Consumer Response to Egg Production Systems and the Effect of Proposition 2 Advertising: A Preliminary Neuroeconomic Analysis

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1. Introduction

Citizen and consumer concern about the impact of confined agricultural production systems on farm animal welfare have increased in recent decades. The benefits and costs of confined agricultural production systems have been debated (e.g., McGlone et al., 2004; LayWel., 2004; De Mol, et al., 2006; UEP, 2010; Norwood and Lusk, 2011a); nevertheless, many consumers favor open production systems that are less efficient and thus more costly but provide animals more space to exhibit natural behaviors. This is evident by the passing of the state-wide ballot initiative Proposition 2 in California, the Prevention of Farm Animal Cruelty Act, in 2008 that established minimum space requirements for laying hens.

Despite the popularity of legislation regulating confined production systems, consumers in the marketplace show less willingness or ability to pay for such practices with fewer than 5% of eggs, for example, coming from organic and cage-free systems (e.g. Norwood and Lusk 2011b). Brooks and Lusk (2012) found that preferences may not reflect voting behavior and this dissonance in behavior is referred to as the “citizen versus consumer” conflict. It is likely that information from advocacy groups surrounding Prop 2 increased citizen concern about confined agricultural production systems. Lusk (2010) demonstrated that media surrounding Proposition 2 led to an increase in demand for organic eggs. It is possible this phenomenon may be related to the fact that consumers are relatively unknowledgeable about the issue and may be responding to peer or informational influence.

Previous experiments have shown that consumers are willing to pay more for food products from agricultural production systems that may increase animal welfare (e.g., Baltzer, 2004; Karipidis et al., 2005; Norwood and Lusk, 2008; Bong, Lusk, and Norwood, 2010); however, it is unclear exactly what consumers think about agricultural production systems. Norwood and Lusk (2011), for example, report that consumers believe a much higher share of eggs are produced using cage-free systems than actually are. Other analyses have examined how consumers’ willingness-to-pay (WTP) is influenced by information about the benefits and costs of confined agricultural production systems (Tonsor, Wolf, and Olynk, 2009); however, many of these studies did not incorporate the types of advocacy information actually used by activist organizations during a campaign.

Neuroeconomics, which integrates the findings of economics, psychology, and neuroscience, can provide unique insights into consumer decisions. Consumers face complex, conflicting, and often incomplete information related to the variation in treatment and quality of care given to hens in different egg production environments. Previous research has addressed this challenge by using experimental methods to determine consumers' WTP for eggs from various production environments, but little is known about *why* some people respond differently than others or what factors motivate consumer choices. Neuroeconomics can help researchers gain a better understanding of the determinants of food choice.

This paper presents partial and preliminary results from a study examining how the human brain activates when making non-hypothetical purchasing decisions about eggs that differ in price and production system. It also examines how these purchasing decisions are affected by an advocacy video either for or against Prop 2. By determining which regions of the brain activate in the context of decisions about price and production system, this research will provide insight into whether consumer concerns about animal welfare are driven primarily by brain regions associated with emotional response or those associated with logical, deliberations.

There is a need to better understand the underlying mechanics behind consumer reactions to agricultural production systems, and the proposed research seeks to provide such information. Results will enable producers and policy makers to better understand consumer preferences for production systems that provide for greater farm animal well-being. Results will also provide marketers with a better understanding of how consumers respond to information about agricultural production practices.

2. Materials and Methods

2.1 Experimental Design

To complete the objectives of this study, participants underwent functional magnetic resonance imaging (fMRI) scanning. Participants underwent two functional scans while performing a food decision-making task — one functional scan before viewing a video and one functional scan after viewing a video. Participants were presented with the following instructions: "In this phase of the experiment, you will make a series of choices between two food products. To choose the option on the left, use your index finger. To choose the option on the right, use your middle finger. Please choose carefully, as you will receive one of the food products you choose at the end of the experiment. In the middle of this phase, there will be a brief pause while the scanner restarts. When you are ready, we will begin."

The two options presented included an identical image of a dozen eggs accompanied by production system and price information for each option. Each choice differed according to three experimental conditions: a "method" condition, in which the method used to produce one option was "closed" (i.e., "caged" or "confined"), and the other "open" (i.e., "cage-free" or "free-range"), but their prices were the same; a "price" condition, in which the price of one option was higher than the other option, but the methods used to produce them were the same; and a "combination" condition, in which the prices of the two options differed, as did the methods used to produce them. Price information began at "$0.99" and varied by $0.50 increments up to "$4.49." Figure 1 illustrates examples of the three experimental conditions.

Respondents made a total of 84 choices during the first functional scan. The choices were made non-hypothetical by informing respondents that one of their choices would be randomly selected as binding and would actually be given to them at the conclusions of the experiment. After undergoing the first functional scan, participants viewed a thirty-second educational video. Participants were randomized to see one of three videos (one which advocated for Prop 2, one which advocated against Prop 2, and a neutral one which advocated neither for nor against Prop 2 and depicted a flowing stream). Immediately following the video, the functional scan described previously was repeated so that there were two functional scans and 168 choices in total. A choice was presented until the participant chose. If the participant chose in under 3,000 milliseconds, the participant's choice was confirmed until 3,000 milliseconds had elapsed since the time the choice was presented, and then for an additional 500 milliseconds, if the choice took longer than 3,000 milliseconds, the choice was confirmed for an additional 500 milliseconds from the time of the choice.

The relevant variable from the fMRI scans is percent blood-oxygen-level-dependent (BOLD) signal change in brain regions of interest while participants were performing a food choice task. In this task, participants were presented with a series of choices between two one-dozen cartons of eggs. Our exploratory hypotheses include the following: (a) we hypothesize that brain activations during choices made about price compared to egg production will activate dorsolateral prefrontal cortex, an area known to be associated with rational decision-making; (b) we hypothesize consumers randomized to view a video promoting farm animal welfare (advocating for Prop 2) will increase WTP for eggs from an open production system.

2.2 Subjects

A sample of ten healthy, right-handed, English-speaking, adult participants (aged 23-46 years; *M* = 28 years; *SD* = 7.4; 5 females) were recruited from the Kansas City metropolitan area to participate in a functional magnetic resonance imaging (fMRI) study. Exclusion criteria included current use of psychotropic medication, current or past substance abuse, diagnosis of severe psychopathology (e.g., depression, schizophrenia), and vegan diet. While N = 10 participants completed the experiment, one participant was excluded from the analyses due to invalid test administration. Participants' body mass indices (BMI) were calculated from their heights and weights (18.4-34.9; *M* = 24.5; *SD* = 4.60). Education level was reported as bachelor's degree (*n* = 7), and graduate degree (*n* = 2).

2.3 fMRI Data Acquisition

All fMRI scans were performed at the University of Kansas Medical Center's Hoglund Brain Imaging Center on a 3-Tesla Siemens Skyra (Siemens, Erlangen, Germany) scanner. Participants' heads were immobilized with head cushions. Following automated scout image acquisition and shimming procedures performed to optimize field homogeneity, a structural scan was completed. T1-weighted, three-dimensional, magnetization-prepared rapid acquisition with gradient echo (MPRAGE) structural images were acquired (repetition time/echo time [TR/TE] = 23/4 ms, flip angle = 8º, field of view [FOV] = 256 mm, matrix = 256 x 192, slice thickness = 1 mm). Then, two gradient-echo blood-oxygen-level-dependent (BOLD) functional scans were acquired in fifty contiguous, oblique, 40º axial slices (TR/TE = 3000/25 ms, flip angle = 90º, FOV = 232 mm, matrix = 80 x 80, slice thickness = 3 mm, in-plane resolution = 2.9 x 2.9 mm, 176 data points). To optimize the signal in ventromedial prefrontal regions of interest in the present study, and to minimize susceptibility artifacts, all participants were positioned such that the angle of the anterior commissure-posterior commissure (AC-PC) plane fell between 17º and 22º in scanner coordinate space, as verified by a localization scan. This careful positioning, utilized by Bruce and colleagues (in press), ensured the 40º acquisition angle was applied uniformly for all subjects, again, minimizing susceptibility artifacts while standardizing the head positions of participants of divergent body sizes.

2.4 fMRI Data Analysis

fMRI data were analyzed using BrainVoyager QX, version 2.4 (Brain Innovation, Maastricht, Netherlands, 2012). Preprocessing steps included trilinear, three-dimensional motion correction, sinc-interpolated slice scan time correction, two-dimensional spatial smoothing with a four-millimeter Gaussian filter, and high-pass filter temporal smoothing. Functional images were realigned to fit structural images obtained during each scanning session, then normalized to the BrainVoyager template image, which conforms to the space defined by Talairach and Tournoux's (1988) stereotaxic atlas. Data from one participant was excluded due to invalid test administration. Neural activation maps were analyzed using statistical parametric methods (Friston et al., 1995) included with the BrainVoyager QX software. Statistical contrasts of neural activation in the experimental conditions of interest (i.e., method, the price, and combination conditions) were conducted using multiple-regression analysis. Regressors representing neural activation in these conditions, as well as regressors of non-interest (e.g., head motion), were modeled with a hemodynamic response filter. Next, group analysis was performed by entering data into the multiple-regression analysis using a random effects model. Finally, a whole-brain analysis was performed, and an assessment of contrasts between the experimental conditions, expressed in terms t statistics, was conducted. For each contrast, voxel values were considered significant if the activation survived a statistical cluster-based threshold of $p < .01$, corrected. We corrected for multiple comparisons using the familywise approach ($\alpha < .05$; $p <.01$, k = 16 voxels), determined by Monte Carlo simulation in BrainVoyager (Goebel et al., 2006; Lieberman & Cunningham, 2009).

2.5 Behavioral Data Analysis

To analyze the choice data, a random utility model, pioneered by McFadden (1974), was utilized. Assume respondent *i* derives the following utility for egg option *j*: $U_{ij} = V_{ij} + \varepsilon_{ij}$, where V_{ij} is the deterministic and ε_{ij} is the stochastic portion of utility. The systematic portion of the utility for option *j* is defined as:

(1) $V_{ij} = \alpha_i Left_j + \beta_{1i} Open_j + \beta_{2i} Price_j + \beta_{3i} Open_j * ForVid_i + \beta_{4i} Price_j * ForVid_i + \beta_{5i} Open_j * AgainstVid_i + \beta_{6i} Price_j * AgainstVid_i$

where $Left_j$ is an indicator variable that equals 1 if option j appeared on the left-hand-side position on the screen and 0 if on the right-hand-side of the screen, α_i is an alternative specific constant measuring a "left-hand-side" bias (i.e., a measure of the likelihood of choosing whichever option appears on the left-hand-side vs. the right-side of the screen that cannot be explained by the characteristics), $Open_j$ is an indicator variable that takes the value of 1 if egg option j is produced with an "open" production system, respectively, β_{1i} is the utility of with an "open" production system, respectively, $Price_j$ is price of alternative j, β_{2i} is the disutility of price increases (or equivalently, the marginal utility of income multiplied by -1), $ForVid_j$ is an indicator variable that takes the value of 1 for the second 84 choices if a respondent viewed the video that advocated for Prop 2, $AgainstVid_j$ is an indicator variable that takes the value of 1 for the second 84 choices if a respondent viewed the video that advocated against Prop 2, and β_{1i}, β_{1i} and β_{1i}, β_{1i} are utility and disutility of production system and price after viewing an advocacy video relative to the neutral video, respectively.

An individual i's WTP for an open production system (which theoretically increases animal welfare) before advocacy information is: $WTP_i = -\beta_{1i}/\beta_{2i}$ and WTP for an open production system after advocacy information is: $WTP_i = -(\beta_{1i} + \beta_{ki})/\beta_{2i}$ where $k = 3$ if a respondent viewed the video that advocated for Prop 2 and $k = 5$ if a respondent viewed the video that advocated against Prop 2. If faced with J choice options (J = 2 egg options in this case), an individual is assumed to choose option j if $U_{ij} > U_{il}$ for all $j \neq l$ If the ε_{ij} are distributed iid extreme value, then the probability of individual i choosing option j is

(2) $$\text{Prob(option } j \text{ is chosen)} = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{il}}},$$

which is the well-known multinomial logit model.

3. Results

3.1 fMRI Results

Whole-brain analyses were conducted for the nine remaining participants. Statistical contrasts between price vs. production system conditions were conducted utilizing a random-effects, multiple regression model, controlling for the experimental contrasts of interest along with other control factors (e.g., head motion). In the price versus production system contrast pre-video, one significant area of activation was observed in left superior frontal gyrus, Brodmann area 9 ($t = 6.56$, $p < .01$). There were 20 contiguous voxels in the region of activation. The voxel of maximum activation was at Talaraich coordinates x = -19, y = 52, z = 36. No areas showed greater activation to production system versus price. See Figure 2.

3.2 Behavioral Results

Table 1 reports the results from the multinomial logit model. Respondents did exhibit "left-hand-side" bias: were more likely to choose the option appearing on the left-hand-side vs. the right-side of the screen. An "open" production system was preferred to a "closed" production system except after viewing the video against Prop 2. On average, the WTP for an "open" production system was $1.97 and increased after respondents viewed the video for Prop 2. After viewing the video for Prop 2, WTP increased to $2.60. The WTP increased to $2.13after viewing the video against Prop 2; however, the coefficient estimate for an "open" production stsyem was not significant.[1]

4. Discussion

Regarding our preliminary neuroimaging analyses, we observed one significant activation in the price versus production system contrast. On average, consumers in our study showed significantly greater activation in a region of the left prefrontal cortex when making decisions about price compared to decisions about system of egg production.

Specifically, we hypothesized that brain activations during choices made about price compared to egg production would activate dorsolateral prefrontal cortex, an area known to be associated with rational decision-making. Consistent with our hypothesis, we observed the left superior frontal gyrus extending to dorsolateral prefrontal cortex (in Brodmann area 9) activate

[1] We examined how WTP changes with brain activation but did not find any significant results. This may change as sample sizes increase from nine observations.

significantly more when individuals make decisions about price than when they make decisions about eggs laid by cage free versus caged hens.

Regions of the prefrontal cortex including superior frontal gyrus and dlPFC have been shown to be integral in decision-making, and some posit that these regions are instrumental in product decision-making (Deppe et al., 2005; Guitart-Masip et al., 2013) and in task-switching (Cutini et al., 2008). Our results are consistent with these findings. We did not, however observe any regions of the brain activate significantly more to production system compared to price choices.

We also hypothesized that respondents viewing the video promoting farm animal welfare (advocating for Prop 2) would increase WTP for eggs from an open production system. The video for Prop 2 did increase utility for eggs from an "open" production system while the video against did not. This finding is consistent with the 2008 voting outcome of Prop 2 which passed with more than 60 percent of voters voting in favor to establish minimum space requirements for laying hens.

One limitation of the current study is the relatively small sample size. We did, however, correct for multiple comparisons and use a conservative statistical threshold. As sample size increases, it will be possible to examine the relationships correlations between brain activation and behavioral choices.

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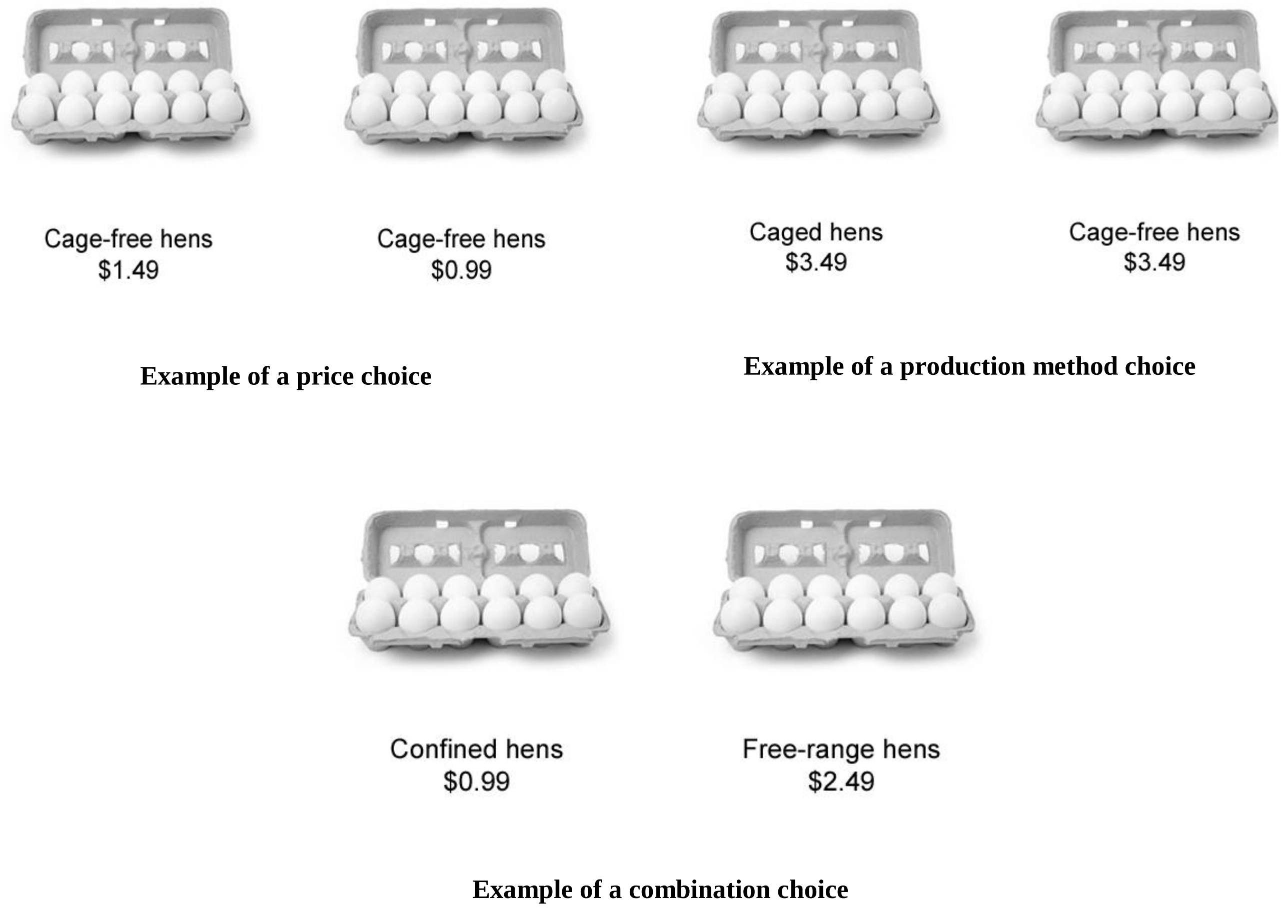

Figure 1. Examples of the three experimental conditions in the food Decision-making task.

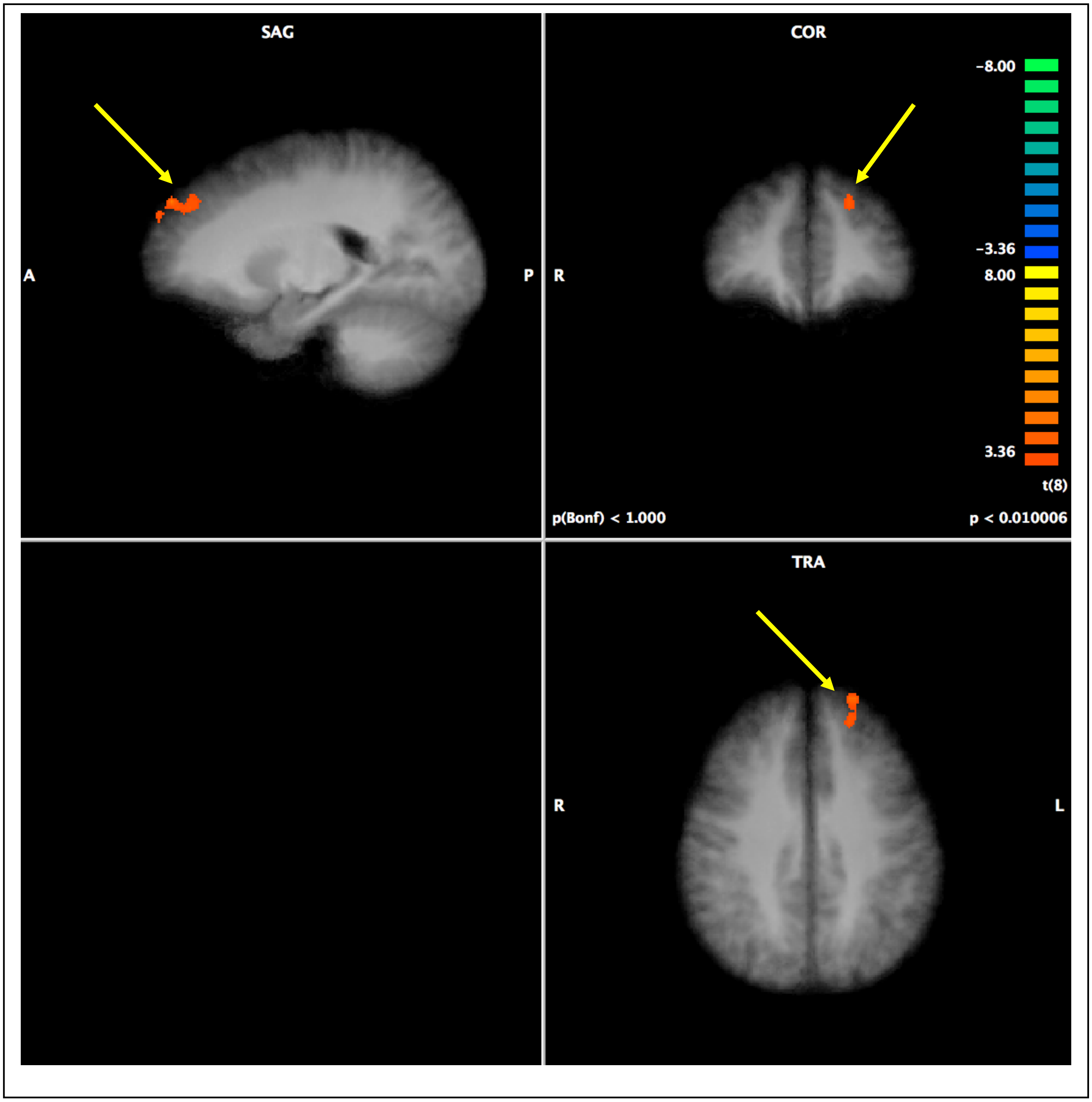
SAG
COR
A
P
R
R
L
TRA
-8.00
-3.36
8.00
3.36
t(8)
p(Bonf) < 1.000
p < 0.010006

Table 1. Results of Multinomial Logit Model

Parameter	Estimate	Standard Error	*p*-Value
Left[a]	0.798***	0.085	<0.001
Open[b]	2.528***	0.156	<0.001
Price	-1.282***	0.081	<0.001
*Open*ForVid*[c]	0.810**	0.411	0.049
*Price*ForVid*[c]	-0.541**	0.227	0.017
*Open*AgainstVid*[c]	0.2058	0.355	0.562
*Price*AgainstVid*[c]	-0.462**	0.217	0.033
Log-Likelihood	-544.37		
Number of Observations	1,512		

[a]Parameter estimate compared to a choice on the right-hand-side position on the screen

[b]Parameter estimate compared to a "closed" production system

[c]Parameter estimates for the 84 choices after viewing an advocacy video compared to a neutral video.