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Assessing Label Frames and Emotional Primes in the Context of Animal Rearing—Response of an Explorative fNIRS Study

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Abstract: Against the background of rising societal interest for sustainable food and nutrition choices, food labels have gained importance in providing important information to consumers. However, little is known about how the differences between quality frames in labels are evaluated and how priming might serve as an anchor for label perception. This study aims to observe the neural reaction of this in the context of differently framed food labels for products of animal origin, claiming the presence or absence of an additional quality aspect and under the impulse of emotional priming. In an explorative setup, we measured the neural prefrontal cortex activity of 26 participants with the neuroimaging technology fNIRS. An idyllic prime and a prime related to a label claiming an additional product quality led to increased neural activity in the OFC and dlPFC. Shedding light on what elements are of importance to identify products that meet consumers' requirements in terms of quality aspects, this could indicate that the prime stressed the meaning of the label. This strengthens the argument to positively phrase and anchor frames regarding quality attributions as opposed to negative declarations. It further demonstrates the ability of fNIRS to capture processing through labels and primes in the context of consumer behavior.

Keywords: consumer neuroscience; food labeling; neuromarketing; message framing; meat label; quality attributes; sustainability

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1. Introduction

Overall, societal interest in sustainable food and nutrition choices is growing. Taking climate gases as one specific example, roughly 17% of the greenhouse gas emissions can be attributed to the agri-food sector [1]. Given the daily complexities and interconnectedness of agri-food systems, what we eat affects not only the environment but also food security, safety, and human health [2–4]. Therefore, sustainable lifestyle and consumption behaviors are becoming more and more important and should be further encouraged. Against this background, companies are working to become more sustainable and to gain better corporate social reputations [5,6]. Additionally, consumers are increasingly interested in and are demanding for more sustainable agricultural and food products. In the context of products of animal origin, there is growing societal concern regarding animal welfare in intensive agricultural production. On the one hand, consumers are concerned that not very animal-friendly production systems could impact food safety, product quality, and their own health [7,8]. On the other hand, it is not always easy for consumers to evaluate the products that meet their requirements in terms of process quality aspects, e.g., with regard to sustainability or animal welfare [9].

Often, process quality information is provided by labelling frames. They provide additional relevant and easily accessible information (e.g., in the form of eco-labels or food labels) to consumers to help them identify certain desirable or undesirable product properties [7,9,10]. Eco-labels, e.g., are thought to increase sustainable consumption patterns because they simplify consumers' decision-making process with regard to the property

under consideration (e.g., animal-welfare) [10]. In this context, the framing of quality aspects in the sense of the phrasing, wording, and formulation gains importance [11]. Often, consumers are not aware that, depending on the frame, they may perceive this information very differently [12,13]. If, e.g., certain product properties describe an absence of a quality aspect or, conversely, the presence of an additional quality aspect, this influences consumers' evaluations, which may be important in the processing of the overall product information [11,12,14,15].

Additionally, product evaluation is triggered by emotional primes that may serve as an anchor for consumers [14,16,17]. Despite the high social relevance, little is known about the role that label framing and priming play for products with sustainable food labels and how this affects the evaluation of the declared process quality. Therefore, this study investigates, in an explorative neuroimaging setup, the effect of label frames claiming the absence or presence of a quality aspect combined with a prime from the context of animal rearing. The question is whether differences with regard to the evaluation of product quality can be traced back to the priming of information.

Background

Labels can highlight a further product quality in the sense of the existence of additional attributes (e.g., fair-trade standards) or the absence of negative aspects (e.g., GMO-free) [18]. Both possibilities then imply a higher or better quality compared to other products in this segment. However, labels can also be used the other way around by underlining a lower product quality. They then declare the presence of rather negative aspects or the absence of positive characteristics (e.g., health risks when smoking), and they then imply that the products appear with lesser or reduced quality than the average product [18–20].

With regard to priming, marketing approaches often use pictures as primes for product presentation because, compared to textual information, they evoke a greater emotional response in consumers, thereby influencing consumers' emotional evaluations about the product [21,22]. Unattractive or deterring pictures might emphasize undesirable consequences that are associated with buying or consuming this product, leading to negative emotional reactions [12,13,23]. One real-life example is shocking pictures combined with health warning messages on tobacco packages, highlighting the negative consequences of smoking behavior and leading to strong negative emotions and perceptions [22,23]. In contrast, beautiful or nice pictures can emphasize the desirable profit or benefits that are associated with buying or consuming a product, leading to positive emotions about the product [13,23]. This approach is often used for products of animal origin, where idyllic or romanticized animal pictures aim to give the consumer a good feeling about the product. However, this does not always correspond to the actual husbandry systems, which is why there is increasing discussion about the use of more realistic images in the marketing of products of animal origin, although they often carry negative associations [24].

Consumers are often unaware of the fact that they are influenced by stimuli that go beyond the sensory taste attributes of a product, which is that product priming and label framing might influence their perception of the product and, in the long run, their behavior (buying vs. not buying the product) [25,26]. Therefore, the provided product and label information and their pre-priming unconsciously serves as an anchor function in the customers' effort to find satisfactory product solutions for their needs [14,25]. The emotional loadings may impair connotative evaluation, thus indirectly influencing the perception of frames for labels and their information processing. Therefore, it would be interesting to better understand the emotional and associative links between the evaluation of label frames and anchored, stored emotional information to understand consumer perception.

For this reason, it is of interest to examine consumers' perception by not "asking" them directly but by using an indirect measurement approach that allows for the investigation of unconscious processes of people [27]. One new approach to this is the investigation of consumers' neural responses [26]. As opportunities grow to observe the neural manifestation of constructs such as "framing" and "priming" in the living brain, mobile, cost-effectively,

and without great effort [28], the purpose of this study was to determine whether there are differences in the neural perception between differently framed messages claiming an absence of a quality aspect or presence of an additional quality aspect. For this, we used labels with regard to the mediation of the presence ("antibiotics"), absence ("antibiotic-free"), or of no additional information of antibiotics in the production system. These label presentations were further primed with rather idyllic vs. rather oppressive pictures of poultry production systems (free-range vs. indoor). We chose this as a context for our labels to follow up on the societal demand to combat the worldwide problem of antibiotic resistance through the establishment of a labeling regime for so-called "antibiotic-free" animal products [29–31]. This is discussed by food manufacturers worldwide, and companies in the US and Denmark are pioneers in establishing antibiotic-free policies and labels and in claiming the absence of antibiotics in the rearing of the animals [32]. It has gained importance in view of the fact that the consumption of chicken meat is continuing to rise worldwide (in Germany, meat consumption as a whole is slightly declining), and as a result, production capacities are also continuously increased [33].

Against the above-described background, we hypothesize that it is possible to measure differences in the prefrontal cortex neural activity between the primes alone and between the differently framed labels in combination with the primes using fNIRS. To investigate the expected differences in neural response of test persons, we applied a new and innovative optical imaging method in consumer neuroscience, the functional near-infrared spectroscopy (fNIRS). This study follows up on the recommendation of [34] to apply fNIRS in studies related to sustainable consumer behavior.

2. Materials and Methods

2.1. FNIRS Technology

Functional near-infrared spectroscopy (fNIRS) visualizes brain activity through hemoglobin's ability to absorb light [35]. With sources of near-infrared light in specific wavelengths (760 nm and 850 nm) penetrating the human tissue, the differences in cerebral oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) can be measured and made visible, which allows for drawing conclusions about the neural activity beneath the surface of the brain at certain times [36]. Beyond that, fNIRS technology provides several advantages over functional magnetic resonance imaging (fMRI), which is the best-known and frequently used imaging technique so far to acquire insights into the human brain: fNIRS is mobile and comfortable, which enables extensive use of this technology, especially for more realistic experimental settings, where greater flexibility of the test persons is required. Compared to other neuroimaging methods, it also has a lower sensibility, which results in a greater robustness against body movements and thus extends the field of application to outdoors or unconstrained environments [37,38]. Furthermore, the fNIRS mechanism is similar to the principle used in fMRI measurements (BOLD signal), which allows the fNIRS signal to be compared to the fMRI signal [39].

2.2. Participants

Twenty-six students were recruited to take part in this study. Of these, 15 were male and 11 were female. The average age was 22.9 years. All participants had normal or corrected-to-normal vision. They participated voluntarily in the experiment, but two vouchers were raffled among all participants as an incentive. Before the experiment started, all participants were informed about the experimental setting and the mobile fNIRS technology. Although fNIRS is a noninvasive method and does not represent a risk to the participants, they were informed that they could stop the experiment at any time with no consequences. All test persons gave their consent to participate in the study. The whole experiment was conducted according to the APA's Ethics Code and is in line with the Declaration of Helsinki. The procedure and the use of fNIRS were approved by the university's ethics committee.

2.3. Stimuli

Our experimental stimuli consisted of twelve different images from poultry farming systems, which were used as primes. Six of them showed different impressions from free-range poultry farming systems, with chickens in a rather idyllic and natural environment (idyllic prime). In contrast, the other six pictures showed animals in a confined, dark room or in large fattening facilities (oppressive prime) (Figure 1).

Figure 1. Six images from free-range or indoor-poultry farming systems showing chicken in an idyllic and natural environment (idyllic prime) or, in contrast, animals in a confined, dark room or in large fattening facilities (oppressive prime).

For the differently framed labels, we used the picture of a meat package with whole chicken breasts on which we placed the different labels to make their use more realistic. The first meat packaging image had a self-designed green label in the upper left-hand corner with the text: "Antibiotika frei" (antibiotic-free). This label information claimed the additional product quality (as an absence of a rather negative aspect) (Label+). The second meat packaging image had a red label and the information "Antibiotika" (antibiotics) on it and claimed a lower product quality (as a declaration of usage of rather negative aspects) (Label–). The third image contained the meat package without any label information and served as a control condition (Figure 2). We did not provide any further information about the terms "antibiotics" and "antibiotic-free", and their definitions to allow the labels to stand in contrast with each other, but we stressed their meanings and differences through the use of the colors green and red. The meat package was bought at a German retail store and photographed for the experiment. We deliberately refrained from making any significant changes to the image and only altered the expiry date and removed the condensation within the packaging using a graphics program (Adobe Photoshop® version 20.0.4, Adobe Inc., San José, USA). We then used the same software to add the labels.

Figure 2. The meat package with a whole chicken breast was used to depict the label information. The first label (green) claimed an additional product quality through the absence of antibiotics ("antibiotic-free") (Label+). The second label claimed a lower product quality through the use of antibiotics ("antibiotics") (Label−). The third image had no additional label information and served as a control condition.

2.4. Experimental Design

The experimental design consisted of six trials. In every trial, each of the six pictures from free-range or indoor-poultry farming was presented one after the other in a randomized order (6 × 4 s) and served as prime. These six pictures were followed randomly by one of the three labeled meat packages (15 s), which served as frame, and a small break (4 s) afterwards. In total, each of the differently framed meat package was shown six times,

three times with the six rather idyllic and three times with the six rather oppressive pictures as primes before. In total, the experiment lasted for 13 min and 26 s (Figure 3).

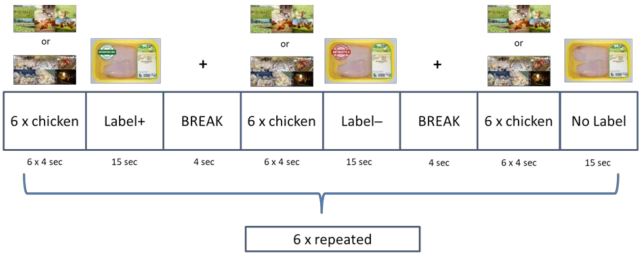

Figure 3. Schematic representation of the experimental design. Label+ represents the green "antibiotic-free" label, which claims an additional quality aspect. Label− represents the red "antibiotic" label as it claims reduced quality. The prime before the labeled meat packages consisted of six chicken images. Those were three times the six rather idyllic and three times the six rather oppressive images. During the break, the participants saw a fixation cross. The experimental design was completely randomized.

To ensure the same circumstances for every participant, the experiment was conducted in a small, windowless room. Care was taken that the light did not fall directly on the fNIRS setup or on the screen in order not to influence data quality and the participant's view. The experiment was conducted on a 13-inch laptop with participants placed at half a meter distance in front of it. Participants had to passively view the images.

2.5. Data Collection and Analysis

Hemoglobin data of the prefrontal cortex were obtained using a mobile fNIRS measurement system (NIRSport; NIRx Medical Technologies, Berlin, Germany). This is a two-wavelength continuous wave system that collects data in parallel at a sampling rate of 7.81 Hz. In this experiment, we used a neoprene headband that consisted of eight sources and seven detectors, which were placed at a distance of three centimeters to each other. This resulted in 22 measurement channels that covered parts of the prefrontal cortex, namely Brodmann areas 9, 10, 11, and 46, which are related to the orbitofrontal (OFC), the dorsolateral (dlPFC), and the frontopolar prefrontal cortex (FPC). A schematic representation of the topographical layout with the channels is shown in Figure 4.

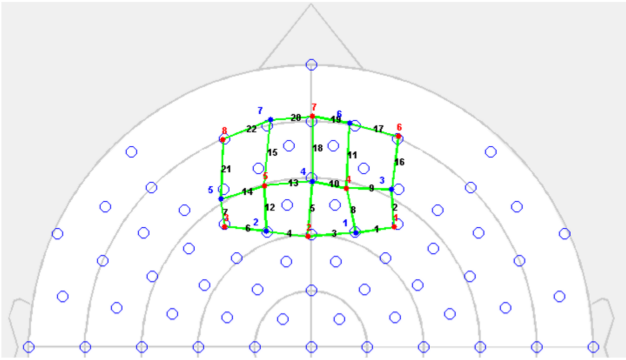

Figure 4. Schematic representation of the topographical layout. Red numbers symbolize the sources (**1–8**), blue numbers symbolize the detectors (**1–7**), and the black areas in between are the channels (**1–22**) representing the different brain areas of the prefrontal cortex.

The headband was placed on the participant's forehead, and after checking the signal quality, we began collecting data (both with NIRStar, version 15.0; NIRx Medical Technologies, Berlin, Germany). The images within the experimental design were presented using the software NIRStim4 (NIRx Medical Technologies, Berlin, Germany). All of the following steps concerning raw data preprocessing and modeling of the neural activity were performed with the software nirsLAB version 2017.6. (NIRx Medical Technologies, Berlin,

Germany) First, we preprocessed the raw fNIRS signal. The data were band-pass filtered to remove strong artifacts (e.g., heartbeat, etc.). Then, through a modified Beer–Lambert law, we transformed the raw optical density signals into the hemoglobin concentration changes (oxy-Hb and deoxy-Hb). We chose the hemodynamic response function to model the neural activity. Data analysis was performed only with oxy Hb because it seems to correlate more strongly with the cerebral blood flow [40]. We performed a channel-based group-analysis based on a general linear model (GLM) analysis of the hemodynamic-state time series during the experimental conditions. We used the GLM for statistical parametric mapping (SPM) level 1 to detect the hemodynamic response of oxy-Hb for all 22 channels under all conditions at the individual level. At the group level, we performed statistical parametric mapping level 2 using the generated beta-value for each subject, channel, and condition to run one-sided *t*-tests to detect the significantly activated channels of the respective two compared conditions. The activation threshold was set to $p < 0.1$. We calculated contrasts for the emotional primes themselves (idyllic vs. oppressive poultry images) and for the combination of the differently framed labels with the previous primes (Idyllic and Label+ vs. Idyllic and Label−; Oppressive and Label+ vs. Oppressive and Label−; and the same compared to the No-label condition). Depending on which of the experimental conditions had a larger relative effect, this resulted in positive or negative *t*-values for significantly stronger activated channels during this contrast. Those *t*-contrast activation maps were afterwards plotted on a standardized brain model, which is included in the nirsLAB software.

3. Results

The results for the primes themselves showed that the contrast of the more idyllic free-range poultry farming images resulted in a significant increase of neural prefrontal cortex activity in channel 20 compared to the rather oppressive images of indoor-poultry farming ($t(26) = 1.78$, $p \leq 0.1$, $d = 0.494$). This corresponds to Brodmann area 10 and contributes to the OFC and FPC (Figure 5).

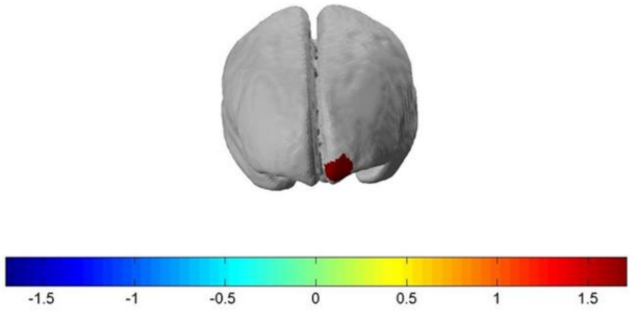

Figure 5. Threshold SPMt image: Increased oxy-Hb neural activation in channel 20 ($t(26) = 1.78$, $p \leq 0.1$, $d = 0.494$) when participants saw the idyllic, free-range poultry farming images compared to the rather oppressive images of indoor-poultry farming.

When it comes to the neural effect of the primes related to the differently framed labels, we detected a significant increase in neural activity when participants saw the green "antibiotic-free" label compared to the red "antibiotic" label with the earlier idyllic prime. More precisely, channel 3 ($t(26) = 1.71$, $p \leq 0.1$, $d = 0.474$) showed increased neural activity, which corresponds to Brodmann area 9 and is part of the dlPFC (Figure 6). This significant difference in the oxy-hemoglobin level was measured amongst all participants. All other label contrasts were performed but did not hold significant results.

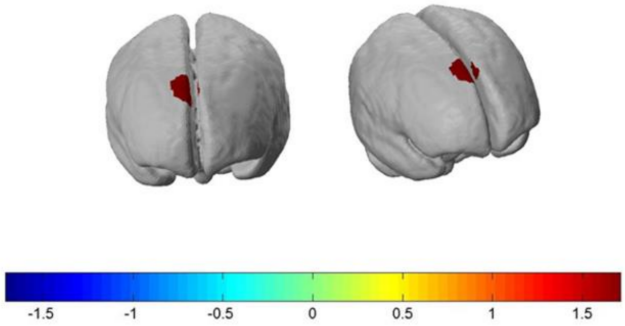

Figure 6. Threshold SPMt image: Increased oxy-Hb neural activation in channel 3 ($t(26) = 1.71$, $p \leq 0.1$, $d = 0.474$) for the green "antibiotic-free" label compared to the red "antibiotic" label, both with the earlier idyllic prime.

4. Discussion

This study used fNIRS to examine consumers' neural perception of differently framed food labels and primes related to different types of poultry rearing. The results showed that it is possible to measure differences in the prefrontal cortex neural activity between primes alone and between the differently framed labels related to the primes.

More specifically, the rather idyllic prime showed a significant increase in BA 10 (OFC/FPC) activity compared to the rather oppressive one. This is in line with another fNIRS study that achieved a significant effect in the same brain area for the evocation of positive and negative feelings caused by different aesthetically pleasing images [41]. Moreover, several other studies that examined the neural perception of art found that the OFC is activated when viewing authentic or aesthetic pictures and images [42,43]. Furthermore, there is evidence that the OFC is associated with the evaluation of hedonic values from different sensory stimuli [43,44]. Due to our explorative experimental setup, we can only speculate at this point about the meaning of our results, but it is possible that the idyllic pictures evoked a rather pleasant emotional processing.

When it comes to the neural prefrontal cortex activity of the differently framed labels in relation to the primes, we found significantly increased activity in the dlPFC related to the idyllic prime when participants viewed a label claiming an additional product quality compared to a label claiming lower product quality. In contrast, the label that highlighted the presence of a negative characteristic did not provoke a reaction by the means of a negative neural response but rather a neutral response. One study in the context of message framing found a stronger neural effect of positively framed messages compared to negatively framed ones, while another found neural activations in similar brain regions [45,46]. Regarding the transfer of additional product quality, it may be an important finding to anchor the process information in a positive manner to target the intended meaning with regard to increase process transparency. This should be further validated in future studies.

Against the background of sustainability and meat consumption, our results can shed light on what elements are of importance to identify products that meet consumers' requirements in terms of quality aspects. Framing and priming of products can evoke preference shifts, which can influence consumer behavior. Within the process of labelling, those effects are important to consider as they are transporting a preferred quality aspect. For example, the less sustainable products or aspects of a product (in this case, the use of antibiotics) could lead to a greater behavior shift in the sense of an avoidance of this product overall than, e.g., highlighting the positive and sustainable aspects of a product, which only provides the consumer with knowledge but does not necessarily result in an action [15,19,47]. We cannot clarify the behavioral aspects with our data, but we recommend to study this further.

The main intention of the study was to reflect consumer neuronal response to different frames under preset primes in order to understand the evaluation process of quality better. The evaluation process and the anchoring of information may be very important, especially

with regard to an educative-intensive credence good, such as sustainable food quality. Studying this evaluation process in depth by using the novel technology of fNIRS and to find out whether it is generally possible to measure the cognitive modulation of these aspects with fNIRS was therefore important.

Given the novelty of the approach and due to the novelty of fNIRS as an imaging technology for examining consumer behavior, this study is of an explorative character. This does not yet allow us to draw conclusions on the relationship between consumers' neural responses and actual behavior. The study did not include a consequent choice-test, which would have allowed for such conclusions. In upcoming studies, it would be useful to add behavioral measurements that would allow us to better explain and embed our results within the underlying brain mechanisms or neural structures. A general explanation of the results with regard to the classification and connection of the neuroimaging results is therefore not possible at this time because, in the area of neuroeconomic and consumer neuroscience, mental processes and underlying brain functions are still much less understood. As such, we can only make first suggestions at the content level. However, it is known that BOLD activations observed when passively viewing images can predict subsequent choices, which justifies our initial considerations in this regard [48]. We aim to start to evolve into consumer behavior and consumers' neural actions, which is why our results should be seen as first explorative insights on what might eventually be possible and what other studies on sustainable marketing and consumer information can build upon.

This study sheds some light on the importance of priming and labeling frames and on the novel measurement technology fNIRS in the context of consumer behavior and food labeling. Our study provides an additional step in using more indirect measurement approaches to understand consumer behavior, such as, in our case, to investigate the neural responses to emotional primes and differently framed food labels. As such, our study is also in line with, e.g., the study by [49], which found that fNIRS is a reasonable setup to measure message framing-related effects in the prefrontal cortex. The use of mobile fNIRS is an appropriate neuroimaging method to detect neural effects of framing and priming in food and sustainability contexts, and it demonstrates that differences are detectable and measurable, especially when stimuli might evoke strong and differing emotional reactions.

However, due to the novelty of fNIRS, there are still many inconsistencies between the effects and results reported in different studies, and a proper comparison is therefore still challenging [50]. Furthermore, there are also technical limitations of fNIRS compared to fMRI: although fNIRS is less sensitive to head and body movements, the quality of the results might be influenced by extracerebral confounds [51]. In addition, there is poorer spatial resolution compared to fMRI due to the fact that fNIRS measurements are based on hemoglobin concentration changes measured through near-infrared light compared to fMRI, where they are measured through the changes in magnetic fields [52]. In fNIRS, this leads to a low light penetration depth, which means that only the superficial areas of the brain can be measured, such as the prefrontal cortex. This makes it more challenging to precisely localize the activated areas, as they are difficult to distinguish from one another.

This study faces several limitations: Our labels were fictitious, i.e., they were unknown to the participants and were not supplemented with additional or explanatory information. This could have caused some uncertainty or confusion concerning the meaning of the labels [20]. Nevertheless, the labels were inspired by existing label schemes detected in markets in the US, Italy, and Germany prior to the survey to ensure consumer familiarity with the overall topic. Additionally, this way, we could ensure that consumers all had the same (i.e., no) attachment to the label and were not co-mediated by different knowledge or trust levels. Thus, using a hypothetical label allowed us to study the effect of the frames in combination with the priming, which could have been "biased" if we had used an existing label.

Another limitation might be that, although other studies have used colors to underline the content of their label information as well, it is quite possible that the perception of the label was intensified by the different colors we gave them. The green ("antibiotic-free")

label might have increased the perceived healthiness of the product and therefore led to a stronger neural activation compared to the red color of the "antibiotics" label, which could have had an additional warning effect [53]. The selective effect of color in a reaction to the frame and in processing information should be clearly differentiated in upcoming studies. Furthermore, in this study, we focused on the neural responses to the stimuli and did not strengthen the findings through a behavioral task (e.g., a choice experiment) by the participants. Using a behavioral task would provide not only a neuronal response but also preference schemes put in action by matter of a choice. Given budgetary limitations and a profound work on consumer behavior in choice experiments in reaction to rearing conditions (e.g., [54,55]), this innovative study was focused on evaluating mechanisms that take place within the evaluation process. In the future, such additional measurements should be carried out to investigate the question to what extent fNIRS can replicate or supplement the results of traditional instruments.

5. Conclusions

To the best of our knowledge, this is the first study that has investigated consumers' perception of primes and their influence on differently framed food labels on a neural basis and with the novel brain imaging technology fNIRS. Our results shed light on what elements are of importance to identify products that meet consumers' requirements in terms of quality aspects. The idyllic prime itself and the prime related to the label that claimed an additional product quality led to increased neural prefrontal cortex activity. The idyllic prime might have enforced the meaning of the label, which could indicate that, in order to target an additional product quality, the process information should be anchored in a positive manner. Our results further demonstrate that mobile fNIRS is an appropriate neuroimaging method to capture emotion-related processing through labels and primes in the context of agricultural production systems and food contexts. In addition, it also demonstrates that differences in perception are detectable and measurable, especially when stimuli might evoke strong and differing emotional reactions. Nevertheless, further research is needed to understand the specific neural activation in more detail and should be extended to other animal production systems and generally to other aspects of sustainability.

Author Contributions: C.M. and A.R. conceptualized the experiment. C.M. ran the experiment. C.M. conducted data analysis. All authors contributed to the interpretation of the results. C.M. and A.R. wrote the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the University of Göttingen (Code: 32/12.17-Mehlhose, 05.02.2018)

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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