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Arousal and Economic Decision Making

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Abstract

Previous experiments have found that subjecting participants to cognitive load leads to poorer decision making, consistent with dual-system models of behavior. Rather than taxing the cognitive system, this paper reports the results of an experiment that takes a complementary approach: arousing the emotional system. The results indicate that exposure to arousing visual stimuli as compared to neutral images has a negligible impact on performance in arithmetic tasks, impatience, risk taking in the domain of losses, and snack choice although we find that arousal modestly increases in risk-taking in the gains domain and increases susceptibility to anchoring effects. We find the effect of arousal on decision making to be smaller and less consistent then the effect of increased cognitive load for the same tasks.

Keywords: Dual System, Sexual Arousal, Impatience, Risk Taking, Behavioral Economics

JEL Codes: C91, D03, D81

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1 Introduction

Dual-system theories (Kahneman, 2002, 2011) propose that people have a hot "emotional" system and a cool "reasoning" system that jointly interact in the decision making process. Insofar as the goals for these two systems conflict, seemingly small environmental factors that disproportionately activate one system over the other, can lead to big shifts in behavior. Experimental studies that have taxed the reasoning system, via a cognitive load task, find results consistent with such an implication: decision making shifts away from economically normative behavior as indicated by less risk-taking, more impatient behavior, and greater susceptibility to anchoring as well poorer math performance (see Deck and Jahedi, 2015). An alternative, but unstudied, method by which to shift the balance between the two systems is to directly excite the emotional system.

In this study, we test whether exciting the emotional system, via exposure to sexually arousing images, has the same general impact on economic decision making as does taxing the reasoning system. Exposure to sexual images has been shown to be a particularly effective method to excite the emotional system of the brain (Arnow et al. 2002; Khn and Gallinant 2011; Wehrum-Osinsky et al. 2014).[1] Moreover, given the fact that people scarcely tire from viewing sexual stimuli, such images are ideal for use in experimentation, since it is possible to maintain a continuous level of arousal for the study duration (Most, 2007; Sennwald et. al, 2015).

Sexual images are pervasive in society: they are used extensively in advertising and entertainment in films, television and magazines; they are easily accessible in online collections; and they are exchanged frequently in personal telecommunications. In a state of arousal, it is reasonable to expect that the desire to pursue sex can cloud one's judgment, often at the expense of other objectives.[2] The most direct effect of sexual arousal is likely to be on actions that increase the chance of having sex. Indeed, studies have shown that participants exposed to sexual stimuli are more willing to take larger sexual risks, such as not using condoms, and are more willing to engage in morally questionable behaviors or rape (e.g. Blanton and Gerrard, 1997; Ditto et al. 2006; Ariely and Loewenstein, 2006). It is less clear whether there is a link between sexual arousal and decision making more generally.

[1] In our study, we ask people to self-report their arousal level while viewing sexually explicit images. A more direct measure that has been used in previous studies is phallometry, or measurement of the penile erection response (Hanson and Bussiere, 1998). We did not elect this procedure as it seemed invasive and overly-cumbersome to implement in return for the additional precision it would offer, but the evidence suggests that sexually explicit images do elicit the desired physiological response.

[2] Deaner et al (2005) find that even male rhesus monkeys are allured by images of female's posteriors, and are willing to take a cut in their fruit juice allowance to view these images. Sex, like hunger and sleep, is a fundamental desire. The physiological effects of sleep on decision making has been discussed by Dickinson, et al. (2014), while Ashton (2016) looks at the effects on hunger.

There is some evidence that the effects of exposure to sexual stimuli spillover to decision making more generally. McAlvanah (2009), for example, found that viewing photographs of the opposite sex leads both males and females to engage in greater economic risk-taking as compared to viewing photographs of cars. Knutson, et al. (2008) found that young male participants who viewed erotic images were more likely to invest in risky stocks than individuals exposed to neutral pictures. In the field, Dreber, et al. (2013) found that males choose riskier strategies in their chess games against attractively-rated females, while Ronay and von Hippel (2010) found that young male skateboarders increased their level of physical risk taking in the presence of attractive females.

There are at least three papers that examine the impact of sexual arousal on impatience and all find that people become dramatically more impatient when sexually aroused. Wilson and Daly (2004) asked participants to make a series of choices for a payment made tomorrow or a payment made at some point in the future. Participants then rated images of either people or cars where the images had been pre-identified as being arousing or not. Finally, participants made another set of temporal payment choices. Males who observed pictures of "hot" women became significantly more impatient than men who observed pictures of less attractive women but the classification of the car images had no effect.[3]

Van den Bergh et al. (2008) showed male subjects either 15 landscapes or 15 pictures of women in sexually alluring attire. Participants were then asked for the amounts that would make them indifferent between receiving 15 euro that day and receiving payment in one week and in one month. Based on these hypothetical responses, Van den Bergh et al. (2008) conclude that males shown the arousing images are significantly more impatient. A similar result was found by handing men physical bras rather than physical t-shirts, not only for cash but also for their willingness to wait for a larger quantity of food items.

Finally, Kim and Zauberman (2013) presented male participants with 15 pictures of either lingerie models or neutral images and asked them to rate the images for attractiveness. Participants were then asked to imagine having received a $65 Amazon.com gift certificate and asked how much larger the gift certificate would need to be for them to wait either 3 or 12 months for it. Again, the hypothetical choices of the participants indicated they were far more impatient when shown lingerie models.

Most experimental studies looking at arousal focus on a single task, have small sample sizes, and are for hypothetical stakes. We improve on this methodology by using real stakes,

[3]Participants in this study were informed that "they could win some money with a lucky throw of dice at the end of the experiment, in which case they would receive one of their choices, randomly selected, so they should make each choice as if it were actually to be paid off." (pS177-S178). No information is given as to what constitutes a luck throw of the die or how future payments would be made, so it is unclear the degree to which the choices were salient to the participants.

large sample sizes, and multiple tasks in a unified within-subject design. As our experiment closely follows Deck and Jahedi (2015), a major contribution of this study is our ability to compare the effect sizes arising from exposure to arousing stimuli (exciting System 1) to the effect arising from an imposition of cognitive load (overloading System 2) for the same set of tasks and procedures. Lull and Bushman (2015) conducted a meta-analysis examining the old adage that "sex sells" and report that ads with more intense sexual content led to poorer recall and buying intentions. They argue that sexual cues demand more cognitive resources than non-sexual cues and that in essence people were paying attention to the sex and not the rest of the ad. If sexual arousal siphons cognitive resources then the effect of sexual arousal on decision making should impact behavior in the same direction as the cognitive load results of Deck and Jahedi (2015), although based on the results reported by Wilson and Daly (2004), Van den Bergh et al. (2008), and Kim and Zauberman (2013), one would expect the effect sizes to be much larger than for cognitive load.

The goal of the current study is to provide systematic evidence of the effect that sexual arousal has on basic economic behavior. Specifically, this paper reports the results of a controlled laboratory experiment, with salient incentives, in which subjects complete a variety of standard economic tasks, including arithmetic tasks, risk tasks, impatience tasks, anchoring tasks, and snack choice tasks. Prior to completing each task, participants are briefly exposed to either a neutral or arousing image, depending on their assigned treatment. Though images in the neutral treatment were rated to be much less exciting than images in the arousal treatment, there was relatively little effect of arousal on decision making. Performance on arithmetic tasks, risk taking in the loss domain, and patience over intertemporal money tradeoffs did not vary according to treatment. Performance in the risk taking for gains statistically improved in the arousal treatment (the higher expected value option was more likely to be chosen) whereas performance in the anchoring task statistically diminished in the arousal treatment although both effects are economically small.

The results when participants are placed under low and high arousal differ from the cognitive load results of Deck and Jahedi (2015). In the arousal treatment, participants are more likely to take risk whereas the opposite was true in the high cognitive load treatment. This is an important finding as it indicates that a tax on the reasoning system is not equivalent to stimulating the emotional system. Whereas dual system theory predicts that in both settings, the emotional system will guide the decision making process, the results show that in one case risk-taking increases and in the other case it decreases. For the other tasks, the effect of sexual arousal was generally smaller than the effect of increased cognitive load.

The remainder of the paper is organized as follows. Section 2 outlines the experimental design and describes choice of stimuli and the various economic tasks in more detail. Section

3 reports the effect of arousal on each task separately. Section 4 compares the results of arousal to that of cognitive load, and makes closing remarks.

2 Experimental Design

2.1 Participants

The participants were 144 adult males who had previously registered in Duke University's Fuqua School of Business Behavioral Lab participant pool. Attention was restricted to males because prior evidence has shown that males are more clearly affected by sexually arousing images. For example, Hamann, et al. (2004) found that sexually explicit images have a much larger effect among males and this difference can be identified at the neurological level. In another fMRI study, Klucken et al. (2009) presented a set of sexually arousing images to male and female participants and found that learning was substantially affected by sexual images and that neural activity was more acute for men than for women.

Potential participants were contacted via email and informed of the opportunity to complete the two part study. The recruitment email disclosed that study participants may be exposed to sexually explicit images. Participants were required to register for two sessions starting at the same time exactly oneweek apart. The first session lasted 60 minutes and the second session lasted 10 minutes. Participants received a $2 payment for the first session and a $10 payment for the second session. Participants were also informed that they could earn additional compensation based upon their choices during the first session.

2.2 Methods

Participants were seated at partially enclosed cubicles to ensure that they could not observe or interact with others. Fifty-three people were assigned to the neutral image condition and 91 were assigned to the arousal image condition. Neutral images included 80 pictures of everyday objects such as office supplies, tiles, and housewares. Arousal images consisted of 80 explicit images of women and heterosexual couples engaging in various sexual acts. Eight of the arousing images were selected from the Center for the Study of Emotion and Attention at the University of Florida's International Affective Picture System (IAPS) database. The remaining images were downloaded from the internet.[4]

[4]The IAPS images that were used are IAPS #4085, IAPS #4141, IAPS #4290, IAPS #4647, IAPS #4658, IAPS #4672, IAPS #4800, and IAPS #4810. For access to images in the IAPS database, interested readers should contact the Center for the Study of Emotion and Attention. Copies of the non-IAPS images are available from the authors upon request.

The use of sexual images to increase sexual arousal is a standard procedure. Rolls (2005) argues that the brain is tricked into believing that there is a potential for sex when viewing such material. Indeed, there is considerable evidence regarding how the brain responds to sexual imagery. Arnow et al. (2002) expose males to erotic videos and measure penile turgidity and brain activation and find clear relationships between the two. In a meta-analysis Khn and Gallinant (2011) find that sexual arousal is associated with activation in both the emotional (amygdala, insula) and the cognitive (parietal cortex, ACC, thalamus, insula) parts of the brain among other regions. Wehrum-Osinsky et al. (2014) report that the neural response network for sexual stimuli is stable within subject.

As described below, participants completed a variety of decisions: Arithmetic, Risk, Impatience, Anchoring, and Snack Choice. Every participant initially read the computerized instructions privately and was allowed to practice sample versions of the tasks he would face in the study. Everyone was shown sample images that are similar in nature to the ones that he would see in the experiment. The pictures in the arousal condition were pixelated in the instructions with the disclosure that images in the study would not be pixelated. The participants were reminded that they could discontinue the study at any time. No participant withdrew from the study.

Before each decision, a participant was presented with a condition appropriate image for 6 seconds. During this time, no action could be made. With the image still on the screen, participants were then given 9 seconds to rate the image on a 10-point scale (from 1 being the least exciting to 10 being the most exciting). After rating the image or time expiring, the image was removed and the participant was presented with a randomly selected decision task, equally likely to be an arithmetic task, a risk task, an impatience task, a snack choice task, or an anchoring task. The random draw of tasks means that different participants observed different numbers of each type of decision task.[5]

Once the participant completed 80 decision tasks, a short computerized survey was administered. The survey included a question about the participant's level of sexual arousal during the study, the participant's sexual activities including pornography use, demographic information, and questions to assess cognitive ability. A copy of the directions and the survey are included in the appendix and a summary of the responses by treatment can be found in Table 2. Once the survey was completed, one task was picked at random and the participant was paid according to their choice in that task.

[5]Almost everybody rated the image before time expired. In the neutral treatment, time lapsed before a rating was registered for 34 out of the 4230 images (approximately 0.8%). In the arousal treatment, 43 out of 7280 images were not rated (approximately 0.6%).

Table 1: Experimental Tasks.

MAIN TASK	
sub-task	Description of how random tasks are generated
ARITHMETIC	paid \$12 for correct answer.
Addition	Add $a_1 + a_2$ where integer $a_1 \sim U\{11, ..., 99\}$ and integer $a_2 \sim U\{1, ..., 9\}$.
Multiplication	Multiply $m_1 \times m_2$ where integer $m_1 \sim U\{13, ..., 19\}$ and integer $m_2 \sim U\{5, ..., 9\}$.
RISK	paid based on outcome
in Gain Domain	Typical question: Endowment of 2. Integer g drawn from $\sim U\{6, ..., 13\}$.
	Binary choice of guaranteed g or 50/50 chance of receiving $(2g + 2, 0)$
	Additional question: Endowment of 2. Guaranteed 12 or 50/50 chance at 22 or 0.
in Loss Domain	Typical question: Endowment of $2g + 4$, where g drawn from $\sim U\{6, ..., 13\}$
	Binary choice of guaranteed $-g - 2$ or 50/50 chance of receiving $(0, -2g - 2)$
	Additional question: Endowment of 24. Guaranteed -10 or 50/50 chance at -22 or 0.
IMPATIENCE	paid based on outcome
less now vs.	Now: \$10.00 In one week: \$10.25
more later	Now: \$10.00 In one week: \$10.50
	Now: \$10.00 In one week: \$10.70
	Now: \$10.00 In one week: \$11.00
	Now: \$10.50 In one week: \$11.00
	Now: \$11.00 In one week: \$11.50
	Now: \$11.50 In one week: \$11.75
	Now: \$11.50 In one week: \$12.00
	Now: \$12.00 In one week: \$12.50
	Now: \$12.00 In one week: \$12.75
	Now: \$12.00 In one week: \$13.00
	Now: \$12.00 In one week: \$14.00
more now vs.	Now: \$10.00 In one week: \$9.50
less later	Now: \$10.50 In one week: \$10.00
	Now: \$12.00 In one week: \$11.00
ANCHORING	paid for \$12 if within five of the accurate count
	A random number, $d \sim U\{0, ..., 99\}$, is shown on the top of the participant's screen. A 10 by 10 table consisting of 5's and S's is briefly flashed to subject after which participant is asked to guess whether the number of S's in the table are above or below the random number d. After the response, the subject is shown the table again and is given 6 seconds to guess the number of S's in the matrix.
SNACK CHOICE	paide based on outcome
	Healthy and Unhealthy Snack Pairs, with accompanying pictures. (see appendix)

2.2.1 Arithmetic Tasks

Two types of arithmetic tasks were included. As detailed in Table 1, Addition tasks required the participant to add a two digit and a one digit number. Multiplication tasks required the participant to multiply a two digit and a one digit number, see Table 1. Participants had 10 seconds to answer the question. A participant's payoff for an arithmetic task was \$12 if the answer was correct and \$0 if the answer was incorrect.

2.2.2 Risk Tasks

Risk tasks were presented in both the domain of gains and the domain of losses. A risk task in the domain of gains gave the participant an endowment of \$2 and asked him to select between two options. One option was a fixed amount of money and the other was a lottery that paid \$0 with a 50 percent chance and some positive amount with a 50% chance. The dollar possible dollar amounts are shown in Table 1. The participant's earnings for the task were based on their choice. In total, there were 9 possible risk tasks in the gain domain. For eight of the tasks, the safe option had a lower expected value than the risky option. For one of the tasks, the safe option had a higher expected value than the risky option.

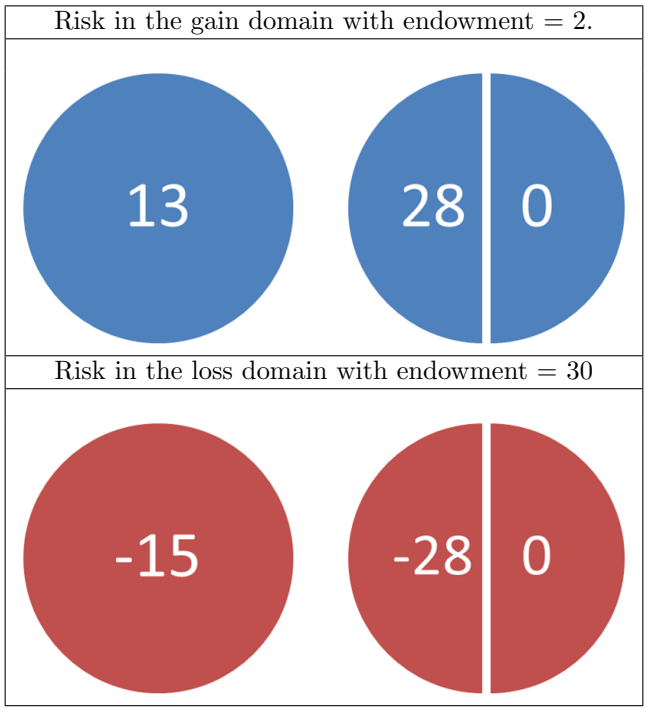

Figure 1: Sample Risk task in gains and losses

For risks in the loss domain, participants were presented a choice between a sure loss and a lottery in which they would lose a larger amount with a 50% chance and with a 50% chance

would lose \$0. See Table 1 for the specific values. The endowment for risks in the domain of losses varied with the size of the lottery such that each risk choice in the loss domain was identical to a possible risk choice in the gain domain in terms of the final payoffs.[6] This means that for eight of the risk tasks in the loss domain, the safe option had a lower expected value than the risky option while for the remaining option, the safe option had a higher expected value than the risky option.

Participants had 10 seconds to make a decision. Failure to answer resulted in \$0 earnings. The sure payment was shown visually as a circle with a dollar amount inside. A lottery was shown visually as a circle divided in half with the smaller payoff in the left semicircle and larger payoff in the right semicircle. This presentation was designed to facilitate subject comprehension of the choices (Eckel and Grossman 2002; Deck and Schlesinger 2014) Figure 2 shows the same sample task in both the gain and loss domains. The sure payment was always presented on the right side of the screen to aid comprehension.

2.2.3 Impatience Task

When asking participants to choose between immediate and future payments, it is important to minimize uncertainty regarding future payments in order to disentangle risk and impatience preferences.[7] We reduced uncertainty about future payments in two ways: (1) we asked participants to sign up for a two-part study, taking place exactly one week apart so participants were aware of the expectation to return prior to signing up, and (2) we skewed the show-up payments to the future (\$2 for the first part, \$10 next week), so that participants had an incentive to return. If subjects are confident that they will return in one week to complete the study, there will be less risk associated with collecting future payments.

The impatience task asked participants to select between being paid $\$X$ today and $\$Y$ in one week. The possible money pairs are summarized in Table 1. For most tasks $\$X \leq \$Y$; however, for three money pairs, participants were given an option where $\$X > \$Y$, so the amount of money today is larger than the amount of money in one week. These three pairs are included as controls to verify that participants are paying attention to the numbers as the future payment was always presented on the right side of the screen to aid comprehension. The choice was presented to the participant using pictures of bills and coins totaling the corresponding amount in addition to a listing of the nominal amount. This was done to

[6] Institutional restrictions did not allow participants to lose money they had prior to entering the laboratory.

[7] Augenblick, Niederle, and Sprenger (2013) have a nice paper that argues impatience should be measured over effort tasks, rather than monetary rewards. The design of this study used monetary rewards for the express purpose of mirroring a previous cognitive load study, so that the results could be compared (Deck and Jahedi, 2015).

parallel the snack choice task described below. The participant's earnings for the task equaled the selected option. Participants had 10 seconds to make a decision. Failure to answer resulted in $0 earnings.

2.2.4 Anchoring Task

The anchoring task involved two stages. In the first stage the participant was shown a randomly generated 10 x 10 matrix of letter "S" and number "5" characters for 2 seconds. The participant was then asked: "Are there more "S" characters or fewer "S" characters in the matrix that flashes below than the following randomly generated number?" The randomly generated number was equally likely to be any integer from 0 to 99 and was independent of the number of "S" characters in the matrix. The random number remained on the screen and serves as the anchor. In the second stage, the participant was shown the matrix a second time and had 6 seconds to count and report the number of "S" characters. The allotted time was insufficient for the typical participant to actually count the characters. If the participant's guess was within 5 of the correct answer the participant's earnings for the task were $12. Otherwise the participant's earnings were $0.

2.2.5 Snack Choice Task

The snack choice task presented two food options to the participant. The participant's earnings for the task equaled the selected option, which was provided one week later. Participants had 10 seconds to make a decision. Failure to answer resulted in no earnings for the task. Delaying the payment of the snack choice eliminated the need to hold multiple units of each snack choice in inventory. Each pair of snack options was selected so that the cost, category, and size were similar. The "healthy" snack in the pair was the one that contained fewer calories. A complete listing of the snack pairs is provided in the appendix.

2.3 Participant Characteristics

Table 2 provides summary statistics from the post-experiment survey. The success of the manipulation is evidenced by the highly significant difference in responses to Q1 "How sexually aroused were you during the study?" For no other characteristic did the two groups differ. Ten subjects reported their sexuality to be something other than heterosexual. The analysis presented in the next section includes all subjects regardless of their stated sexual preferences; excluding non-heterosexual individuals does not qualitatively change the findings.

Table 2: Survey Responses (mean), by Treatment

		Neutral ($N = 53$)	Arousal ($N = 91$)	
Q1:	"How sexually aroused were you during the study? 1=least, 5=most"	1.14	2.74	***
Q2:	"How would you describe your sexuality?"			
	- heterosexual	98%	91%	
	- homosexual	0%	5%	
	- bisexual	2%	2%	
	- other / prefer not to answer	0%	2%	
Q3:	"How many minutes do you spend viewing pornography in a typical week?"	34.4	40.3	
Q4:	"How many times have you experienced an ejaculation in the last month?"	14.6	15.7	
Q5:	"Which of the following best describes your relationship status?"			
	- committed	39%	45%	
	- casual	12%	10%	
	- no relationship	49%	45%	
Q6:	"In what year were you born? (YYYY)"	1987	1987	
Q7:	"What is your college class?"	3.71	4.05	
Q8:	"What is your college Grade Point Average?"	3.49	3.45	
Q9:	"What is your race/ethnicity?"			
	- caucasian, non-hispanic	31%	30%	
	- Hispanic	8%	5%	
	- black or African	17%	17%	
	- Asian	42%	40%	
	- other / prefer not to answer	2%	8%	
Q10:	"What was the total income for the HH where you lived when you were 17?"			
	- less than $25,000	15%	14%	
	- $25,000 - $50,000	12%	20%	
	- $50,000 - $75,000	21%	24%	
	- $75,000 - $100,000	17%	14%	
	- over $100,000	35%	27%	
Q11:	"A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?" (percent correct reported)	33%	43%	
Q12:	"If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?" (percent correct reported)	35%	39%	
Q13:	"In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days to fill, how long for half?" (percent correct reported)	54%	54%	
Q14:	"When you flip a penny, what is the probability of it landing heads-side-up?" (percent correct reported)	94%	93%	
Q15:	"Good things come to those who wait. 1=disagree 5=agree"	3.65	3.56	
Q16:	"Anticipation leads to greater enjoyment. 1=disagree 5=agree"	3.67	3.85	
Q17:	"It is better to be safe than sorry. 1=disagree 5=agree"	3.33	3.64	
Q18:	"Suppose that you earned $100k in a lottery. How much would you invest in an asset to either HALVE or DOUBLE in two years time with equal chance?"	41%	39%	

*** denotes a significant difference at the 1% level in survey responses across treatments. A two-sample t test was used for mean comparisons while a Kolmogorov-Smirnov test was used to test equality of distributions.

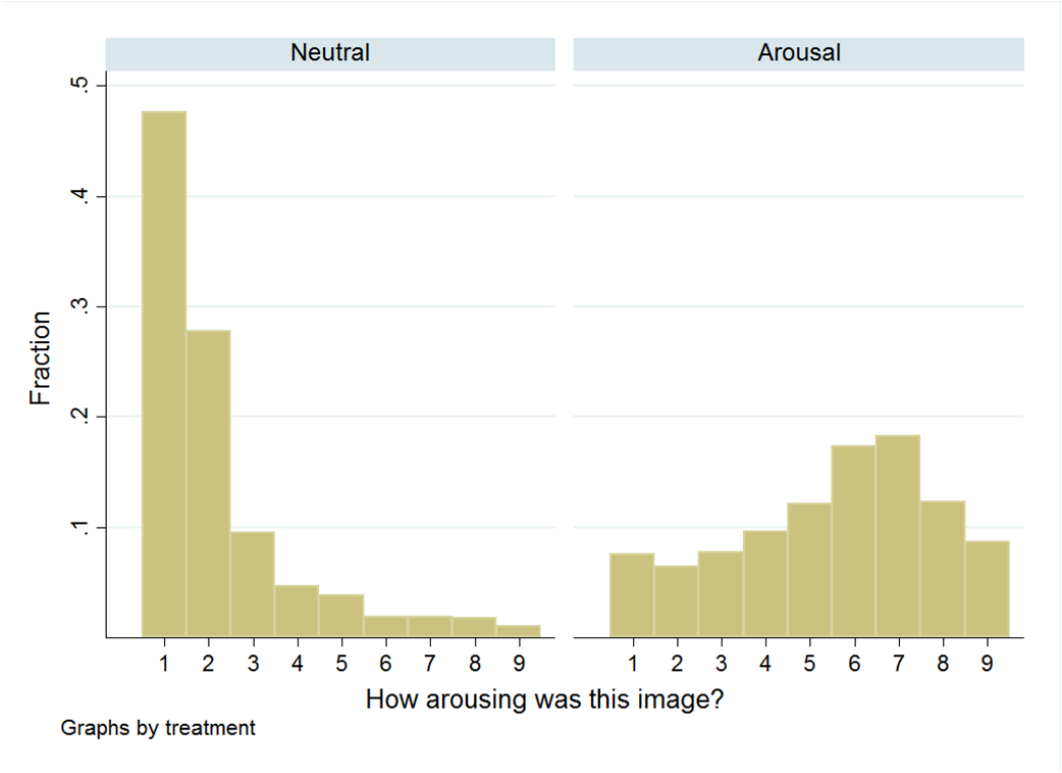

Figure 2: Image Rating Reported Across Treatment

3 Results

Figure 2 shows the average rating of images across treatments. The mean rating given to images in the neutral treatment was 2.18 out of a 9-point scale while the mean rating given to images in the arousal treatment was 5.50. A two-sample Kolmogorov-Smirnov test rejects the hypothesis that the two ratings come from the same distribution ($p < 0.001$).[8]

Table 3 provides basic summary statistics. For each task and in each treatment, the mean performance, the standard error, and number of observations are reported. The average image rating associated with each task is also reported, as is the average number of seconds spent. Note that the average image rating differs greatly by treatment, but not across tasks. The average time spent in each task does not vary by treatment, but does vary across tasks.

Table 3 also indicates where the mean performance for a task differed across treatment using stars. For each task, a single regression was run on the mean performance in the task on a treatment dummy, with clustered standard errors at the participant level. The arousal treatment increases normative behavior for the Risk in Gains task (Wald test, $p = 0.058$) and reduces normative behavior in the Anchoring task (Wald test, $p = 0.046$). No other

[8]Neither the image ratings, nor any of the results, change if we drop the self-reported homosexuals from the sample.

Table 3: Summary Statistics by Task and Treatment

	Mean Performance	Std. Error	Observations	Image Rating	Seconds Spent
Addition: *percentage correct*					
Neutral	97.5%	(0.8%)	403	2.19	2.7
Arousal	97.7%	(0.6%)	730	5.49	2.6
Multiplication: *percentage correct*					
Neutral	80.8%	(1.9%)	417	2.20	5.6
Arousal	79.7%	(1.5%)	738	5.52	5.6
Risk in Gains: *higher expected value, could be safe or risky bet*					
Neutral	50.9%	(2.5%)	389	2.17	4.1
Arousal	60.9% (*)	(1.8%)	717	5.57	4.3
Risk in Losses: *higher expected value, could be safe or risky bet*					
Neutral	48.1%	(2.5%)	403	2.19	4.2
Arousal	48.4%	(1.9%)	686	5.45	4.2
Impatience: *larger amount of money, could be in the future or immediately*					
Neutral	62.5%	(1.7%)	834	2.17	3.4
Arousal	63.7%	(1.3%)	1440	5.5	3.4
Snack Choice: *choose the healthy snack*					
Neutral	48.1%	(1.7%)	896	2.17	3.6
Arousal	45.9%	(1.3%)	1487	5.51	3.7
Anchoring: *guess is within range of S-value*					
Neutral	44%	(1.7%)	886	2.19	5.7
Arousal	38.6% (**)	(1.3%)	1468	5.51	5.3

* and ** denote significance at the 10% and 5% level, respectively.

significant differences were found.

Below, we report regression results for each task separately. In all cases a series of regression results are provided, where standard errors are clustered at the participant level. Model 1 includes only a dummy variable for the arousal treatment and mimics the analysis done in Table 3. The second specification includes a time trend to account for the possibility that the arousing images might have a cumulative effect, that participants might become desensitized, or that there is learning in the tasks. The third specification controls for the image rating to test the effect of more arousing ratings on behavior. The fourth specification compares the most arousing images to the least arousing images. It repeats the same analysis as Model 1, but does so on half of the observations: the 50% of neutral tasks with the lowest average rating and the 50% of arousal tasks with the highest average rating. Model 5 allows

for task-fixed controls: a dummy for each of the different types of questions that participants might receive for that task. Model 6 controls for all the demographic characteristics gathered from the survey responses. Finally, the last specification adds in all the controls jointly.

3.1 Arithmetic Tasks Results

Tables 4 and 5 analyze the effect of sexual arousal on addition and multiplication problems respectively. Overall, the participants answered 98% of the addition problems correctly; however, as revealed by the top row of Table 4, the performance does not differ between the arousal and neutral conditions, regardless of what controls are included.

Not surprisingly, overall performance on the multiplication task was lower than in the addition task (a Wald test of the baseline performance in Model 1, $p < 0.001$), indicating that it was a harder task with participants answering 80% of the problems correctly. In fact, a larger fraction of participants failed to provide an answer in the allotted time for the multiplication problems (5.0%) as compared to the addition problems (0.1%). Nonetheless, there is no effect of sexual arousal on multiplication performance (see Table 5) across any of the specifications, though participants did exhibit a slight improvement in performance across the course of the experiment (see Model 2 and Model 7).

3.2 Risk Tasks Results

Tables 6 and 7 analyze the effect of sexual arousal on risk taking. In the arousal treatment, subjects are marginally more likely to take risks in the domain of gains. For most specifications in Table 6, a Wald test shows that the arousal treatment is 10 percentage points more likely to choose the higher expected value option, at the 10% significance level. Hence, we do find at least weak evidence that sexual arousal leads to greater risk taking (at least in gains), consistent with Knutson, et al. (2008). In the loss domain, there is no statistical difference between the treatments for any of the specifications in Table 7.

Almost everybody responded to the questions in the allotted time. Fewer than 0.5% of participants ran out time in the risk task and the rate was nearly identical for gains and losses. For most questions, the risky option had a higher expected value. In situations where the safe option had the higher expected value, people were more likely to choose the higher expected value option, but not significantly so.

Table 4: Addition Task

Dependent variable is whether the addition problem was answered correctly.
OLS regressions, standard errors clustered by participant.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Arousal Treatment	0.002	0.001	-0.011		-0.002	0.018	0.01
	[0.020]	[0.019]	[0.023]		[0.019]	[0.014]	[0.014]
Period		0.000					0.000
		[0.000]					[0.000]
Image rating			0.004*				0.000
			[0.002]				[0.001]
Extreme image comparison				-0.004			
				[0.018]			
task-fixed					X		X
demographics						X	X
Constant	0.975***	0.971***	0.966***	0.979***	1.035***	0.154***	0.240***
	[0.016]	[0.024]	[0.018]	[0.013]	[0.023]	[0.041]	[0.070]
R^2	0.000	0.000	0.003	0.000	0.101	0.479	0.542
Observations	1133	1133	1128	547	1133	1069	1065

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 5: Multiplication Task

Dependent variable is whether the multiplication problem was answered correctly. OLS regressions, standard errors clustered by participant.	Model 1 b/se	Model 2 b/se	Model 3 b/se	Model 4 b/se	Model 5 b/se	Model 6 b/se	Model 7 b/se
Arousal Treatment	-0.011	-0.013	-0.024		-0.015	0.056	0.055
	[0.044]	[0.044]	[0.048]		[0.043]	[0.048]	[0.048]
Period		0.001**					0.002***
		[0.001]					[0.001]
Image rating			0.004				0.003
			[0.009]				[0.006]
Extreme image comparison				0.025			
				[0.049]			
task-fixed					X		X
demographics						X	X
Constant	0.808***	0.757***	0.796***	0.801***	0.907***	0.479**	0.485**
	[0.034]	[0.041]	[0.043]	[0.042]	[0.055]	[0.223]	[0.232]
R^2	0.000	0.006	0.001	0.001	0.028	0.210	0.250
Observations	1155	1155	1147	558	1155	1077	1069

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 6: Risk in Gains Task

Dependent variable is whether higher EV option was chosen. OLS regressions, standard errors clustered by participant.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Arousal Treatment	0.100*	0.101*	0.108*		0.097*	0.117	0.125*
	[0.053]	[0.052]	[0.064]		[0.052]	[0.072]	[0.074]
Period		0.000					0.000
		[0.001]					[0.001]
Image rating			-0.002				-0.006
			[0.009]				[0.008]
Extreme image comparison				0.095			
				[0.061]			
task-fixed					X		X
demographics						X	X
Constant	0.509***	0.495***	0.513***	0.507***	0.618***	0.825**	0.987***
	[0.043]	[0.049]	[0.045]	[0.049]	[0.056]	[0.334]	[0.335]
R^2	0.009	0.010	0.010	0.008	0.023	0.156	0.167
Observations	1106	1106	1103	580	1106	1043	1041

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 7: Risk in Losses Task

Dependent variable is whether higher EV option was chosen.
OLS regressions, standard errors clustered by participant.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Arousal Treatment	0.003	0.003	-0.045		0.004	0.077	0.076
	[0.055]	[0.055]	[0.066]		[0.055]	[0.076]	[0.085]
Period		-0.001					-0.001
		[0.001]					[0.001]
Image rating			0.016				0.004
			[0.010]				[0.011]
Extreme image comparison				0.023			
				[0.059]			
task-fixed					X		X
demographics						X	X
Constant	0.481***	0.505***	0.446***	0.482***	0.437***	0.631**	0.568*
	[0.042]	[0.047]	[0.046]	[0.044]	[0.059]	[0.289]	[0.313]
R^2	0.000	0.001	0.004	0.000	0.012	0.188	0.205
Observations	1089	1089	1084	504	1089	1018	1013

* significance at 10%, ** significance at 5%, *** significance at 1%

3.3 Impatience Task Results

Before presenting the overall pattern of results for the impatience task, we report that on the three questions where the participants were asked to choose between more money now and less money in the future, the delayed payment was only selected approximately 2% of the time and this rate did not differ between the arousal and neutral treatments. This indicates that subjects were paying close attention to the choices and not simply behaving randomly or automatically. In only 0.2% of all of impatience tasks did participants fail to make a selection in the time allotted.

Table 8 provides the econometric evidence for determining if there is a treatment effect on impatience. There is not - in no specification is the treatment significant even marginally. It is worth noting that in all specifications, the sign of the arousal coefficient is positive, in the direction of aroused participants being more patient. This stands in direct contrast to Wilson and Daly (2004), Van den Bergh et al. (2008), and Kim and Zauberman (2013).

3.4 Snack Choice Task Results

Participants chose the healthy snack option slightly less than half of the time, but this did not differ by treatment as evidenced by Table 9. It is also worth noting that there is no time trend in snack choice. That is, the data do not indicate that participants experienced a depletion of their will power, contrary to previous work by Shiv and Fedorikhin 1999 and Baumeister 2002. The non-response rate was 4.6% for snack choices.

3.5 Anchoring Task Results

In the anchoring task, participants were flashed a random number, between 0 and 99, and then asked to guess the number of "S" characters in a matrix. Participants knew that the random number was not associated in any way with the task, yet the average guess of responses exhibited quite a bit of anchoring. The guess of respondents was twice as likely to be on the same side of the true number as the anchor rather than on the opposite side. That is, if there were 50 "S" characters in the matrix and the anchor was 10, respondents were twice as likely to make a guess that was below 50 than to make a guess above 50. Similarly if there were 50 "S" characters in the matrix and the anchor was 90, respondents were twice as likely to make a guess that was above 50 than to make a guess that was below 50. This did not differ across treatments.

In Table 10, we define normative behavior in the Anchoring task as whether participants' guess was within the allotted range to receive payment. In the neutral treatment, 44% of

responses were in the correct range whereas in the arousal treatment, 38.6% of guesses were in the correct range. The difference remains similar in magnitude and significance across most specifications, indicating that arousal caused participants to do worse on the Anchoring task. It is important to note that a decrease in the anchoring performance does not imply that people are more susceptible to anchoring; rather, it may simply be the case that people in the arousal treatment are more distracted.[9]

There is a positive time trend, indicating that respondents improved their behavior over time. Interestingly, there is a negative coefficient on the image rating, indicating that images with higher ratings are associated with a worse performance. In Model 4, where we compare performance in the Anchoring task of those images rated lowest in the neutral treatment as compared to those images rated highest in the arousal treatment, we find that the effect size of the treatment grows to 9%.

4 Discussion

Overall, we find rather minimal evidence that viewing erotic images has an impact on decision making. Contrary to previous studies, we find no evidence that sexual arousal leads to more impatience, despite the fact that the stimuli used in our study were generally more explicit than the stimuli reported in other studies.[10] We do however find evidence in favor of more risk-taking in the gain domain when viewing explicit images, although not as dramatically as in Knutson, et al. (2008). Taken together, the evidence suggests that sexual arousal does not generate the same behavioral patterns as cognitive load.

One possible explanation for why we do not find a large effect of arousal on preferences is that our study uses real incentives, rather than hypothetical choices. It is possible that the incentive payments are large enough that respondents are motivated to make good decisions in spite of being exposed to arousing stimuli. Alternatively, it is possible that participants realize the effect that arousal might have on their decision making and take additional steps to self-regulate their decision making process. For instance, they may take more time on a question if they are exposed to an arousing image as compared to a neutral image so to ensure that they reach the correct answer. Based on the time spent on each task however, this does not appear to be the case (see Table 3).

[9]While it is outside the scope of this study, one could design a method to differentiate the effect of distraction and arousal on anchoring performance. For instance, it is possible to gather distracting images for use in both the neutral and arousal group. If the result was due to a distraction, there should be no difference in behavior across the groups.

[10]Pilot studies were conducted with images of women in lingerie, similar to Kim and Zauberman (2013), but no effect was identified and thus more extreme images were used.

Table 8: Time Preference Task

Dependent variable is whether larger money option was chosen. OLS regressions, standard errors clustered by participant.	Model 1 b/se	Model 2 b/se	Model 3 b/se	Model 4 b/se	Model 5 b/se	Model 6 b/se	Model 7 b/se
Arousal Treatment	0.012	0.012	0.021		0.012	0.097	0.113
	[0.061]	[0.061]	[0.071]		[0.059]	[0.088]	[0.088]
Period		-0.000					0.000
		[0.000]					[0.000]
Image rating			-0.003				-0.002
			[0.010]				[0.008]
Extreme image comparison				0.030			
				[0.064]			
task-fixed					X		X
demographics						X	X
Constant	0.625***	0.638***	0.632***	0.616***	0.986***	-0.349	0.049
	[0.049]	[0.050]	[0.052]	[0.052]	[0.040]	[0.339]	[0.339]
R^2	0.000	0.000	0.000	0.001	0.177	0.208	0.376
Observations	2274	2274	2265	1118	2274	2137	2129

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 9: Snack Choice Task

Dependent variable is whether healthy snack choice was chosen.
OLS regressions, standard errors clustered by participant.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Arousal Treatment	-0.022	-0.022	-0.036		-0.022	0.077	0.051
	[0.060]	[0.060]	[0.068]		[0.059]	[0.085]	[0.085]
Period		0.000					0.000
		[0.000]					[0.000]
Image rating			0.003				0.015*
			[0.009]				[0.008]
Extreme image comparison				-0.009			
				[0.065]			
task-fixed					X		X
demographics						X	X
Constant	0.481***	0.464***	0.477***	0.463***	0.594***	0.226	0.334
	[0.048]	[0.051]	[0.052]	[0.053]	[0.060]	[0.330]	[0.324]
R^2	0.000	0.001	0.001	0.000	0.019	0.189	0.212
Observations	2383	2383	2372	1208	2383	2238	2228

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 10: Anchoring Task

Dependent variable is whether guess is within specified range of actual. OLS regressions, standard errors clustered by participant.	Model 1 b/se	Model 2 b/se	Model 3 b/se	Model 4 b/se	Model 5 b/se	Model 6 b/se	Model 7 b/se
Arousal Treatment	-0.054**	-0.052*	-0.018		-0.053**	-0.088**	-0.045
	[0.027]	[0.026]	[0.031]		[0.025]	[0.035]	[0.035]
Period		0.003***					0.003***
		[0.000]					[0.000]
Image rating			-0.012**				-0.012**
			[0.005]				[0.005]
Extreme image comparison				-0.089***			
				[0.034]			
task-fixed					X		X
demographics						X	X
Constant	0.440***	0.332***	0.468***	0.458***	0.925***	0.420***	0.892***
	[0.022]	[0.027]	[0.025]	[0.027]	[0.066]	[0.123]	[0.139]
R^2	0.003	0.018	0.006	0.008	0.156	0.061	0.214
Observations	2354	2354	2344	1143	2354	2203	2193

* significance at 10%, ** significance at 5%, *** significance at 1%

Table 11: Comparison of Treatment Effects

	Low Load	High Load	Change due to Cognitive Load	Neutral	Arousal	Change due to Arousal
Addition	97.8%	97.0%	-0.8%	97.5%	97.7%	0.2%
Multiplication	71.6%	55.9%	-15.7%	80.8%***	79.7%	-1.1%***
Risk in Gains	59.5%	52.7%	-6.8%	50.9%***	60.9%	10.0%***
Risk in Losses	45.7%	43.9%	-1.8%	48.1%	48.4%	0.3%
Time Preference	56.9%	50.0%	-6.9%	62.5%*	63.7%	1.2%*
Snack Choice	43.7%	39.4%	-4.3%	48.1%	45.9%	-2.2%
Anchoring	50.1%	40.9%	-9.2%	44.0%	38.6%	-5.4%

Of course, it is difficult to compare studies given the many differences in their procedures. However, a study that closely mimics this one (Deck and Jahedi, 2015) uses the exact same set of tasks to test for the effect of cognitive load on decision making. Table 11 compares the results of the two studies.

Note that the baseline conditions of the two studies (low load and neutral images) are rather similar. Stars in the Neutral column of Table 11 indicate whether the neutral treatment and the low cognitive load treatment differed significantly. There is no difference between the two studies for the Addition, Anchoring, Snack Choice, and Risk in Losses tasks. The participants of this study, which consisted of male Duke students, did score statistically better on the multiplications questions and were statistically more patient when it came to money as compared to the male and female Arkansas students who participated in the cognitive load study. That the Duke students exhibit statistically less normative behavior in risk taking is somewhat surprising given that males are often found to be more risk loving (see Eckel and Grossman 2008). However, none of the differences are economically substantial. The fact that the two studies, conducted at different institutions and using different gender compositions, have somewhat similar baselines suggests that the tasks are broadly robust to replicability.[11]

In the cognitive load study, normative behavior always decreased as a result of cognitive load. In the arousal study, the effect of sexual arousal sometimes diminished normative behavior and sometimes improved normative behavior. The stars in the 'Change due to

[11]The experiments in Deck and Jahedi (2015) were conducted at the University of Arkansas and had male and female participants. Unfortunately, gender data is not available for the participants in Deck and Jahedi (2015).

Arousal' treatment of Table 11 compare the effect of sexual arousal to the effect of cognitive load. Most interestingly, for the Risk in Gains task, participants that were aroused were 10 percentage points more likely to choose the higher expected value outcome. This is a big contrast to the effect of cognitive load on the Risk in Gains task, where participants were 6.8 percentage points less likely to choose the higher expected value outcome. This difference is significant both statistically and economically. One implication of this finding is that a tax on cognition and the arousal of emotion do not have the same effect on risk-taking, despite the fact that they both conceivably diminish cognitive ability.

These findings suggest that a shift away from using cognitive resources can impact behavior in a domain-specific way. In some instances (under cognitive load), the intuitive response leads to a reduction of risk-taking whereas in other instances (sexual arousal), the intuitive response leads to an increase in risk-taking. Of course, in our experiment, risk-taking was overwhelmingly associated with a higher expected value payoff. The same result need not necessarily hold if risk-taking is associated with a lower expected value payoff. Nonetheless, our findings suggest that the behavioral impact of a stimulus can rely heavily on its context and that a more nuanced interplay might be required when working in the dual system framework.

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Appendix

This appendix contains information observed by the participant. The first section includes the directions for the neutral image condition. Directions for the arousal treatment are available upon request. The second section contains the post study survey and the third section presents the images used for the snack choice task.

Participant Directions

Instructions:

Welcome, and thank you for participating in this experiment.

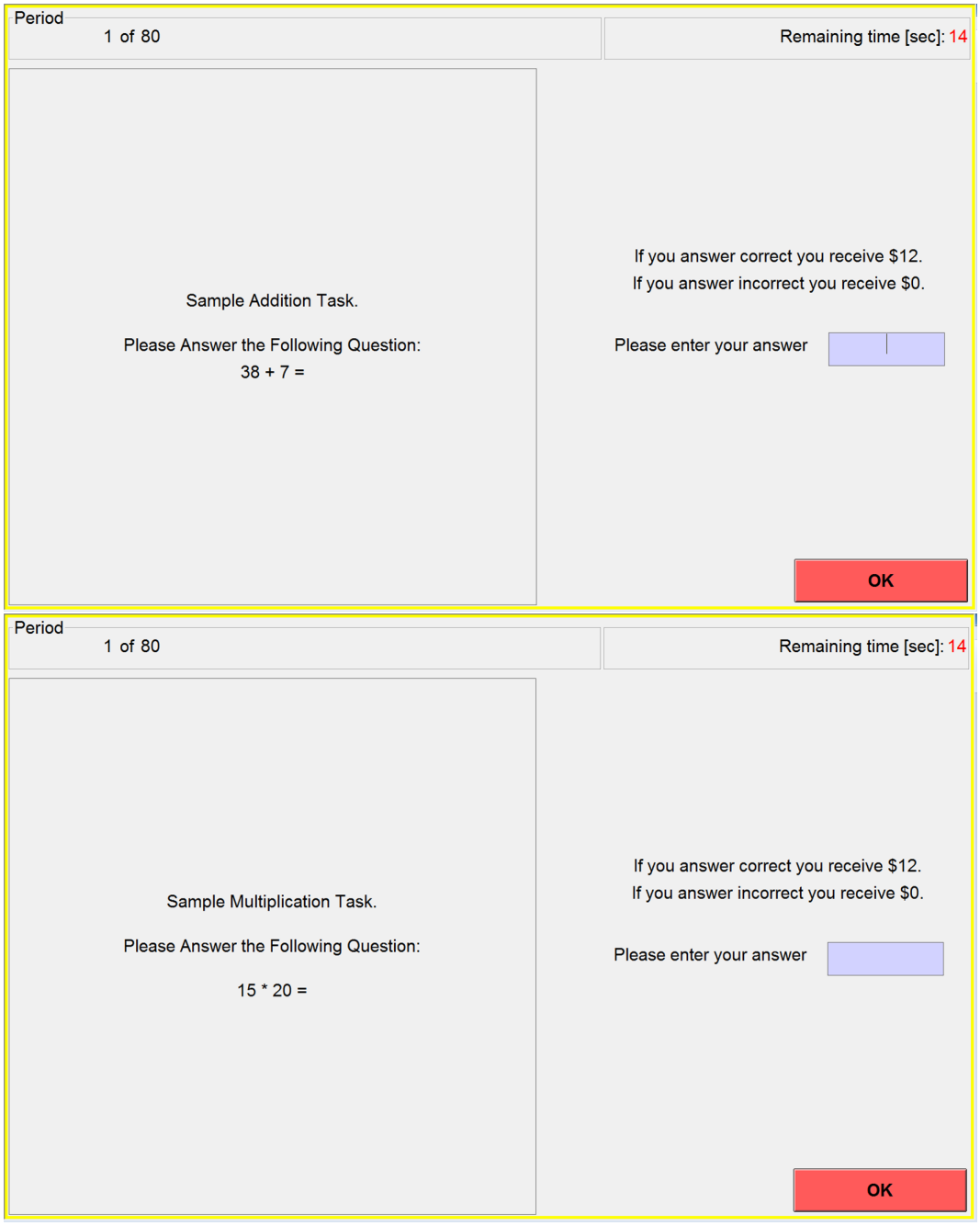
The study will take place in two parts. The first part will last about 60 minutes. For participating in this part, you will be guaranteed a $2 payment. The second part will take place exactly one week later and will last about 10 minutes and will pay a guaranteed show-up fee of $10. You can earn additional money based on the decisions that you make, therefore it is important that you read the directions carefully. If you have any questions during the experiment, please raise your hand and wait for the experimenter to come to you. Please do not make noise or communicate with others for the duration of the experiment as this is grounds for dismissal. Note that you can leave at any point during the experiment, and you will be paid a $2 show-up fee.

In this study, there will be 80 periods. In each period, you will be shown a picture and asked to rate it. Once you enter your rating, the picture will disappear and you will be given a decision task. Your goal will be to complete the decision task in the allotted time. The type of task will vary by period and will be described in more detail below. After all tasks are completed, one of them will randomly be chosen by the computer to count towards your final payment.

The Decision Tasks In each period, you will be given a decision task. The decision tasks vary from one period to the next, but can be categorized into 5 broad groups: (1) math problems, (2) counting problems, (3) a choice between lotteries, (4) a choice regarding your preference for money allocation across time, and (5) a choice between two consumption bundles. You will be allowed to practice each type of decision task on the following pages.

Decision Task: Math Problems For the math problems, you will be asked either addition or multiplication questions. If you get the problem correct, you will receive

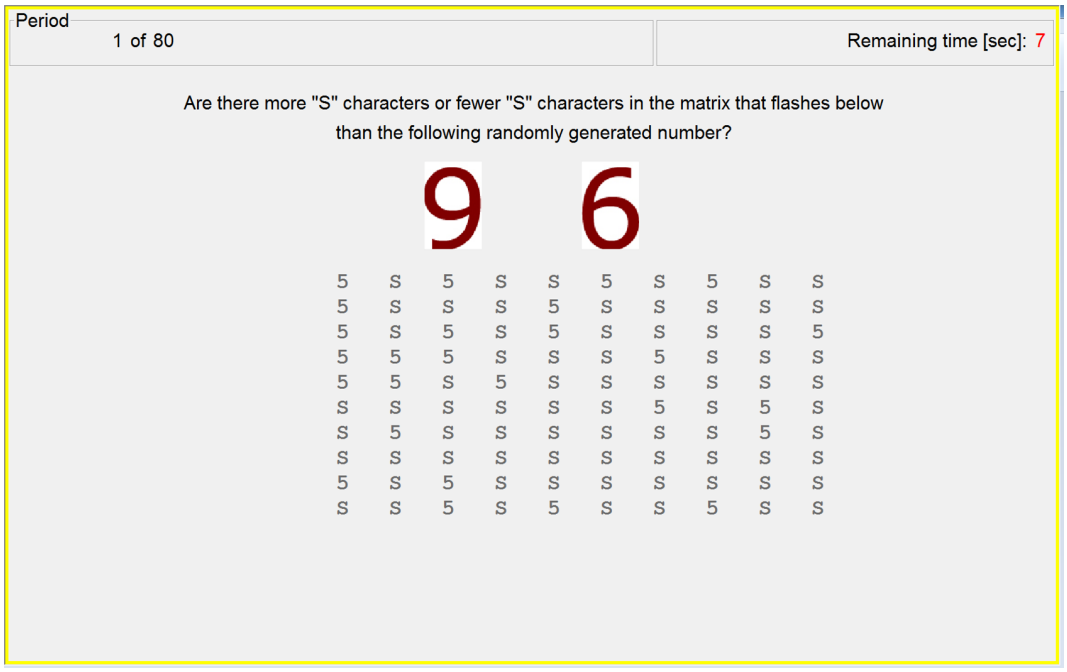
$12 for the task. If you get the problem incorrect or if you run out of time without answering, you will receive $0 for the task. Please click Continue to practice some math problems.

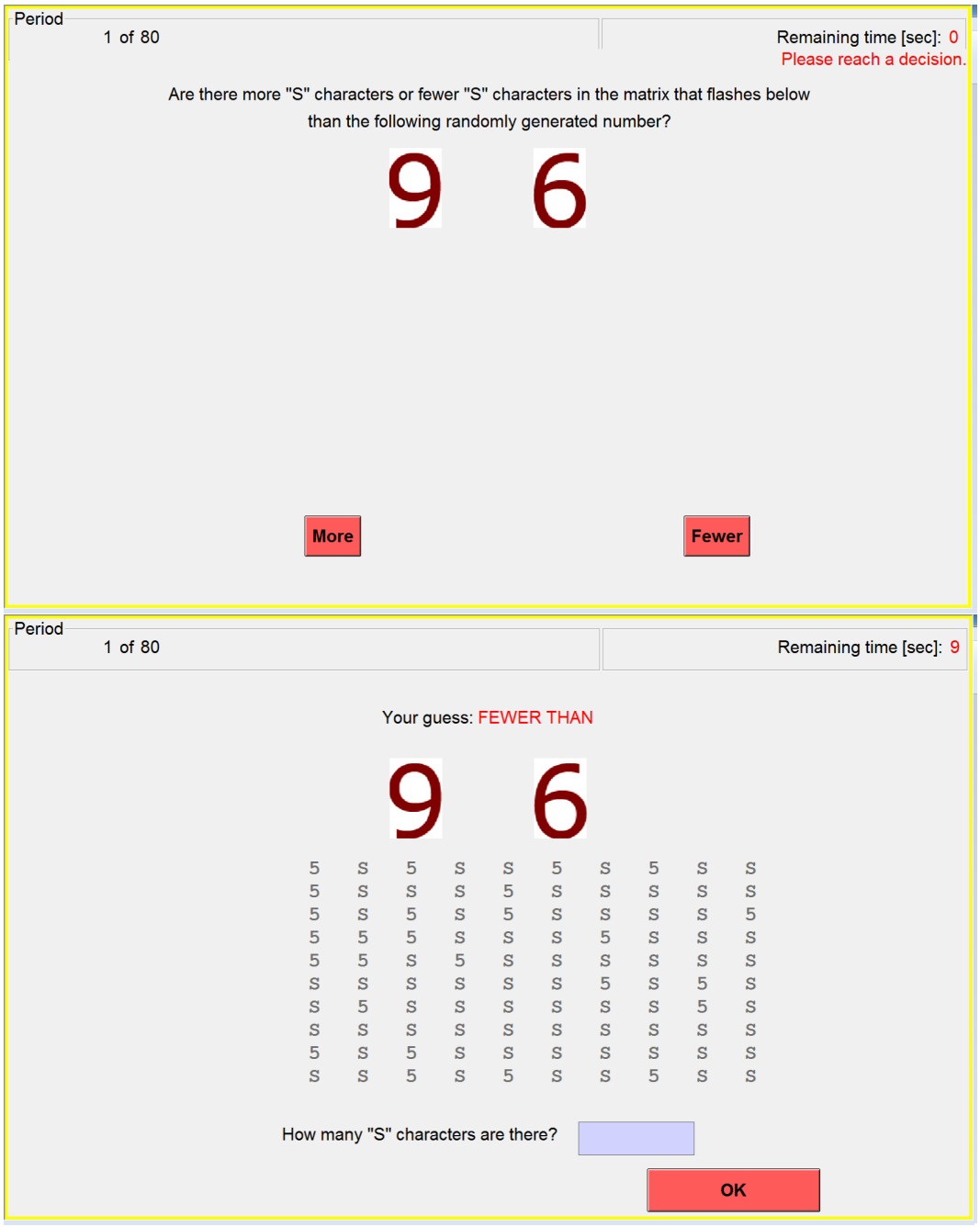


Decision Task: Counting Problems Besides the math problems, you may also face counting problems. The counting problem consists of two parts. In the first part, you will briefly be shown a matrix of S characters and 5 characters and be asked to guess whether the number of S's in the matrix is more or fewer than a random generated

number. The randomly generated number has no association to the number of S's in the matrix.

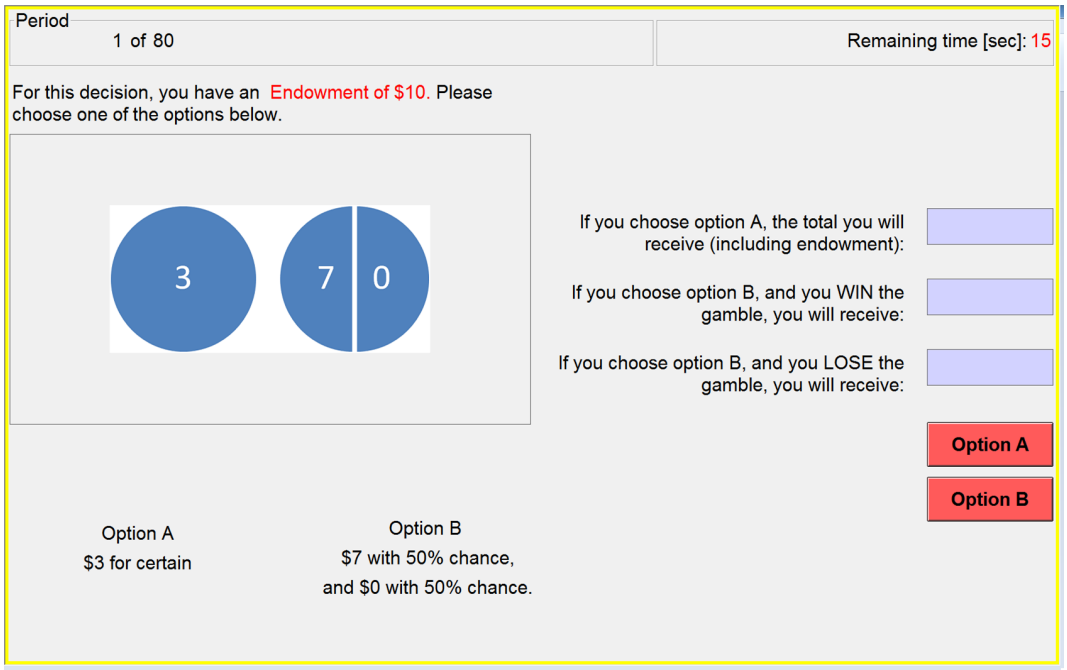
Once you make your guess, you will be shown the same matrix again for ten seconds and asked to state the exact count of "S" characters in the matrix. In order to get paid, your guess must be made in time and be within five of the actual amount of "S" characters in the matrix. If you meet this criteria, you will be paid $12. Otherwise, you will be paid $0. Please note that it is easy to run out of time for this question. Please click Continue to practice some counting decision problems.

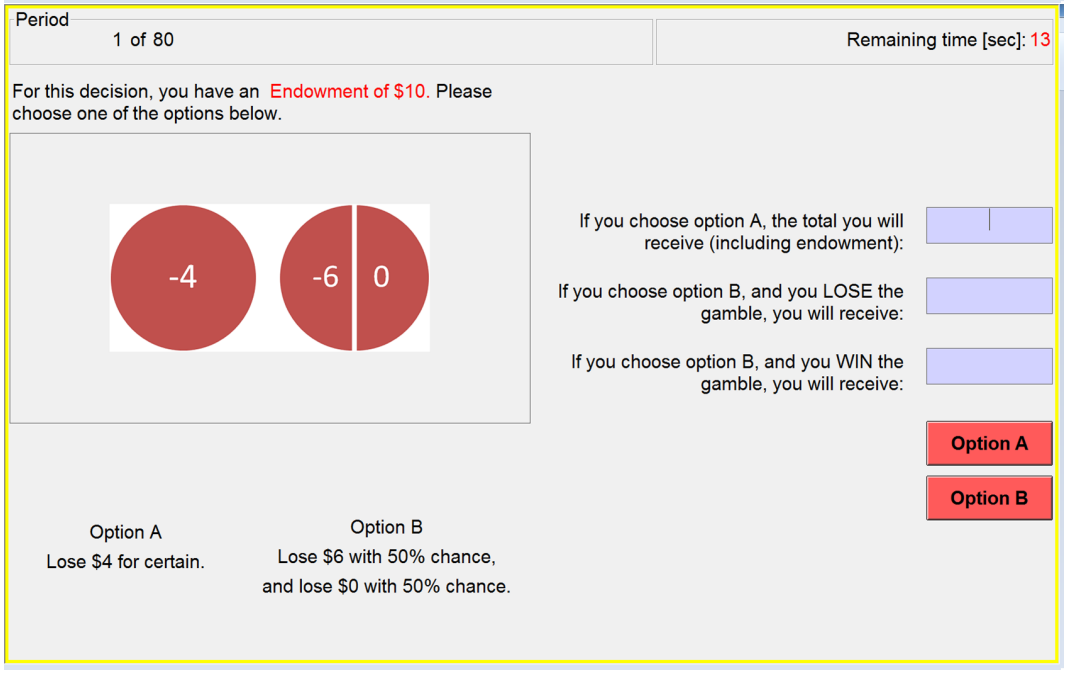




Decision Task: Choice between Lotteries Besides the math and counting problems, you may also face a choice between lotteries. For the lottery problems, you will be given additional money (an endowment) to use towards your decision. You will always be asked to choose between two options: (1) a lottery that returns a sure outcome with certainty OR (2) a lottery that returns either a larger outcome or zero, with 50 percent chance.

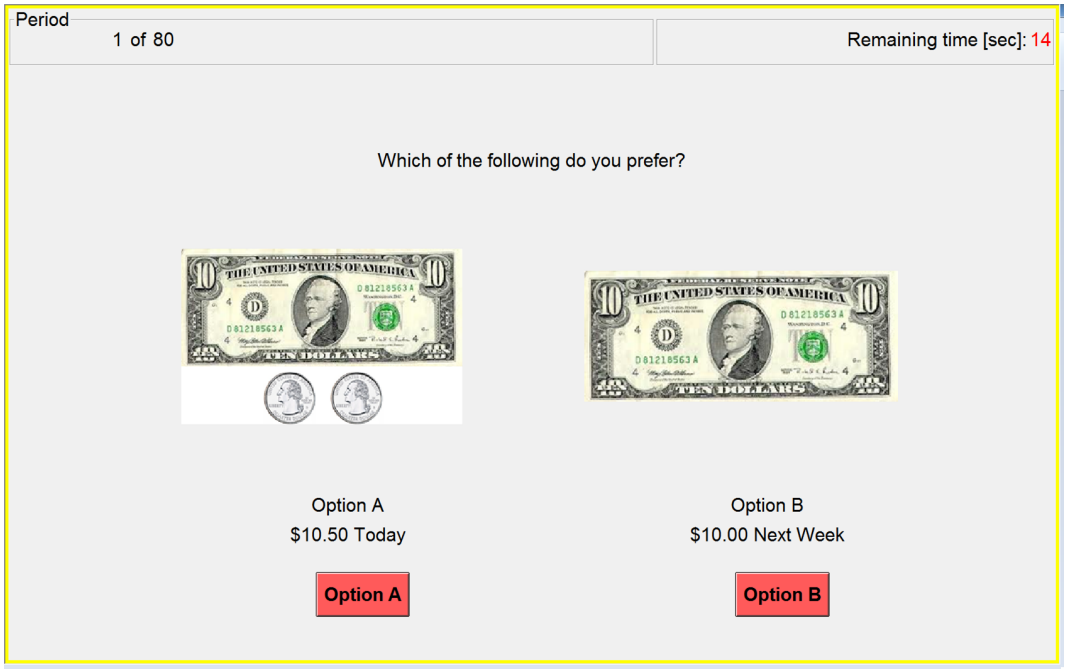
Please click Continue to practice some lottery decisions. You will be asked some additional questions (that will not be on the actual lottery task) just to make sure that you understand your payoffs.



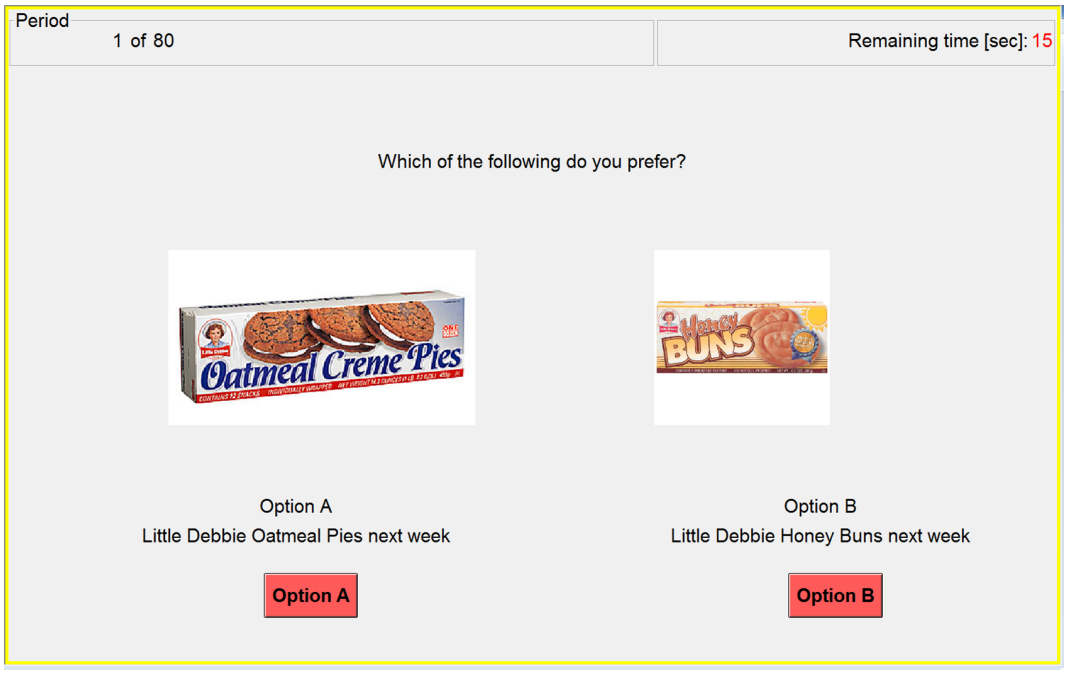


Decision Task: Time Allocation Problem Besides the math, counting, and lottery problems, you will also face choices about your preference for money allocation across time. You will be asked whether you prefer some amount of money today or a different

amount of money next week. For example, you may be asked to choose between \$10 today or \$12 next week. This question is for real stakes. So if you choose to receive money today, you will get it at the end of today's part of the experiment. If you choose to receive the money next week, it will be given to you along with your show-up fee next week. If you run out of time before reaching a decision, you will receive \$0 for the task. Please click Continue to practice some time allocation problems.



Decision Task: Consumption Bundles Besides the math, counting, lottery problems, and time-money preferences, you will be asked about your preference regarding two sets of goods. The two goods are consumption bundles, which will be awarded next week. So whatever you choose, it will be given to you along with your show-up fee next week. If you run out of time before reaching a decision, you will not receive anything next week. Please click Continue to practice consumption bundle problems.



Final Payoff Determination In total, you will make 80 decisions in this experiment, one in every period. Once all decisions have been made, you will be asked a few survey questions. After that, you will have completed the experiment. The computer will randomly select only ONE of the periods to be your "payoff determining task." The payoff determining task will be used to calculate your earnings for the experiment. Please note that since it is equally likely that any of the 80 decisions that you make are chosen to determine your payoff, it is important that you treat each decision as if it were the one that counts.

Your final payment will be the sum of your $2 show-up fee today, your $10 show-up fee next week, and the amount of money or the items of products that you made in the payoff determining task.

If you have any questions, please raise your hand and the experimenter will answer it.

If there are no questions, you may continue to the experiment.

Table A.1: Snack Choice Pairs.

Snack Pair	Healthy Choice	Unhealthy Choice
1		
2		
3		
4		
5		
6		

Continued on Next Page. . .

Table A.1 – Continued

Snack Pair	Healthy Choice	Unhealthy Choice
7		
8		

Post Experiment Questionnaire

1. On a scale of 1 to 5, with 1 being not at all aroused and 5 being extremely aroused, how sexually aroused were you during the study? {1, 2, 3, 4, 5}

2. How would you most accurately described your sexuality? {heterosexual; homosexual; bisexual; other / prefer not to answer}

3. How many minutes do you spend viewing pornography in a typical week?

4. How many times have you experienced an ejaculation in the last month?

5. Which of the following best describes your relationship status? {Married or in a committed relationship; Not married or in a committed relationship, but in one or more casual relationships; Not in a relationship}

6. In what year were you born? (YYYY)

7. What is your college class? {Freshman; Sophomore; Junior; Senior; Graduate; Not in college}

8. What is your college Grade Point Average?

9. What is your race/ethnicity? {Caucasian, non-Hispanic; Hispanic; Black or African; Asian; Other/Prefer not to Answer}

10. What was the total income range for the household where you lived when you were 17? {Less than $25,000; $25,000-$50,000; $50,000-$75,000; $75,000-$100,000; Over $100,000}

11. When you flip a penny, what is the probability of it landing heads-side-up?

12. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?

13. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

14. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

15. Suppose that you earned $100,000 in lottery winnings. How much of the $100,000 would you be willing to invest in an asset to either HALVE or DOUBLE in two years time with equal probability? {None of it; 10%; 20%; 30%; 40%; 50%; 60%; 70%; 80%; 90%; All of it}

On a scale of 1 to 5, with 1 being complete disagreement and 5 being complete agreement, how much do you agree with the following statements:

16. Good things come to those who wait. {1, 2, 3, 4, 5}

17. Anticipation leads to greater enjoyment. {1, 2, 3, 4, 5}

18. It is better to be safe than sorry. {1, 2, 3, 4, 5}