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Neural antecedents in reflection:

The application of food choice analysis with fNIRS methodology

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Abstract

Recently, neuroeconomic approaches are getting more important to behavioral economic research. Often this involves the use of fMRT and EEG studies, which offer high temporal and spatial resolution for the detection of neural activity. This paper assesses how functional near-infrared spectroscopy (fNIRS), an optical method which visualizes brain activity through hemoglobins' ability to absorb near-infrared light, is able to reproduce findings of other neuroeconomic studies. If so, this would enhance the toolbox of neuroeconomic research techniques to more realistic research scenarios (e.g. Shopping environment) due fNIRs' mobility and applicability.

Introduction

Neuroeconomic approaches offer the possibility to assess neural antecedents for behavior, which has earlier been studied by direct or indirect inquiries (Lusk et al. 2016). Most commonly this involves the use of fMRT and EEG studies, which offer high temporal and spatial resolution for the detection of neural activity. Functional near-infrared spectroscopy (fNIRS) is an optical method which visualizes brain activity through hemoglobins' ability to absorb near-infrared light (Kenning 2014). The use of fNIRS for neuromarketing for food and agriculture research is still in its infancy, but due to its mobility and lower sensibility compared to other neuroimaging methods, the application in more realistic research scenarios, such as a shopping environment (Krampe & Gier 2018), is promising new insights into consumers' food choice behavior (Kopton & Kenning, 2014). In 2016, Lusk et al. confronted the Random Utility Model, which is often applied in econometric models, with a measurement of fMRI data for the case of choice for eggs. Even though the activation in brain areas could not be related to value formation with regard to price, differences in neural blood flow could be related with regard to quality evaluation.

Quality of foods is mainly determined by food labels. Food labels have a significant effect on consumer demand, because they are providing additional relevant information to consumers (Grabenhorst, Rolls, & Bilderbeck, 2008). A label therefore serves the consumer as an identification function for certain desired or undesired product properties (Ölander & Thøgersen, 2014). Most of the common ethical labels are positive labels, claiming the existence of certain qualities e.g.in the Fairtrade label; or the absence of some negative aspects e.g. in the GMO-free label, or as a label for the non-use of antibiotics during the animal production (Grankvist, Dahlstrand, & Biel, 2004; Liaukonyte, Streletskaya, Kaiser, & Rickard, 2013). Interestingly, consumers seem to respond differently to labeling. Positive labels seem to enhance the general understanding of the claimed product quality, but negative label seems to influence consumer's decision more (Van Dam & Jonge, 2015). The shift of consumers' purchase behavior towards the desired alternative of a product could therefore rather be caused by a negative label which explicitly claims e.g. the use of antibiotics

during the production. This assumption is based on the negativity bias of the brain, which means that negative stimuli or information have a stronger effect on evaluations than positive ones (Ito, Larsen, Smith, & Cacioppo, 1998), because a loss of something carries more weight in subjects than the gain of the same thing would do (Kahneman & Tversky, 1991).

The aim of the current contribution is twofold. On the one hand, it is aimed to study the value formation of quality with regard to food labelling for differentiated negative labels by studying the brain activity using fNIRs methodology. As such, it is aimed to confess differences with regard to selective levels of quality attributions. On the other hand, it is purposed to evaluate measurements of fNIRs methodology for food marketing research by comparing this novel technique with other techniques of neuromarketing research, such as fMRI.

Methodology

Chicken breast was used as a quality differentiated product which varied with regard to the usage of antibiotics within the production. Chicken breast is a familiar, widely consumed product. The quality characteristics differed with regards to antibiotic usage ("antibiotic-free", "guaranteed antibiotic-free") and price (6.48€/kg; 12.98€/kg; 19.48€/kg). In a block design, participants were presented with four alternating blocks, while wearing the fNIRS cap. In the four different phases, a passive viewing phase, a choice phase, a choice phase with extreme values and a questionnaire part (without fNIRS), were included. The subjects did not consciously notice the different phases, as the experiment was carried out without interruption. In addition to the procedure described below, the subjects were guided through the experiment with information texts and instructions. The trial did consist of eleven different conditions and the average processing time was 12 minutes (768 seconds). The duration for answering the questionnaire was eight minutes, so the total duration of the experiment averaged 20 minutes.

The first passive viewing phase focused on whether and how the neuronal activities in the prefrontal cortex differed between the individual blocks. Participants were shown different pictures of a 496 g chicken breast or a blurred baseline image. We used a controlled block design with an overall of four conditions with four images each. Each block was followed by a blurred baseline as displayed in figure 1. The blocks differed by whether the chicken was labelled with a high price (prices randomly varied from 12.98 €/kg to 19.48 €/kg in 2.16 € increments), a low price (prices randomly varied from 2.16 €/kg to 8.59 €/kg in 2.16 € increments), an antibiotic-free label or a guaranteed antibiotic-free label. The antibiotic-free label contained an information text "Antibiotic injections during rearing" or "Antibiotic injections during the first months of life", the guaranteed antibiotic-free label contained "No antibiotics during the entire lifetime" or "This product is antibiotic free". Stimulus presentation time was four seconds with an interstimulus interval of 0.5 seconds. The blurred images were displayed after each block for 12 seconds to compare the participants' neuronal reactivity to a

stimulus containing visual information like the stimuli in experimental blocks. All four blocks were shown three times.

The aim of the second phase, the choice-phase was to find out whether the activities from the passive viewing phase could be used to make predictions about the decisions in the second phase. We used a choice experiment in which 18 different products in nine choice sets were shown to the subjects. Each chicken breast was labelled with a price (6.48€/kg, 12.98 €/kg or 19.48 €/kg) and a specific antibiotic-free label, like phase one. The additional information text of the antibiotic-free label was “Antibiotics injections during rearing”, the one of the guaranteed antibiotic-free labels was “No antibiotics during the entire lifetime”. The choice combinations were determined randomly. Each choice-set was followed by a break, a white “cross” on a black background (figure 2). This break was presented for 12 seconds to set neuronal activity back to the baseline (KENNING, 2014). For each choice set, two products were displayed next to each other. The order of the sets was randomized. The subjects had to choose one of the products or "no purchase". The research task was presented on a computer screen using the software Presentation. Data recording was eased by using the software package NIRStar. Data analysis was facilitated using *nirsLAB*.

The present study utilizes data from healthy right-handed German-speaking students from Georg-August-University of Goettingen. The study was conducted between January 23th and February 3rd, 2019. A total of 25 participants were recruited (56% male and 44% female; mean age: 26.12; age range: 22-34 years). All subjects participated voluntarily and were verbally informed about the experimental procedure in advance. Due to poor fNIRS data quality six subjects were excluded from the survey.

Results

The choice phase consisted of two parts. The randomly defined choice-sets (part one) and the determined choice-sets with extreme values (part two). Over all, the higher-priced guaranteed antibiotic-free product was chosen “100% of the time” (nine out of nine) by 15,79% of the participants, 31,58% of the subjects chose the higher-priced guaranteed antibiotic-free method “at least 75% of the time” and 52,63% chose the mentioned method “50% of the time or less”. The lower-priced antibiotic-free product was chosen “100% of the time” (five out of five) by 31,58% of the subjects, 15,79% chose the mentioned method “at least 75% of the time” and 52,63% for “50% of the time or less”. Considering the frequency of all choices in comparison to an alternative product, participants chose the guaranteed antibiotic-free products, regardless of price about 53,59% more frequently than the alternative product. If the decisions from part two are considered separately, it became apparent that in the case that both products are labelled as guaranteed antibiotic-free, 74% chose the cheaper product. When choosing between the antibiotic-free and guaranteed antibiotic-free product for the same price, 95% chose the second product. The other 5% chose “no buy”. The choice was identical, when choosing between a product without label and the guaranteed antibiotic-free product. Therefore, we can confirm the hypothesis that labels with the claim "free of" are chosen more often than "contains". Nevertheless, the price appeared to be a decisive factor.

The aim of the passive viewing phase was to show that the two labels and price gradations differ in terms of their neuronal activity. Therefore, SMP Level 1 was performed for each participant. The conditions, price high vs price low (C4-C5) and antibiotic-free vs. guaranteed antibiotic-free (C6-C7) were considered. A t-test was performed to show differences in neuronal activity during the passive viewing of the products. The p-value was set to 0.05. A t-value was generated for each of the 22 channels, if it showed a significant difference. SMP Level 1 results showed, that the products with the higher price showed significant results of the t-test for 84% of the subjects. This means that neuronal activity was significantly higher when comparing the higher priced products with the lower priced (C4 > C5). Another 84% showed significant results in brain activation when watching the lower priced

products vs. the higher priced ones (C5 > C4). The two labels showed differences in the brain activation. For the antibiotic-free labelled product, 63% of the participants had a significant higher brain activation compared to watching to the guaranteed antibiotic-free labelled product (C6 > C7). Other than expected, 94% showed a higher activation when watching the guaranteed antibiotic-free product in comparison to the antibiotic-free one (C7 > C6).

Discussion

This study focused on the neural activation of the prefrontal cortex during the passive viewing of differently labelled chicken breast and the comparison with later product choices. The study focused on the perception of antibiotic-free labels with differentiated quality labelling. We found that more participants show greater neuronal activation for the guaranteed antibiotic-free label. These results are in line with MEHLHOSE and RISIUS (2019) who investigated differences in neuronal activity for products that are labelled "with antibiotic" and "antibiotic-free". They measured a significant increase in the neural activation of the dlPFC for the positive label compared to the negative. That might be explained by the effect of positive labels. They enhance the general understanding of the quality of the products, evoke positive association and feel like a reward (LEVIN and GAETH, 1988). However no group differences could be detected and studies with increased sample size should validate the findings based on class dependent differences.

In the second section of the study the results from passive viewing phase were used to predict later choices. The results from the summary statistic lead to the assumption of differences in the choice decision between subjects with different neuronal activity level for the different label and price ranges. The guaranteed antibiotic-free products were chosen 65% of the time by participants with higher preference for the antibiotic-free label. In comparison, they were only chosen 44% of the time by participants with higher prefernece for the guaranteed antibiotic-free labels. The variation in the PFC when viewing high vs. low prices might also be a predictor of the subsequent choice of higher and lower priced products. Participants with higher preferences for low prices chose the lower-priced products more often than the higher-priced. Cheaper products with the same label were chosen 78% of the time by participants with higher preferences for the lower prices and 88% of the time by participants with higher preferences for the guaranteed antibiotic-free label. The results could be compared with the findings from LUSK et al. (2015). Participants with higher value for higher prices and for the cage free label, selected the higher priced cage free eggs 65,2% of the time. The choice fell to 36,4% for people with

negative values. Therefore, this leads to the assumption that fNIRs can reproduce validate results and may be suitable to use in other realistic choice settings.

Conclusion

Using fNIRS, we may be able to gain a differentiated understanding of value formation with regards to quality attribution for labels. In regard to comparing this novel fNIRS methodology with other methods of neuronal marketing, the study points towards the finding that the fNIRS-measurement was able to reproduce the findings of other neuroeconomic consumer studies. As such, it might be a good and feasible way towards a better understanding of consumers' behavior and to carry out more research at the point of sale or consumption.

Further in depth analysis of the choice analysis may also unveil a qualitative reflection with regard to RUM framework. It may have to be reflected, whether which level of differentiation may be applicable in communicating quality attribution of food products. This may enhance communication about different food production qualities through labels.

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