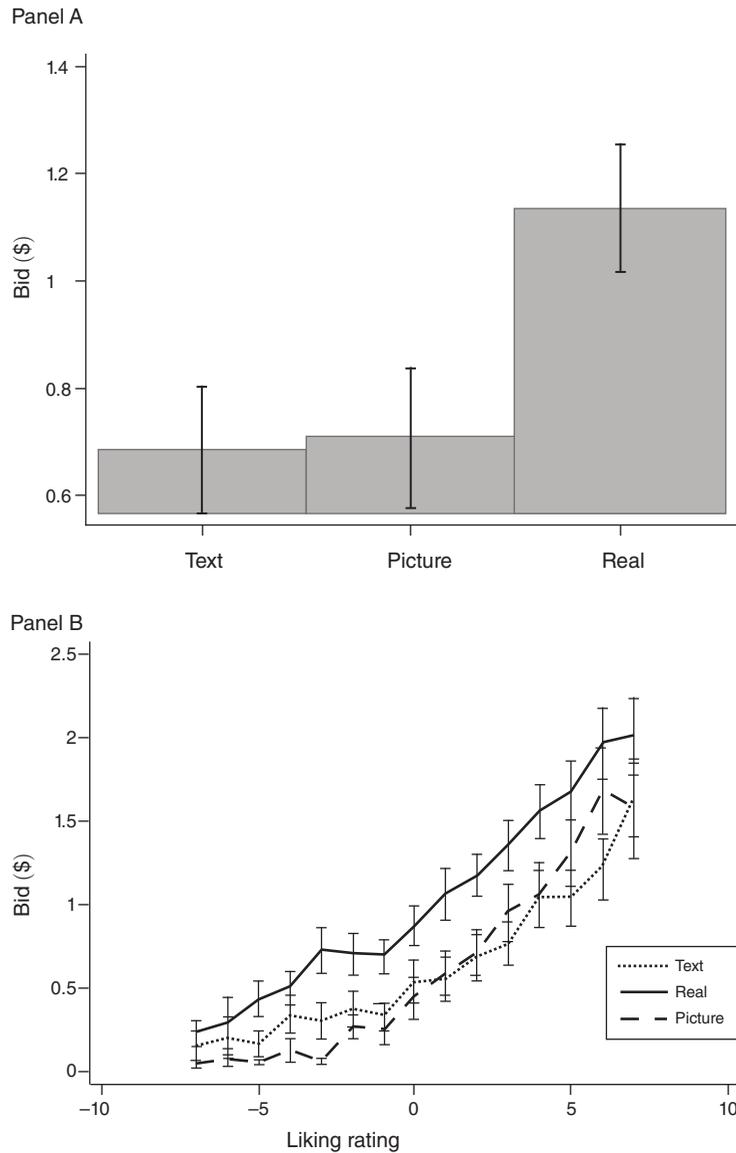


FIGURE 1. RESULTS FOR EXPERIMENT 1

Notes: Consumer's willingness-to-pay for a food item is larger when it is physically present. Panel A: Average bids and standard error bars in the three treatments: text, image, and real presentation. There was no significant difference between the text and picture conditions, but both were significantly lower than bids in the real condition ($p < 0.004$). Panel B: Bids as a function of self-reported liking ratings for each of the treatments. There was no statistically significant change in the linear slope of these curves across conditions.

is approximately equal to the average bid in the picture condition (71 cents, standard deviation = 0.53, two-sided t -test $p = 0.88$), and both of them are significantly smaller than the average bid in the real condition (113 cents, standard deviation = 0.61 two-sided t -test $p < 0.004$). Note that the average liking ratings were marginally higher in the text condition (mean = 1.43),

than in the real (mean = 1.16) or picture conditions (mean = 0.58), which implies that the effect cannot be attributed to differences in the underlying value of the food items. As the bottom panel illustrates, a random effects linear model with random intercepts and slopes showed no significant differences between the slopes of the bidding curves (i.e., bids as a linear function of liking rating) in any of the three conditions.

In order to investigate the possibility that the effect might work only with unfamiliar items, we compared average bids for familiar and unfamiliar items. The main effect of displaying the real item was similar across the two groups: for highly familiar items (familiarity rating = 3) the average bid in the real condition was 50 cents higher than in the two other conditions ($p < 0.006$); and for less familiar items (rating < 3) the bid difference was 41 cents higher ($p < 0.001$).

C. Discussion

These results suggest that the form in which an item is displayed can have a sizable impact on real choices: subjects' willingness-to-pay for snacks increased by 61 percent when they were presented with the real items as opposed to text or image displays.

Several aspects of the results are worth highlighting. First, contrary to our prior expectations, there was no difference between the text and image displays. This is particularly puzzling since the text and image displays contain different amounts and types of information. Second, the display mode had no effect on the relationship between the liking ratings, which are an independent measure of the consumption value of the items, and the value that is computed at the time of bidding. Instead, the real display basically added a constant markup to all of the items. Third, subjects bid positive amounts even for some items that they had earlier rated as aversive (i.e., negative liking rating). There are two potential explanations for this. One is that the constant exposure to food during the experiment increased their hunger, and thus made some of the aversive items desirable. The other is that the liking-rating scale did not do a good job picking up the valence of the foods (the mean bid for neutrally rated items was 63 cents, standard deviation = 53).

The results raise two important questions. First is the question of robustness: Does the effect occur only with foods and hungry subjects? Or, does a similar phenomenon occur in other subjective states and for other types of items? The second question has to do with the underlying mechanisms generating the effect: What can explain the difference between the text, picture, and real conditions?

A natural hypothesis for economists is that the real condition increases the amount of information that subjects have about the goods and that, by decreasing uncertainty, it increases their willingness-to-pay for them. This is hard to reconcile with all the evidence. Most of these items were highly familiar to our subjects, and the magnitude of the real-condition effect was similar for familiar and unfamiliar items. Furthermore, the largest increase in information takes place between the text and display conditions, instead of between the display and real ones. Finally, additional evidence against the information hypothesis is provided in experiments 3 and 4 below.

Note also that the experiment cannot be explained in terms of changes in transaction costs: since only one food item is chosen for consumption at the end of the experiment, the cost of actually getting the item is the same across display conditions.

Instead we developed three alternative hypotheses based on previous findings from psychology and neuroscience. The first one focused on the role of odors, which are potentially unconscious. Previous research (George Loewenstein 1996) has argued that real items, especially highly appetitive ones, can trigger visceral urges that affect valuation in a more potent way than images or words. Thus, one potential explanation for our findings is that real displays involve the sense of smell, and that adding it into the sensory representation of the item might trigger emotional

responses that affect valuation in a way that images alone do not. In addition, the activation of multiple sensory representation of the choice item might have a superadditive effect on the valuation systems (Nicholas P. Holmes and Charles Spence 2005).

The second hypothesis is based on the idea that activating the experienced reward circuitry at the time of choice might increase the decision value that is assigned to it. In an extreme example of this phenomenon, consider the impact that taking a puff could have on a smokers' desire for a cigarette. Based on this, we hypothesized that exposure to the real items at the time of choice might induce an especially strong activation of the experience reward circuitry (in comparison to the picture and text representations) and that this might lead to an increase in subjects' willingness-to-pay.

The third hypothesis is taken from the animal learning and behavioral neuroscience literatures. A sizable and growing body of evidence suggests that environmental cues can have an effect on the value assigned to items at the time of choice (Balleine, Daw, and O'Doherty 2008; Rangel, Camerer, and Montague 2008; Seymour, Singer, and Dolan 2007). In particular, Balleine (2005) and Balleine, Daw, and O'Doherty (2008) have argued that the physical presence of an appetitive item can trigger Pavlovian consummatory processes that lead animals to make contact with the reward. In the language of animal learning theory, the physical presence of the appetitive stimulus (e.g., food) serves as an unconditioned stimulus (US) triggering the consummatory response. As with every Pavlovian process, it is possible for organisms to learn to associate other cues (called conditioned stimuli, CS) with the presence of the US (given by the actual presence of the appetitive item). When the pairing is sufficiently strong, the mere presence of the CS can trigger the approach/consummatory responses. This type of learning explains, for example, why highly trained pigeons peck at a light that predicts the delivery of actual food.

According to this hypothesis, the Pavlovian consummatory response is triggered in Experiment 1 for the real condition, since the presence of the food serves as a US, but not in the text or picture conditions, because these stimuli are not CSs which are as strongly associated with the US. Although a priori there is nothing precluding the text or pictures from serving as a CS capable of triggering the approach response, the data suggests that they have not acquired the required association with the US and thus the pairing is weaker than that in the real treatment. One potential reason why this might be the case is that our subjects are unlikely to have been trained repeatedly to pair the text and pictorial stimuli with the US. That is, in contexts outside the experiment, the names and pictures of foods (e.g., in advertisements) are not frequently associated with the presence of the foods, so there is no associative link that can trigger the approach response.

In order to test this third hypothesis, we conjectured that the Pavlovian consummatory processes might not be activated in situations in which the items cannot be accessed. This could happen because the response is not activated in the first place, or because it is overridden by competing behavioral responses that take into account the fact that the stimulus is not accessible.

The rest of the paper describes the results of three additional experiments designed to address the issue of robustness and to investigate the relative contribution of the three proposed mechanisms.

II. Experiment 2: Robustness and the Role of Smell

In order to address the issue of robustness, and to investigate the role that smell plays in the previous results, we repeated Experiment 1 using trinkets instead of foods.

A. Methods

Sixty Caltech undergraduate and graduate students participated in this experiment. Since the design is extremely similar to Experiment 1, here we describe only the differences between

them. First, instead of snack foods, subjects bid on 20 different small value trinkets such as Caltech mugs and various DVDs. All of the items were sold at the Caltech bookstore at the time of the experiment and had a maximum in-store price of \$20. Second, subjects were not required to stay for 30 minutes at the end of the experiment. Instead, any trinkets purchased during the experiment were mailed to them at the end of the day. Third, prospective subjects faced no exclusion criteria. Fourth, the trinkets were displayed without any packaging in all of the pictures and in the real condition. Twenty subjects participated in each of the conditions.

B. Results

Figure 2 summarizes the results. As can be seen in the top panel, the average bid in the text condition (1.02 cents, standard deviation = 0.54) is approximately equal to the average bid in the picture condition (1.01 cents, standard deviation = 0.53, two-sided t -test $p = 0.9806$), and both of them are significantly smaller than the average bid in the real condition (142 cents, standard deviation = 0.61 two-sided t -test $p < 0.008$). This represents a 41 percent increase in the subjects' willingness-to-pay for the items, which is commensurate with the effect size that we found in Experiment 1. Note that the average liking ratings were not significantly different in the three conditions (minimum p -value in a two-sided test 0.45), which implies that the effect cannot be attributed to differences in the underlying value of the trinkets. As the bottom panel illustrates, a random effects linear model with random intercepts and slopes showed no significant differences between the slopes of the bidding curves in any of the three conditions.

C. Discussion

A comparison of figures 1 and 2 shows that the results for the food and trinket experiments are remarkably similar. It follows that the real-exposure effect is not limited to the case of snack foods. Furthermore, since smells are unlikely to play a role in the case of the trinkets, we can conclude that they are not the mechanism behind the real-exposure effect in both experiments.

III. Experiment 3: The Role of Experienced Reward Processes

The next experiment addressed the role of experienced reward on the valuation processes. To do this we repeated the picture food condition with a twist: subjects had to eat a small sample of each food while deciding how much to bid. The idea behind the experiment is that if experiencing the rewards generated by an item has a positive effect on valuations, then a taste of an appetitive food should have a positive effect on the bids even when it is not physically present.

A. Methods

Seventeen Caltech undergraduate and graduate students participated in this experiment. Since the design is extremely similar to the picture condition of Experiment 1, here we describe only the differences between them. First, instead of 80 snack foods, subjects placed bids on only 20 of them. The 20 foods were chosen at random from those used in Experiment 1. We reduced the number of foods to facilitate the process of data collection given the additional difficulties described below.

Second, after seeing the picture of the food item, subjects were asked to taste and swallow a small amount (about 10 grams) of it prior to entering their bids. This was done as follows. The experimenter sat next to the subject and had access to 20 small paper cups, each containing a sample of one of the foods. After the image of a food was presented in the screen for 3 seconds

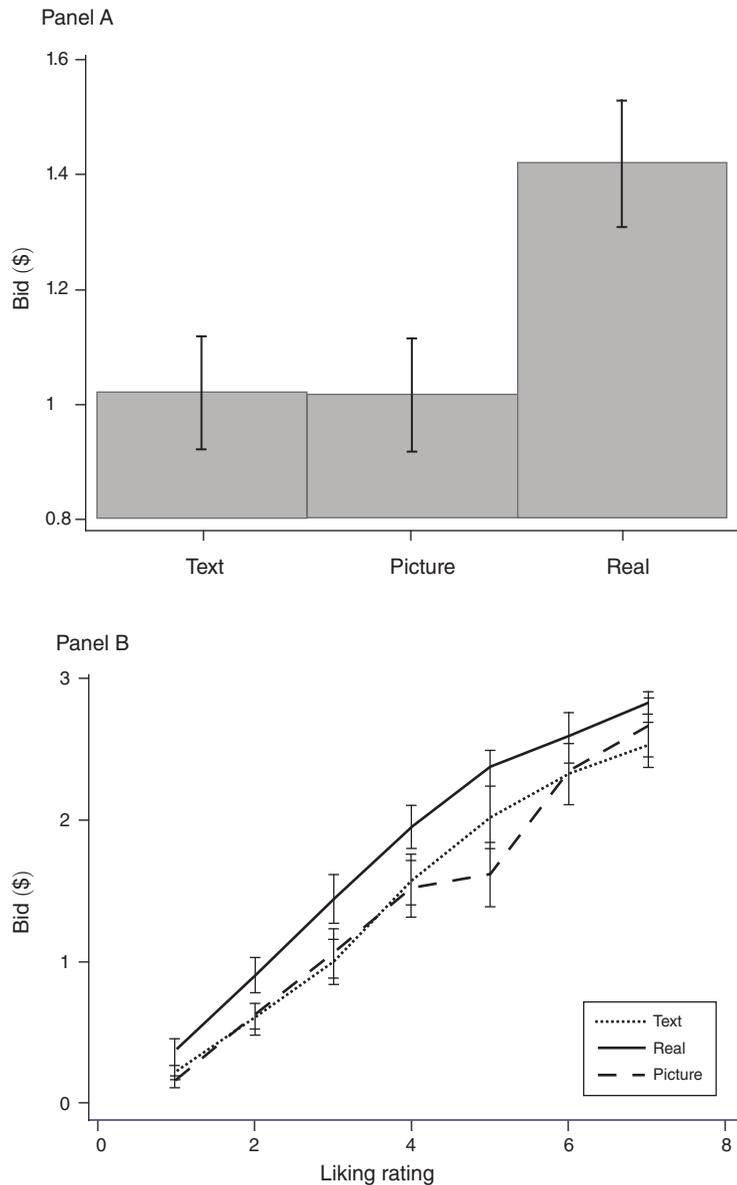


FIGURE 2. RESULTS FOR EXPERIMENT 2

Notes: Consumer's willingness-to-pay for a trinket is larger when it is physically present. Panel A: Average bids and standard error bars in the three treatments: text, image, and real presentation. There was no significant difference between the text and picture conditions, but both were significantly lower than bids in the real condition ($p < 0.008$). Panel B: Bids as a function of self-reported liking ratings for each of the treatments. There was no statistically significant change in the linear slope of these curves across conditions.

the experimenter handed a sample of that item to the subject, who had to eat it before entering a bid. The picture of the food stayed on the screen until a bid was entered. In order to facilitate the process of running the experiment, the order of food presentation was randomized but kept constant across subjects.

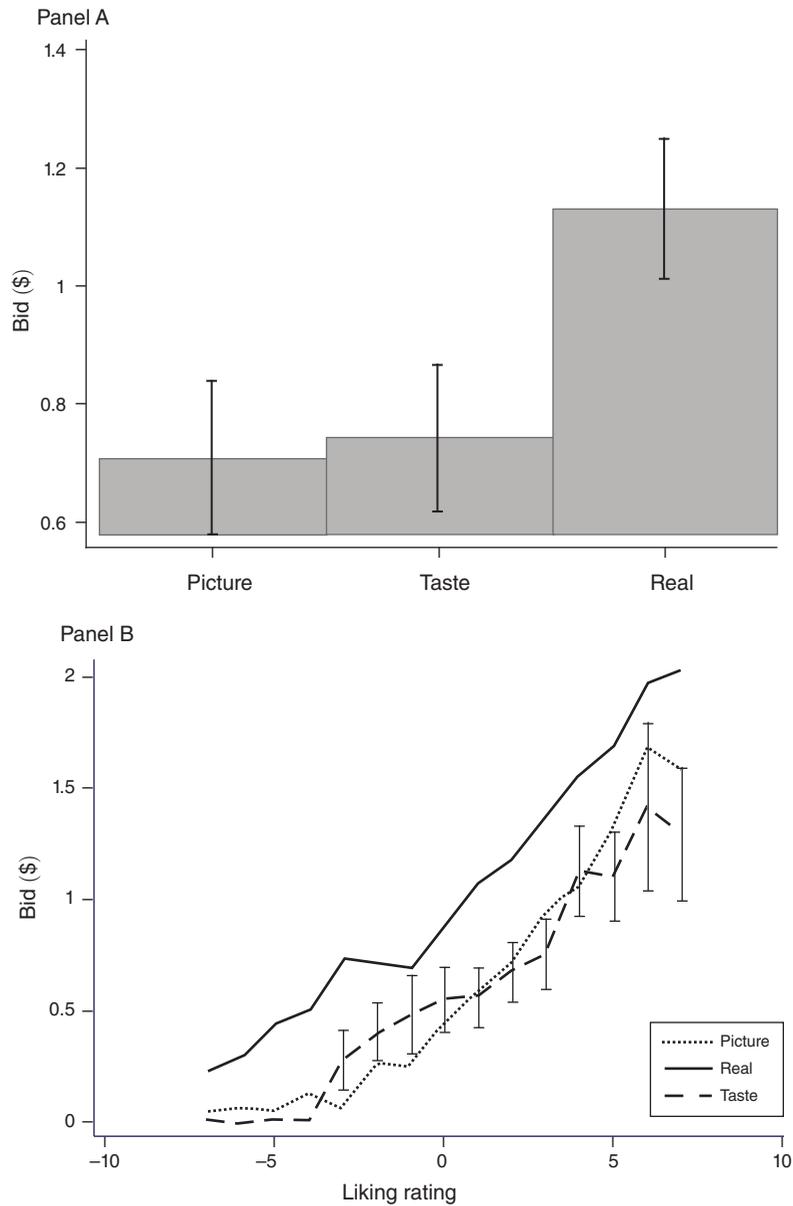


FIGURE 3. RESULTS FOR EXPERIMENT 3

Notes: A small taste of the food item in the picture condition has no impact on subject's willingness-to-pay. Panel A: A comparison of average bids and standard error bars in the picture, taste, and real presentation treatments. There was no significant difference between the picture and taste conditions, but the bids in the taste case were lower than in the real condition ($p < 0.029$). Panel B: Bids as a function of self-reported liking ratings for each of the treatments. There was no statistically significant change in the linear slope of these curves across conditions.

Note that, in contrast to the real condition in Experiment 1, the subjects were not exposed to packages or full samples of the foods. In fact, most of the time subjects did not even take a look at the contents of the paper cups since they knew that it was just a sample of the food displayed on the screen.

B. Results

Figure 3 summarizes the results. For comparison purposes, the figure compares the results of this experiment with those of the picture and real conditions in Experiment 1. As can be seen in the top panel, the average bid in the taste condition (74 cents, standard deviation = 0.51) is approximately equal to the average bid in the picture condition (70 cents, standard deviation = 0.53, two-sided t -test $p = 0.85$), but substantially smaller than the average bid in the real condition (114 cents, standard deviation = 0.53, two-sided t -test $p < 0.029$). Note that the average liking ratings in the taste condition (mean = 2.01) were marginally higher than those in the real condition (mean = 1.16), which implies that the effect cannot be attributed to differences in the underlying value of the food items. As the bottom panel illustrates, a random effects linear model with random intercepts and slopes showed no significant differences between the slopes of the bidding curves in any of the three conditions.

C. Discussion

The results of this experiment show that giving subjects a taste of the item has no effect on their willingness-to-pay when the item is not physically present. In fact, as can be seen in Figure 3, the bidding curves for the taste and picture and picture only conditions are nearly identical. These results are valuable for two reasons. First, they provide evidence against the hypothesis that experienced reward processes are responsible for the real-exposure effect. Second, since getting a taste of the item should increase the amount of information that subjects have about the foods, it provides further evidence against informational explanations for the effect.

IV. Experiment 4: The Role of Pavlovian Cues

The final experiment investigated the Pavlovian consummatory mechanisms explanation of the real-exposure effect. The experiment is almost identical to the real condition of experiment except that we placed a fully transparent plexiglass wall between the subject and the food, while keeping the physical distance between subject and food constant. Our hypothesis was that if consummatory cues are at work, then the presence of a physical barrier would decrease the likelihood that the processes would be deployed (because the subjects knew that the barrier made the items unavailable), thus reducing the impact of real exposure on the subject's willingness-to-pay. Keep in mind that the use of clear plexiglass means that all sensory cues are still present, so the information hypothesis predicts that the results of this experimental treatment should be much like the original finding of a real-exposure effect.

A. Methods

Thirty Caltech undergraduate and graduate students participated in this experiment. Since the design is almost identical to the real condition of Experiment 1, here we describe only the differences between them. First, instead of 80 snack foods, subjects placed bids on only 20 of them. These were the same 20 foods used in Experiment 3 and were chosen at random from those used in Experiment 1. Second, although the physical set-up of the experiment was unchanged (including the distance of the experimenter from the subject), a fully transparent plexiglass wall (dimensions 8 ft. by 8 ft. by ¼ inch) was placed midway between the subject and the experimenter. The barrier was large enough so that the foods shown by the experimenter were out of the subject's reach.

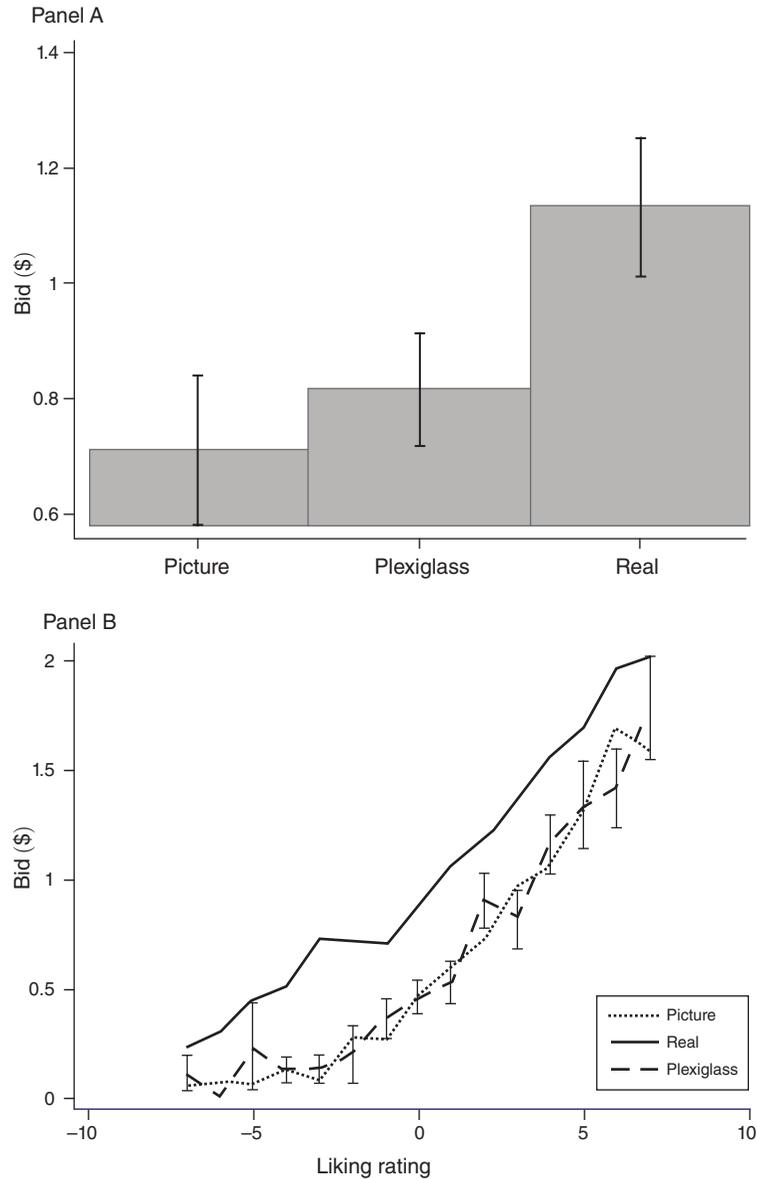


FIGURE 4. RESULTS FOR EXPERIMENT 4

Notes: The introduction of a transparent plexiglass barrier between the subjects and the foods eliminates the difference between the real and picture conditions. Panel A: A comparison of average bids and standard error bars in the picture, real with plexiglass, and real without plexiglass conditions. There was no significant difference between the picture and plexiglass conditions, but the bids in the plexiglass case were lower than in the real condition ($p < 0.042$). Panel B: Bids as a function of self-reported liking ratings for each of the treatments. There was no statistically significant change in the linear slope of these curves across conditions.

B. Results

Figure 4 summarizes the results. As before, the figure compares the results of this experiment with those of the picture and real conditions in Experiment 1. As can be seen in the top panel,

the average bid in the plexiglass condition (81 cents, standard deviation = 0.53) is approximately equal to the average bid in the picture condition (70 cents, standard deviation = 0.53, two-sided t -test $p = 0.51$), but substantially smaller than the average bid in the real condition (114 cents, standard deviation = 0.53, two-sided t -test $p < 0.042$). Note that the average liking ratings were marginally higher in the plexiglass condition (mean = 1.62), than in the real condition (mean = 1.16), which implies that the effect cannot be attributed to differences in the underlying value of the food items. As the bottom panel illustrates, a random effects linear model with random intercepts and slopes showed no significant differences between the slopes of the bidding curves (i.e., bids as a linear function of liking rating) in any of the three conditions.

C. Discussion

The introduction in the real condition of a transparent plexiglass barrier between the subject and the food, which has no impact on the sensory information available to the subject, reduces the willingness-to-pay almost to the level of the picture condition, thus eliminating the real-exposure effect. Given that this was a surprising and somewhat farfetched prediction of the Pavlovian account, that it is quite hard to explain the effect of the plexiglass barrier using an alternative theory, and that there exists a considerable amount of neural evidence for the presence of these types of mechanisms, the experiment provides significant support in favor of this theory of the real-exposure effect. Note, in addition, that the amount of information provided in the real and plexiglass conditions is identical, and therefore the experiment provides further evidence against an informational explanation of the phenomenon.

V. General Discussion

The experiments in this study suggest the following three main results. First, the physical presence of an accessible appetitive (i.e., desirable) item at the time of choice leads to a sizable increase in subject's willingness-to-pay for it, a phenomenon that we have labeled the real-exposure effect. Second, the effect is at work in the evaluation of basic rewards such as high-caloric items for hungry subjects and non-basic rewards such as low value consumer products. Third, Pavlovian consummatory processes triggered by the item's presence might be responsible for the real-exposure effect.

We emphasize three aspects of the Pavlovian consummatory processes theory that we posit as a potential explanation for our findings. First, the text and picture of the stimuli do not seem to be able to serve as CSs capable of triggering the consummatory response through their association with the US given by the actual presence of the food. One potential explanation for this finding is that subjects are unlikely to have received extensive training in pairing these stimuli with the actual physical presence of the foods, which is the US triggering the Pavlovian approach response. Second, the Pavlovian consummatory are not deployed when the stimuli cannot be acquired because, for example, it is placed behind a large plexiglass wall. This could happen because the Pavlovian processes are sophisticated and take into account that there is no point in deploying a Pavlovian response that cannot succeed, or because in these circumstances the response is inhibited by alternative competing processes. Third, the Pavlovian consummatory processes are triggered by the presence of very different appetitive items, which is necessary to explain why we get similar results for foods and trinkets.

An important open question for future research is to explore further what makes a stimulus a predictive CS capable of triggering a Pavlovian consummatory response, and the extent to which appropriate CSs are domain specific. Our limited understanding of the nature of these cues is highlighted by the fact that a taste of the food, which one might have speculated should be a

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powerful CS associated with the presence of food, did not activate the approach response. This is puzzling since the taste of a food is typically associated with having more of the same food available.

The results have practical implications in a number of domains. First, consider again the problem of a restaurateur who has to decide whether to provide customers with a written menu, a picture-based menu, or a dessert tray. The results in this paper suggest that dessert sales should go up significantly if the restaurant uses the dessert tray as opposed to the other two options. Furthermore, the results of the plexiglass experiment suggest that a transparent glass dome should not cover the dessert tray, as is the practice in some establishments. Second, the results also help to explain companies' efforts to find the right packaging and display for their products. In particular, they suggest that stores might want to display real products to consumers and allow more sensory interaction (e.g., test-driving cars which have the "new car smell"). Producing these effects is especially challenging for Internet commerce since, by necessity, Internet sellers are restricted to image, text, and sound displays. Third, the results described above suggest a scope for government regulation of packaging and displays of items that are associated with unhealthy consumption, such as addictive substances and junk foods, to help consumers self-regulate (Klaus Wertenbroch 1998). Finally, our findings might also extend to social bargaining situations. A common legal practice is to present a plaintiff with a signed check when making an offer for a settlement. Our results suggest that this practice might increase the likelihood that the settlement offer is accepted.¹

Our results also provide insight into the findings of two recent studies on the valuation of economics goods. The first one shows that subject's valuations for small toys (e.g., a Slinky) increase when they are allowed to touch them (Joann Peck and Suzanne B. Shu 2009). This can be explained within our framework by the fact that the touch manipulation involves direct and unencumbered proximity to the items, which can trigger Pavlovian approach mechanisms towards the desirable items. The second study shows that the occurrence of the classic endowment effect (Daniel Kahneman, Jack L. Knetsch, and Richard H. Thaler 1990; Knetsch and Jack A. Sinden 1984), in which subjects' valuations for items depend on whether or not they own them, depends on the actual items being physically present at the time of the experiment. In fact, a recent study (Knetsch and Wei-Kang Wong 2009) found no endowment effect when two goods were simply passed around and inspected by subjects (but not physically proximate at the time of decision), and a strong effect when an endowed good was in front of a subject. Again, this observed difference is explained by the Pavlovian consummatory mechanisms described here.

Our results are related to several other findings about the effects of displays and environmental cues on decision making. Here we describe these findings briefly and discuss their similarities and differences with the real-exposure effect and the Pavlovian consummatory mechanisms that we think are at work.

First, a series of experiments have studied the impact of display mode on self-control (Walter Mischel and Bert Moore 1973; Mischel and Bill Underwood 1974; Baba Shiv and Alexander Fedorikhin 1999; Wertenbroch 1998). These studies show that subjects are less likely to choose a tempting option when it is represented symbolically (e.g., in a picture) than when it is put in front of the subjects. Previous interpretations of the experiments have emphasized the tempting nature of the goods, but a mechanistic explanation has not been provided. The results in this paper

¹ In a sequential trust game, Sara J. Solnick (2007) found that subjects in the second-mover trustee role returned only half as much actual cash as other subjects who were asked to return play money or make a numerical statement of the intended cash return. Since money is a highly conditioned stimulus, the results of this experiment can also be explained through our mechanism. Under this explanation, the physical presence of money triggers approach responses that make it hard to transfer it to the other player.

suggest that Pavlovian consummatory processes could be at work in these studies, and that this might contribute to self-control problems when the tempting good is present. In fact, choosing between immediate and delayed rewards sometimes confounds an actual physical display of the immediate reward with a symbolic or imagined delayed reward. It follows that some aspects of preference for immediacy may be intimately related with the real-exposure effect we document.

Second, several studies have found that cues associated with being watched by others seem to increase prosociality in simple economic games. For example, Kevin Haley and Daniel M.T. Fessler (2005) demonstrated the effect of subtle social cues on the dictator game by using a pair of eyes (to cue a sense of being watched) and noise-muffling headphones (to cue a sense of being alone). They found that the eyes cue increased giving, but the headphones did not decrease it. Melissa Bateson, Daniel Nettle, and Gilbert Roberts (2006) found that eye pictures increased voluntary payments for coffee in an office. Mary Rigdon et al. (2008) demonstrated that three small dots at the top of a piece of paper, when oriented in a way that mimics a face, increases giving in a dictator game for males (but not for females). Terence C. Burnham and Brian Hare (2007) found that people give more in a public good game in the presence of a robot that was built to appear lifelike. All of these are examples of how social cues at the time of decision making can affect behavior. Although the exact mechanisms at work in these results are not known, it might also be the case that they activate highly evolved behavioral programs in response to the presence of others (which the brain might detect through the perception of real or artificial faces). Note, however, that the types of cues and mechanisms at work are different from the real-exposure effect. In our case, the triggering cue is the presence of the item itself and the mechanisms at work are Pavlovian consummatory processes that activate behaviors that lead to making contact with appetitive items. In contrast, the cue here is real or abstract faces and the underlying psychological processes are unknown.

Third, cues have also been shown to have strong effects in drug cravings and consumption. Addicts often experience a craving, and are more likely to consume, when cues associated with previous drug use are present. This often leads to relapse even after years of abstinence (see B. Douglas Bernheim and Rangel 2004 for a review of the evidence). Although direct exposure to a drug of choice is thought to trigger the type of Pavlovian consummatory mechanisms discussed in this paper, other drug cues can trigger cravings and recidivism even if the actual drug is not present. Such cues include seeing a place or friend associated with drug use, or watching films showing the use of drug paraphernalia. This is thought to operate through at least two separate mechanisms. First, drug cues trigger physiological “opponent process” which causes unpleasant withdrawal like symptoms (Shepard Siegel 1975; David Laibson 2001). This is thought to increase the marginal utility of consuming the substance. Second, cues are also thought to trigger habitual behavioral responses that promote drug seeking behaviors even if utility maximization calculations suggest that this is not the optimal course of behavior (Bernheim and Rangel 2004; David A. Reddish 2004; Rangel, Camerer, and Montague 2008).

Finally, cues can also affect behavior through a mechanism known in the behavioral economics literature as projection bias (Loewenstein, Ted O’Donoghue, and Matthew Rabin 2003). Here, environmental cues that change the current experienced utility of consuming an item (e.g., the current level of hunger or weather) can affect choices, even if cues (which can also be thought of as states) are not predictive of the actual state of the world at the time of consumption. Because such states or cues do not affect eventual consequences, their effects on choice violate the “consequentialist view” of idealized choice described in the introduction. For example, Daniel T. Gilbert, Michael J. Gill, and Timothy D. Wilson (2002) showed that shoppers who were given a muffin to eat before entering a supermarket were more likely to restrict their purchases to the items in their shopping list, rather than adding unplanned impulse purchases. This finding shows that the value assigned to foods that won’t be eaten until much later depended on the level of hunger at the

time of decision, which is presumably uncorrelated with the hunger state at the time of consumption (see also Daniel Read and Barbara van Leeuwen 1998, for a closely related result). Michael Conlin, O'Donoghue, and Timothy J. Vogelsang (2007) report field evidence for a similar effect of weather: unusually cold weather at the time of ordering cold-weather clothes from a catalog predicts whether goods are later returned. Note that projection bias is quite distinct from the real-exposure effect that we have identified in this paper. In projection bias, cues affect behavior because subjects overestimate the extent to which the future experienced utility of consuming an item will be equal to the experienced utility of consuming it now. Thus, it is due to a cognitive bias. In addition, the cues at work have nothing to do with the physical presence of the good itself.

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