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Are Consumers as Constrained as Hens are Confined? Brain Activations and Behavioral Choices after Informational Influence

Alex J. Francisco
University of Missouri - Kansas City

Amanda S. Bruce
University of Kansas Medical Center

John Crespi
Iowa State University, jcrespi@iastate.edu

Jayson L. Lusk
Oklahoma State University

Brandon McFadden
University of Florida

See next page for additional authors

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Keywords
eggs, insula, decision-making, production methods

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Authors
Alex J. Francisco, Amanda S. Bruce, John Crespi, Jayson L. Lusk, Brandon McFadden, Jared M. Bruce, Robin L. Aupperle, and Seung-Lark Lim

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***Corresponding author: Amanda S. Bruce,** University of Kansas Medical Center, Kansas City, KS, USA; Children's Mercy Hospital, Kansas City, MO, USA, E-mail: abruce@kumc.edu
Alex J. Francisco, University of Missouri-Kansas City, Kansas City, MO, USA
John M. Crespi, Iowa State University, Ames, IA, USA
Jayson L. Lusk, Oklahoma State University, Stillwater, OK, USA
Brandon McFadden, University of Florida, Gainesville, FL, USA
Jared M. Bruce, University of Missouri-Kansas City, Kansas City, MO, USA
Robin L. Aupperle, Laureate Institute for Brain Research, Tulsa, OK, USA; University of Tulsa, Tulsa, OK, USA
Seung-Lark Lim, University of Missouri-Kansas City, Kansas City, MO, USA

Introduction

In 2008, California voters passed a controversial statewide ballot initiative, Proposition 2, also known as the Prevention of Farm Animal Cruelty Act. This amendment to the state's constitution established minimum physical space requirements for egg laying hens. Despite the popularity of legislation regulating confined production systems, consumers tend to show less willingness, or ability, to pay for such practices in the marketplace, with fewer than 5% of eggs coming from organic and cage-free systems (e.g. Norwood and Lusk 2011).

Dissonance in buying preferences and voting behavior has been referred to as the "citizen versus consumer" conflict (Brooks and Lusk 2012). The discrepancy between voting behavior and purchasing behavior has large implications for egg producers who adopt production methods that consumers are not willing to support in the marketplace. This type of conflict may arise from people having little prior knowledge about egg production methods and effective information campaigns from animal rights advocacy groups. For example, information from advocacy groups surrounding Proposition 2 led to an increase in political, reported demand for organic eggs (Lusk 2010). Moreover, consumers believe a much higher share of eggs are produced using cage-free systems than actually are (Norwood and Lusk 2011). The result is legislation that favors specific production methods for a product, without a corresponding increase in purchasing behavior.

Research into the effects of general advertising effectiveness suggests that well made ads can be highly effective in advocating for a product (Kumar and Raju 2013). Research into the specific effects of food advertising on

subsequent choices in adulthood, however, is varied, and meta-analyses do not reveal any specific consistent patterns of behavior change induced by targeted advertisements (Mills, Tanner, and Adams 2013). Previous research has demonstrated that specific neural activity in the dorsolateral prefrontal cortex (dlPFC) can predict responsiveness to previously viewed advertisements when making subsequent decisions (McFadden et al. 2015), particularly when these advertisements are directed at ethical concerns on production methods. Similarly, ethical concern for food related decisions after informational influence elicits particular patterns of neural activity, primarily in prefrontal regions (Cherry et al. 2015). However, investigations into neural changes *during* the decision making process after information concerning ethical food choices have yet to be carried out. Economic research has sought to determine consumers' willingness-to-pay (WTP) for eggs from several production methods (e.g., Baltzer 2004; Karipidis et al. 2005; Chang, Lusk, and Norwood 2010; Allender and Richards 2010), and examined the effects external information can have on WTP (e.g., Tonsor, Wolf, and Olynk 2009). Yet, little is known about what kinds of changes individuals may experience in response to competing types of information, and employing a neuroeconomic approach may be useful for gaining a better understanding of responsiveness to this kind of advocacy information.

It may come as a pleasant surprise to many economists as a defense of random and expected utility theory, to learn that theoretical models in neuroscience posit that individuals making choices between two options that vary in multiple attributes assign values to the individual attributes and sum them to obtain an overall value for each option (Bettman, Luce, and Payne 1998; Hare, Malmaud, and Rangel 2011; Camus et al. 2009; Kahnt et al. 2011; Linder et al. 2010). Such models posit that value, or a type of expected utility, for each option are compared and an optimal choice is made by choosing the option that provides the greatest value. Multi-attribute choice options with conflicting individual attribute values increase the uncertainty of value prediction (Kahnt et al. 2011). For example, people prefer to make purchasing decisions that both increase animal welfare *and* pay low prices; however, this is not a realistic option for eggs in the marketplace and people must make a tradeoff between conflicting individual attributes (animal welfare vs. price). The conflict between production method and price increases uncertainty of value prediction; in this choice the decision does not involve a discrete preference for one attribute over another attribute. To explore the more precise effects of advertising on changes during these types of ethical food decisions, we employed identical decisions between food options before and after information that advocated for or against egg production methods, in comparison with a neutral condition.

Materials and Methods

Many of the details here may be examined more closely in McFadden et al. (2015).

Participants

A sample of 50 healthy, right-handed, English-speaking, adult participants (24 females; mean age = 29.6 ± 0.21, SEM; age range, 21–55 years) 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 50 participants completed the experiment, non-standard procedures were used on four participants, resulting in insufficient data for the purpose of analysis. These individuals were excluded from the analyses. Thus, our investigations were conducted using observations from 46 participants.

Stimuli

Subjects underwent two functional magnetic resonance imaging (fMRI) scans while performing a food decision-making task – one functional scan before viewing a 30-second video and one functional scan after viewing the 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."

Each decision involved the presentation of two options that included identical images of a dozen eggs. Along with each image was a block of text that indicated the production system and price information corresponding to that option. The three decision-type conditions were contrasted

on three variables – (1) a "method" condition, in which the method used to produce one option was "closed", as such eggs were labeled "caged" or "confined", and the method used to produce the other option was "open" so labeled "cage-free" or "free-range". In this condition, the prices for both options were equal. In (2) the "price" condition, one option was higher priced than the other option but the production methods were identical; and (3) a "combination" condition, in which the production methods and prices of the two options differed in a manner that the open method was always accompanied with a higher price. Of most interest, decisions in the "combination" condition forced subjects to make a tradeoff between animal welfare and price. Price information began at "$0.99" and varied by $0.50 increments up to "$4.49." Figure 1, adapted from McFadden et al. (2015), illustrates examples of the three experimental conditions.

Task

Respondents made 84 choices during the first functional scan prior to information: 28 choices per experimental condition (i.e., combination, method, and price). The presentation order of the choices was randomized across respondents. 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 conclusion of the experiment. Participants received a dozen eggs upon the completion of the experiment. After undergoing the first functional scan, participants viewed a 30-second educational video. Participants were randomly assigned one of three videos; one video advocated for Proposition 2, one video advocated against Proposition 2, and a control video depicted a flowing stream. The egg-advocacy videos were actual commercials that aired in California prior to the vote on Proposition 2. The anti-Proposition 2 video focused on issues related to the economic ramifications, lower production rates, and decreased supply of eggs due to Proposition 2's regulations. The pro-Proposition 2 video consisted primarily of animal welfare advocates speaking of animal mistreatment and visceral images of strictly confined hens. Immediately following the video, the functional scan described previously was repeated so that there were two functional scans of 84 choices; 168 choices in total (84 prior to information and 84 after information). A choice was presented on screen until the participant made a selection. If the participant chose in under 3,000 ms, the participant's choice was confirmed until 3,000 ms had elapsed since the time the choice was presented, and then for an additional 500 ms. If the choice took longer than 3,000 ms, the choice was confirmed for an additional 500 ms from the time of the choice. Details for the fMRI Data Acquisition are given in the appendix.

Results

Behavioral Data

We expected subjects to consistently choose the lower priced option in the price condition and the open

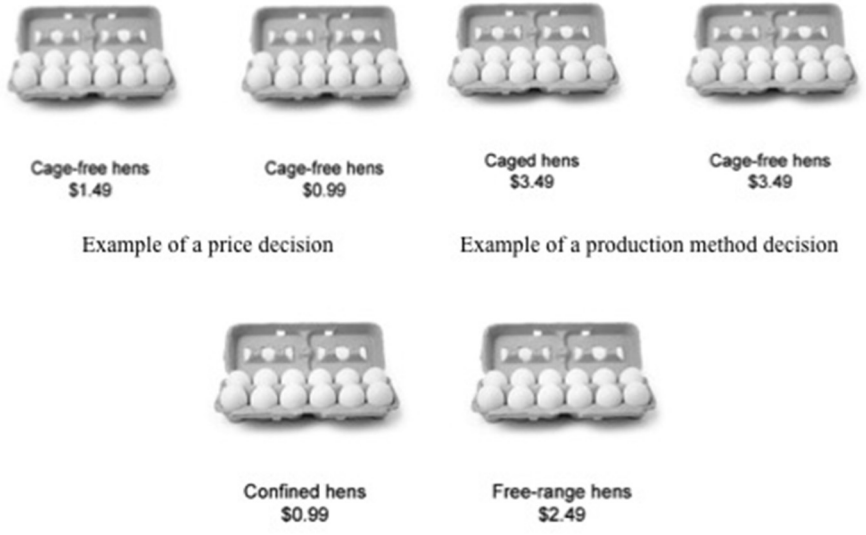

Figure 1: Examples of the three experimental conditions in the food decision-making task.

production method option (free range; cage-free) in the method condition. Choice outcomes in the combination condition were more ambiguous, where subjects were forced to make tradeoffs between preferences for production method and price. Analyses were then focused on choices made in the *combination* condition, where subjects were forced to choose between a higher priced, open method option versus a lower price, closed method option.

As demonstrated with this dataset by McFadden et al. (2015), when production method varied alone, averaged across video treatments, the open-method option was chosen 99.9% of the time; when price varied alone, the low price option was chosen 98.6% of the time. This suggests first that individuals understood the task, and were paying attention, but more importantly that individuals consistently prefer lower prices, but when price is held constant, people prefer open production to closed production methods. Averaged across video treatments, subjects chose the high price, open method option 52% of the time in the combination condition. McFadden et al.'s, (2015) results showed that *prior* to informational influence, anti-Proposition 2 subjects chose the high-price, open method option 57% of the time, control subjects chose this option 42% of the time, and pro-Proposition 2 subjects chose the high price, open method option 50% of the time. *After* video information, the proportion decreased slightly to 56% for the subjects who viewed the anti-Proposition 2, while it increased slightly to 44% for the control group, and increased to 61% for the pro-Proposition 2 video. The anti-Proposition 2 and control videos did not significantly affect the proportion of subjects choosing the high price, open method option, however, viewing the pro-Proposition 2 video did have a significant effect. McFadden et al. (2015) demonstrated that subjects who viewed the pro-Proposition 2 video were significantly more likely to choose the high price, open method option after receiving video information (i.e., in addition, subjects were more prone to pay a premium for the cage free and free range eggs).

fMRI Data

Our fMRI data were collected and analyzed in a block-design, averaged across the duration of each block, which consisted of a single decision type. Results of the fMRI analyses focused on changes in neural activity when making decisions pre/post informational influence separately for the three groups, again focusing on decisions where participants were forced to choose between a higher price open method option, and a lower price closed method option. Neurofunctional activity was measured as percent BOLD signal change between conditions. Functional MRI data were analyzed in Brain Voyager QX 2.4, using random effects, $p_{corrected}$ <.01, with a cluster threshold of 14 voxels, as determined by Monte Carlo simulation.

Based on this whole brain analysis, participants in the Pro-Prop 2 Video group ($N = 16$) demonstrated significantly greater activations ($p < 0.01$ corrected) post-video compared to pre-video in a cluster of 18 voxels in the left insular cortex ($x = -37$, $y = -2$, $z = -6$). Significant increases ($p < 0.01$ corrected) were also seen in a cluster of 15 voxels in the right occipital cortex ($x = 8$, $y = -92$, $z = 6$). Figure 2 illustrates these changes in neural activity. No significant differences were seen in neural activity for subjects who viewed the Anti-Prop 2 Video. However, subjects in the control condition exhibited increased activity in a cluster of 24 voxels in the right insula ($x = 38$, $y = -14$, $z = 3$), $p = 0.0003$, as well as decreased activation in a cluster of 16 voxels in the medial frontal gyrus ($x = 11$, $y = 49$, $z = 12$) after their passive viewing condition ($p < 0.01$ corrected).

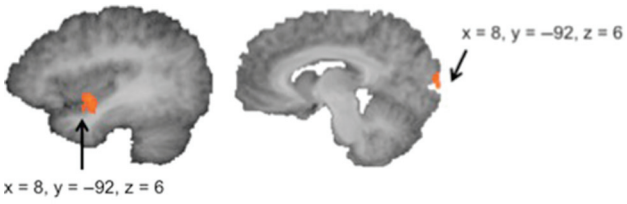

Figure 2: Increased neural activations after viewing pro-Proposition 2 video.

Discussion

Our investigation focused on changes in neural activity before and after information advocating for, or against, ethical egg production methods. To elucidate these changes, participants first made a series of non-hypothetical decisions between eggs that varied on price and method of production, and were then presented with a video advocating for or against Proposition 2, then repeated an identical set of decisions. McFadden and colleagues (2015) showed that this advocacy information influenced behavior; individuals who saw information

supporting Proposition 2 showed an increase in selection of the high-priced ethical production method eggs, a behavior pattern not seen in control or anti-Proposition 2 subjects. In examining the brain activity before to after information in a video, our results showed that the increase in decisions towards high-priced open production eggs exhibited by pro-Proposition 2 subjects was accompanied by increased activity in the left insula and right occipital cortex.

Research supports a wide variety of reasons behind insula activations. Specific to purchasing decisions, recent evidence suggests that the insula plays a role in processing social risk in purchases, driving consumer behavior away from socially unacceptable products (Yokoyama et al. 2014). Our results support this hypothesis, with individuals prompted for humane cage methods showing increased insula activation during our combination decisions. Previous research has shown behavioral choices in our task for pro-Proposition 2 subjects increased toward higher-priced, open caged method eggs after seeing information advocating for the proposition (McFadden et al. 2015). This use of informational influence may have increased the "social risk" involved with choosing the lower priced, caged method eggs, which was reflected with both neural and behavioral changes during decision-making. Other research (Knutson et al. 2007) has suggested insula activity can be used to predict decisions *not* to purchase. In our paradigm, this neural activity in the insular cortex may reflect the decision *not* to buy the lower priced, caged method eggs, as opposed to the decision to purchase the high price, open caged method. To support this idea, the video advocating for Proposition 2 was focused on the negative effects that closed-cage production methods have on hens. This may not have increased a desire for higher priced open-method cage systems, but instead driven consumer behavior *away* from the closed-method cage systems that the video was advocating against. Future studies should examine the direction of this motivation and behavior change more closely, as our paradigm and results do not lend themselves to such an analysis.

In the 2008 vote, Proposition 2 passed with 63% of voters voting in favor of increasing animal confinement space (Lusk 2010). The results here suggest that the pro-Proposition video was more effective in changing consumers' neural activity, which supports Lusk's (2010) work that determined Proposition 2 advertising increased consumer demand for organic eggs. Our functional MRI investigations into these decisions show that individuals who received information advocating for ethical egg production methods had increased insula activations when making decisions between higher-priced, open method eggs and lower priced, conventional method eggs. Additionally, increases in right insula activity were seen in our control group participants. This poses an issue for our interpretation of the results seen in the pro-Proposition 2 participants, as insula changes were also seen in that group. Future research should seek to delineate how repeated ethical decisions in the absence of informational influence may change brain activity. It is possible that our control participants, given time to consider their decisions during the control video, were more aware of the social ramifications involved in continuing to choose the lower priced, conventional production method eggs. A direct comparison of pro-compared to control manipulations should be conducted in larger samples.

Following this, it may be that the effect of the *anti-Proposition 2* video was to dampen the emotional response to these repeated ethical decisions, as no neural or behavioral change was seen in this group. While the increase in right insula activation seen in control participants is slightly confounding, our results do show lateral differences between the increased insula activation seen in control and pro-Proposition 2 groups. The pro-Proposition 2 group exhibited significant increase in the left insula specifically (compared to the right insula in controls), and research has suggested that the left insula may have unique contributions to awareness of emotional influence during cognition (Craig 2009). This result supports the hypothesis that pro-Proposition 2 participants had greater consideration for the ethical and emotional ramifications of their purchasing decisions after informational influence. In contrast, individuals who received information advocating against Proposition 2 did not increase their ethical-based decisions, and showed no significant changes in neural activation when making their decisions pre to post video.

By separating our sample into three video treatments, our study was slightly limited by sample size particularly when estimating pre-video to post-video changes. Future research should consider potential long-term effects of these advertisements, investigating real-life consumer behavior changes, as well as follow-up neural activations. However, taken together, our results provide evidence that there is a significant behavioral and neural effect from informational influence, and that effect differs depending on whether the advertising is advocating for or against a decision.

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Appendix

fMRI Data Acquisition

Functional scans took place at the University of Kansas Medical Center's Hoglund Brain Imaging Center on a 3-Tesla Siemens Skyra (Siemens, Erlangen, Germany) scanner. A structural 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 = 8°, field of view [FOV] = 256 mm, matrix = 256 × 192, slice thickness = 1 mm) was carried out following automated scout image acquisition and shimming procedures performed to optimize field homogeneity. Two gradient-echo blood-oxygen-level-dependent (BOLD) functional scans were acquired in fifty contiguous, oblique, 40° axial slices (TR/TE = 3,000/25 ms, flip angle = 90°, FOV = 232 mm, matrix = 80 × 80, slice thickness = 3 mm, in-plane resolution = 2.9 × 2.9 mm, 176 data points). Participants were positioned in a manner so that the anterior commissure-posterior commissure (AC-PC) plane fell between 17° and 22° in scanner coordinate space. Using this procedure, assured the 40° acquisition angle was applied uniformly for all subjects, in order to minimize artifacts while standardizing the head positions of participants

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 corresponds to Talairach and Tournoux's (1988) stereotaxic atlas. Neural activation maps were analyzed using statistical parametric methods (Friston et al. 1995) inside the BrainVoyager QX package. Contrasts of neural activity in the experimental conditions of interest were conducted using multiple-regression analysis. Regressors representing neural activation in these conditions, as well as regressors of non-interest, were modeled with a hemodynamic response filter. Finally, a group analysis was performed by entering data into the multiple-regression analysis using a random effects model.