Exploring Frontal Alpha Asymmetry as a Neural Indicator of Consumer Preferences: The Impact of Evaluative Conditioning with Climate-Change Related Stimuli

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Abstract

Introduction: Many social problems, including climate change, are partially driven by the behavior of individuals. One area where individual choice-behavior impacts the climate is in the context of supermarket purchases. This study aimed to investigate Frontal Alpha Asymmetry (FAA) as a neural indicator of consumer preferences, with a particular focus on the effects of evaluative conditioning (EC).

Methods: We conducted a pilot study to collect and validate the video stimuli used in this research, these videos were paired with images of supermarket products in an EC experiment. Three conditioning types were used, consisting of positive, negative and neutral videos. During the experiment, electroencephalography (EEG) was conducted to calculate FAA scores, which were compared before and after conditioning.

Results: No significant effect of conditioning type or time on FAA scores was found. Additionally, no interaction effect between conditioning type and time was observed. The results suggest that EC did not influence the FAA scores and may not be a reliable neural indicator of consumer preferences in the context of supermarket product packaging.

Discussion: This study contributes to investigating the use of FAA as a neural indicator for behavior change in the context of climate change. Although no direct link between EC and FAA scores was found, the findings provide valuable insights for future research into neural mechanisms underlying consumer preferences. The results underscore the complexity of using FAA as a standalone neural indicator, suggesting its role within a broader network processing emotional valence and motivation.

Keywords: Pro Environmental Behavior, Evaluative Conditioning, Climate Change Related Videos, Supermarket Products, Frontal Alpha Asymmetry.

Plain language summary

Background: Climate change has serious effects, like extreme weather and the loss of animals and plants. The food we buy in supermarkets plays a role in this. Food production, packaging, and transport cause pollution. Choosing local, plant-based, or less packaged products can help, but many people don't always make these choices, even if they care about the environment. This difference between beliefs and actions is called the attitude-behavior gap. Sustainable choices can seem more expensive, less convenient, or less appealing. Research shows that footage of climate change can create emotions that influence behavior. A method called evaluative conditioning (EC) links products to positive or negative stimuli to change preferences. This study looked at whether watching climate-related videos could change how people feel about supermarket products and if this change could be seen in frontal brain activity (FAA scores). We thought that positive and negative videos might make people prefer sustainable products and that this would show up in their brain activity. Understanding this can help find better ways to encourage people to make sustainable choices.

Methods: A total of 53 people (22 men, 31 women) between the ages of 20 and 73 took part in this study. First, participants read an information letter and signed a consent form. Then, they answered a few online surveys about their background, their views on the environment, and their shopping habits. The main experiment had three parts: before, during, and after EC. In the first and last part, participants viewed 20 supermarket products while their brain activity was recorded. In the middle part (EC phase), they watched short videos about climate change coupled with the supermarket products. Some products were shown with positive videos, others with negative or neutral videos.

Results: Against our expectations, there was no difference in FAA scores while watching supermarket products before and after the EC. Furthermore, there was also no difference between the positive, negative and neutral videos. After watching the videos, 83% of participants correctly remembered which product was shown with each video.

Conclusion: This study looked at whether watching climate-related videos could change how people feel about supermarket products and if this change could be seen in frontal brain activity (FAA scores). We thought that positive and negative videos might make people prefer sustainable products and that this would show up in their brain activity. However, our results did not support this idea. We found that watching the videos did not affect FAA scores. This suggests that FAA may not be a reliable way to measure consumer preferences for sustainable products. One reason for these different results could be that some product-video pairings did not feel realistic to participants, reducing their impact. Another possibility is that people were not shown the product-video pairings enough times for

the effects to fully take place. Our study shows that FAA alone may not fully explain how people make choices about sustainable products. Consumer decisions are complex and influenced by emotions, motivation, and other brain processes. Future research should explore how different parts of the brain work together when people form opinions about products and sustainability.

Keywords: Pro Environmental Behavior, Evaluative Conditioning, Climate Change Related Videos, Supermarket Products, Frontal Alpha Asymmetry.

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1. Introduction

In today's society, the effects of climate change are severe, influencing different aspects of society in various ways. A clear example of this is global warming, which causes extreme weather events, sea-level rise, and biodiversity loss (SPM, p.5). Many social problems, including climate change, are partially driven by the behavior of individuals. One area where individual behavior impacts the climate is in the context of supermarket purchases. The production and consumption of food are partly responsible for global greenhouse gas emissions. Furthermore, food processing, packaging and transportation contribute heavily to environmental degradation (Poore & Nemecek, 2018). These impacts can be reduced if individuals change their choices in supermarkets. For example, consumers could prefer locally produced, plant-based, or minimally packaged products (Poore & Nemecek, 2018). Understanding the mechanisms behind these choices is crucial, and one potential neural factor that is associated with this decision-making is Frontal Alpha Asymmetry (FAA). As a neural metric associated with emotional valence and motivation, FAA may provide insight into the neural processes that drive consumer behavior.

The increasing urgency of climate change requires immediate action according to IPCC (2021). It is known that individual behavior can play an important factor in climate change (Swim et al., 2011; Swim, Stern, et al., 2011; Wynes & Nicholas, 2017). Pro-environmental behavior (PEB) refers to the behavior of an individual that contributes to protecting the environment. PEB includes, on the one hand, behaviors that directly benefit the environment (e.g., purchasing sustainable products) and, on the other hand, the avoidance of behaviors that harm the environment (e.g., using less plastic packaging) (Steg et al., 2014; Carman & Zint, 2020; Leeuwis et al., 2022).

Many people show their commitment to environmental sustainability, for example by saying that they prefer sustainable and waste-free products over less sustainable alternative products (Rokka and Uusitalo, 2008). However, this does not always translate into action. Although individuals report pro-environmental beliefs and intentions, they often fail to actually show the PEB in their daily lives (Jerzyk, 2016; Vezich et al., 2016; Leeuwis et al., 2023). This difference between words and deeds, known as the attitude-behavior gap (Kennedy et al., 2009), may come from an internal conflict that arises within the individuals. The individuals recognize that PEB is the right choice, however this choice is often perceived as more challenging, time-consuming, costly or less enjoyable compared to environmentally harmful alternatives (Steg et al., 2014; Leeuwis et al., 2022). Therefore, this gap between attitude and behavior needs to be addressed to encourage more PEB and bridge the discrepancy. Previous research has demonstrated that visualizations of climate change impacts can evoke emotional responses (O'Neill and Nicholson-Cole, 2009; Schertz & Berman, 2019; Lehman et al., 2019; Fabbro et al., 2021) and increase engagement (O'Neill, 2019) among viewers. Therefore, these visualizations could be included into behavior change interventions to promote PEB in supermarkets.

One intervention that incorporates these types of visualizations is evaluative conditioning (EC). This intervention aims to change an individual's attitude toward a neutral stimulus by coupling it with a positive or negative stimulus. EC is a form of classical conditioning, where a neutral conditioned stimulus (CS) is repeatedly paired with an affective unconditioned stimulus (US). This causes the individual to develop a positive or negative evaluation of the CS based on the valence of the US. Classical conditioning primarily involves mostly physiological responses. On the contrary, EC is a form of conditioning aimed at emotional and behavioral responses. The aim of EC interventions is to modify an individual's preference for a conditioned stimulus (Hofmann et al., 2010). This is achieved by creating an association between the stimulus and its corresponding emotional response (Eder et al., 2019; De Houwer & Hughes, 2020). Various studies have shown the effectiveness of EC in changing behavior, thereby bridging the attitude-behavior gap. For instance, in the health domain research has shown that EC can be used to promote healthier eating behaviors. Houben et al. (2010) found that coupling healthy food products with positive images increased consumers' preferences for these products. Similarly, Hollands et al. (2011) showed that associating unhealthy foods with aversive images reduced the desirability of the foods. These findings suggest that EC can effectively influence food choices by altering emotional responses to specific items.

Furthermore, the effectiveness of EC is not limited to short-term food choices, but extends beyond them. Halbeisen and Walther (2021) concluded that pairing healthy foods with positive images led to sustained shifts in participants' food preferences over time. Despite these promising results, the long-term effects of EC remain uncertain. Namely, Hollands and Marteau (2016) showed that while EC has been successful in inducing short-term behavioral changes, such as healthier food choices, the persistence of these effects has yet to be fully proven. This view is supported by Moran et al (2022), who found that while EC's effects were evident in the short term, its long-term impact on behavior remains unclear.

Beyond food choices, EC is also effective in changing social attitudes of individuals. Olson et al. (2006) demonstrated that racial biases can be reduced after conditioning with positive stimuli. This finding suggests that EC can be used to alter social attitudes by stimulating positive emotional associations with previously negative perceived stimuli. Furthermore, within environmental research, studies have shown that EC can effectively promote PEB by altering individuals' attitudes and emotional responses towards sustainable items. Studies within this domain use visualizations of environmental impacts and pair these with positive or negative emotions, thereby conditioning participants to associate positive feelings to PEB. Ischen et al. (2022) concluded that sustainable design elements can condition consumers to perceive products as more sustainable. Additionally, Leeuwis et al. (2024) focused on the role of EC in shaping consumers attitudes towards sustainable product packaging in supermarkets, they paired supermarket products with affective images on either positive nature themes or negative climate change impacts. The study concluded that EC can be a powerful intervention for promoting PEB in consumers. These studies thereby show that EC can shift consumers’ preferences towards sustainable products which are beneficial against climate change.

This shift in consumer preferences may not only be observable through explicit behaviors and attitude but also through implicit indicators, such as neural activity. Previous studies considered implicit associations with health (Koenig-Lewis et al., 2021) or sustainability (Leeuwis et al., 2024) as outcome. The effect of EC is particularly seen in emotional responses (Eder et al., 2019; De Houwer and Hughes, 2020). Individuals often find it difficult to assess this behavior explicitly, as highlighted by the attitude-behavior gap, which shows discrepancies between what individuals say and how they actually behave. As proposed by Leeuwis et al. (2022), Doell et al. (2023), and Krebs & Sawe (2024), an implicit measure using neuroscientific methods to assess emotional behavior change in sustainable behavior is more applicable.

One commonly applied implicit neural metric is FAA, which refers to the lateralization of alpha-band activity in frontal regions of the brain. FAA is often used as a measure of emotional valence, reflecting the degree of positive or negative emotions evoked by stimuli (Schöne et al., 2015; McFarland et al., 2016; Lehman et al., 2019). In addition to emotional valence, FAA is also associated with motivation. More specifically, FAA reflects the difference between approach and withdrawal motivations (Gable & Dreisbach, 2021; Campbell et al., 2023). Increased left frontal activity (higher FAA scores) has been linked to approach-related motivation, while increased right frontal activity (lower FAA scores) is associated with withdrawal-related motivation (Briesemeister et al., 2013; Harmon-Jones & Gable, 2017). This dynamic suggests that FAA can serve as a valuable neural indicator not only for assessing emotional responses to stimuli but also for understanding the underlying motivational forces driving behaviors, such as those of consumers.

This EEG study aims to investigate FAA as a neural indicator of consumer preferences, with a particular focus on the effects of EC. By recording frontal lobe activity while participants look at supermarket products, both before and after they view climate-change related videos coupled to these products in the EC. The study explores the brain mechanisms that underlie motivational responses to climate change stimuli. We hypothesize that EC has an effect on FAA scores after the conditioning, reflected in increased right frontal activity (lower FAA score) following exposure to negative climate change-related videos, compared to the effect of pairing the products to neutral videos. Understanding these neural processes will give valuable insights into emotional factors that influence consumer decision-making. These findings could enhance the understanding of how to promote PEB and contribute to more effective strategies for encouraging behavior change in the context of climate change.

2. Methods

2.1 Participants

Prior to the experiment, a power analysis was conducted using G*Power software to calculate the required sample size. The analysis for a within repeated measures ANOVA was conducted with a power set at 0.95, the alpha level at 0.05, and the effect size of the primary outcome at $d = 0.50$, which followed a review on evaluative conditioning (Hofmann et al., 2010) and was used in later studies e.g. (Hollands et al., 2011; Weber et al., 2020). Based on this analysis, a total sample size of 43 participants was determined to be necessary.

A group of 53 participants (22 Male, 31 Female), aged between 20 and 73 years ($M_{age} = 36.3$, $SD_{age} = 17.0$), participated in the study and received monetary compensation of €25. All participants were Dutch and recruited through the Unravel Research panel. Participants had to be at least 18 years and right-handed. The latter criteria was included to to minimize variability in brain activity associated with handedness, as supported by prior findings (McAssey et al., 2020).

The Tilburg School of Humanities and Digital Sciences Research Ethics and Data Management Committee (REDC number: TSHD_RP203) approved the study protocols. Prior to the start of the experiment all participants read the information letter and signed the informed consent form.

2.2 Procedure

The study was conducted in the Unravel Research laboratory using a desktop computer. An overview of the procedure is illustrated in Figure 1. At the beginning of the study, participants were provided with an information letter (Appendix A) and asked to complete an informed consent form (Appendix B). Following this, participants completed three questionnaires via Qualtrics (http://www.qualtrics.com): a demographics survey, the New Environmental Paradigm (NEP; Dunlap et al., 2000) and a set of questions about each product category to determine whether they ever purchase products from that category, and thereby check consumer engagement..

Participants were seated in front of a computer screen, after which the electroencephalography (EEG) was applied. The eye tracking (ET) system was calibrated, the preparation time in total took approximately 15 minutes. Prior to the main task, a baseline trial was conducted with participants' eyes open. During this 20-second trial, participants fixated on a dot in the center of the screen and were instructed to "try to think about as little as possible".

The main task was divided in three phases: the pre-EC phase before the conditioning, the conditioning phase and the post-EC phase. During the pre- and post-EC phase, the EEG signals were recorded as participants viewed 20 product images (Pre- and Post-EC FAA). Each product was presented twice for 6 seconds, with an inter-trial interval of 1500 ms. After this phase, the conditioning phase started, during which participants were exposed to affective information about the products and their packaging via climate-related videos. These videos were either highly positive (condition 1), highly negative (condition 2), or neutral (condition 3) based on valence ratings. 15 products were assigned to one of the three conditions. Five products were paired to positive videos, five products paired to negative videos, and five products were paired with neutral videos. This means that for each participant, randomly five products were not included in the during the conditioning phase, and served as a test-retest measurement to see how fatigue induced by the experiment may change the responses.

Initially, the pairing of a product with a video was completely randomized. However, after testing with several participants, it became apparent that some found it unrealistic when similar packaging (e.g., two products in jars) were paired with videos of different valences—one positive and the other negative. To address this issue, we decided to assign the same valence (positive, negative, or neutral) to all products with similar packaging for each participant. For example, if two different jarred products were shown, both would be paired with videos of the same valence. This adjustment was made to ensure that participants could more easily remember the associations and avoid confusion, which might otherwise hinder the conditioning of the product and the video.

Each video was shown for 5 seconds, followed by a product lasting 2.5 seconds. A gray inter-slide with a fixation cross on the screen was displayed between trials, with an inter-trial interval of 3 seconds before the next product was shown. All product-video pairings were shown four times to reinforce associative learning. The presented screens during the EC phase are displayed in Figure 2. After each block of trials, participants had the option to take a break and resume the experiment when they were ready.

Once all four EC blocks were completed, the participants once again, during the post-EC phase, viewed all 20 products twice, this time without the videos. Additionally, participants were asked through a questionnaire whether they still remembered which product was associated with each video. After the experiment finished, participants were debriefed, and the EEG was removed.

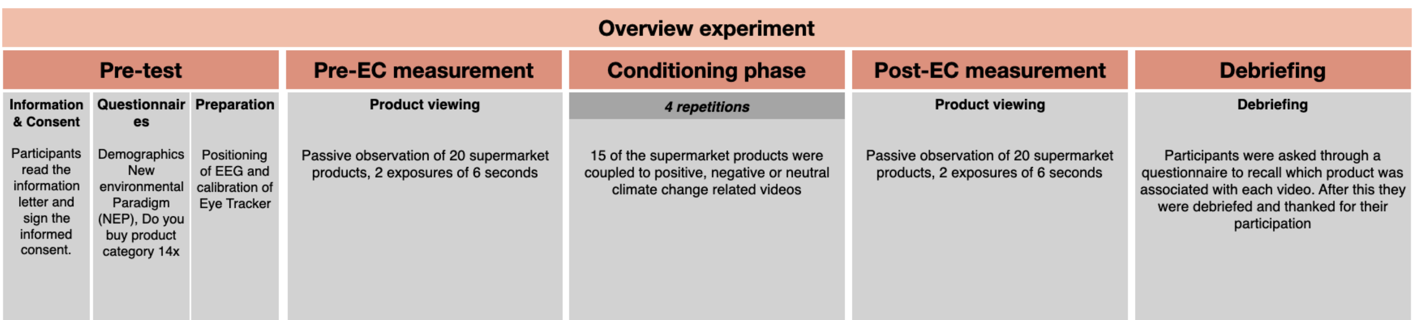

Figure 1: *Overview of the procedure of the study*

Note. Abbreviations: *NEP,* New Ecological Paradigm*; EEG,* electroencephalogram.

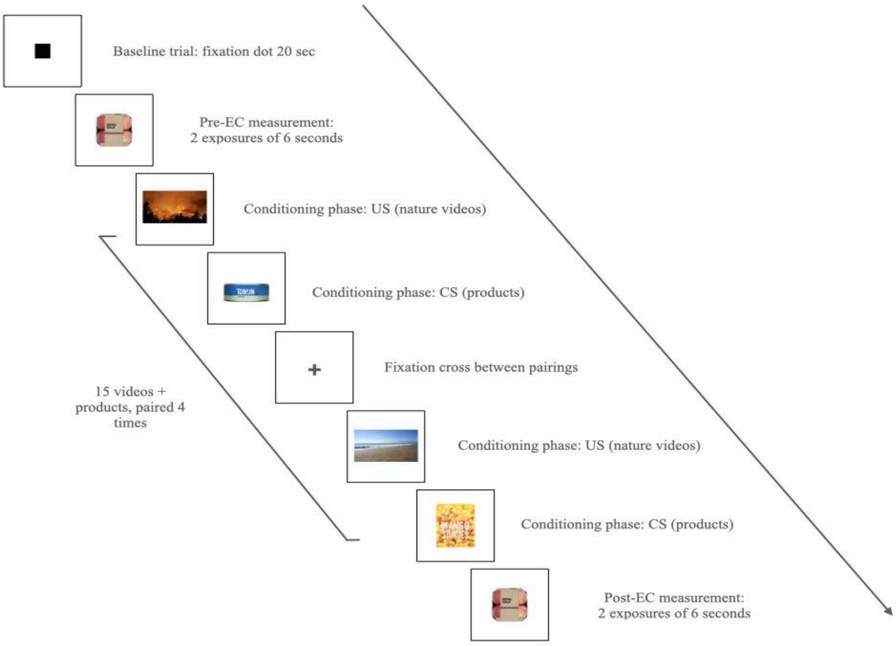

Figure 2: The presented screens during the phases of evaluative conditioning, between the pre- and post-test.
Note. Abbreviations: *US,* Unconditioned Stimulus*; CS,* Conditioned Stimulus.

2.3 Materials

2.3.1 Questionnaires

Pre-EC: The demographics survey included questions regarding participants' age and gender. Furthermore, participants filled in the NEP Scale. This scale was designed by Dunlap et al. (2000) to measure participants' environmental belief. This scale consists of 15 items, in which participants indicate their agreement with each statement by choosing one of five options on a Likert scale: strongly agree, mildly agree, unsure, mildly disagree, or strongly disagree.

Post-EC: After the conditioning phase participants were asked through a questionnaire whether they still remembered which product was associated with each video. The recall was assessed explicitly through a question at the end of the study.

2.3.2 Stimuli

Supermarket products

The supermarket products that were used during the experiment were obtained from a database created and validated by Leeuwis et al. (2024; study 1). All products were rated on (un)sustainability of their packaging. We included the stimuli that were rated to be neither unsustainable nor sustainable, indicating participants' uncertainty about their sustainability qualities, i.e. the 20 products in the middle scale. These stimuli exhibited the greatest variation in sustainability scores, making them the most likely candidates to be influenced by evaluative conditioning (Leeuwis et al., 2024; study 4). The product stimuli are shown in Figure 3. From these 20 products, 15 were randomly picked for each participant to be included in the EC.

Figure 3: Product images that were used in the study.

Climate change related videos (Pilot study)

Prior to the main experiment, we conducted a pilot study to select and validate appropriate video stimuli used in the main study. The aim of the pilot study was to create video pairs consisting of a negative climate change-related video and a positive counterpart that was contextually similar to the negative video. Additionally to the videopairs, neutral videos were selected as control stimuli. The selection of the video stimuli followed specific criteria: the videos could not contain people or text, had to be contextually related to nature or climate change, and needed to be filmed in landscape orientation with a high resolution at 1920 × 1080 pixels. Furthermore, the videos had to have minimal color and contrast editing, avoid rapid scene transitions, and preferably consist of a single continuous scene. Video stimuli were sourced from platforms such as Pexels and YouTube.

A group of 80 participants (39 Male, 37 Female, 4 Other; $M_{age} = 42.09$, $SD_{age} = 14.13$), took part in this pilot study. They rated the videos on a 9-point Likert scale assessing four dimensions valence, arousal, relevance and the extent to which each video evoked action in the participants (see Figure 4a). Additionally, participants completed a pairing task, where each negative video was presented alongside four screenshots from positive or neutral videos. Participants rated these screenshots on a 4-point scale based on visual and conceptual congruence with the negative video, identifying the best and worst positive counterpart (see Figure 4b). This pairing task aimed to identify the most appropriate counterpart matches, based on participants' evaluations. The survey was administered using Qualtrics. Participants first completed the rating task, in which they evaluated a random subset of 20 videos (out of 38) presented in a random order. Following this, they completed the pairing task, in which they rated 5 out of 9 video pairs that were included in the study. Finally, they answered demographic questions and completed the NEP questions.

For the data analysis, we compiled a table for each negative video, listing all possible positive counterparts resulting from the pairing task, and evaluated these counterparts based on the maximal difference in valence scores between the positive and negative video to identify the most suitable and emotionally differentiating match.

Based on the results, the five pairs of climate-related videos (positive vs. negative) with the highest valence difference between positive and negative were selected for the EC phase. Additionally, five neutral videos that received the most neutral valence ratings were also selected for the EC phase. The final set with screenshots of the 15 videos used in the main study is shown in Figure 5.

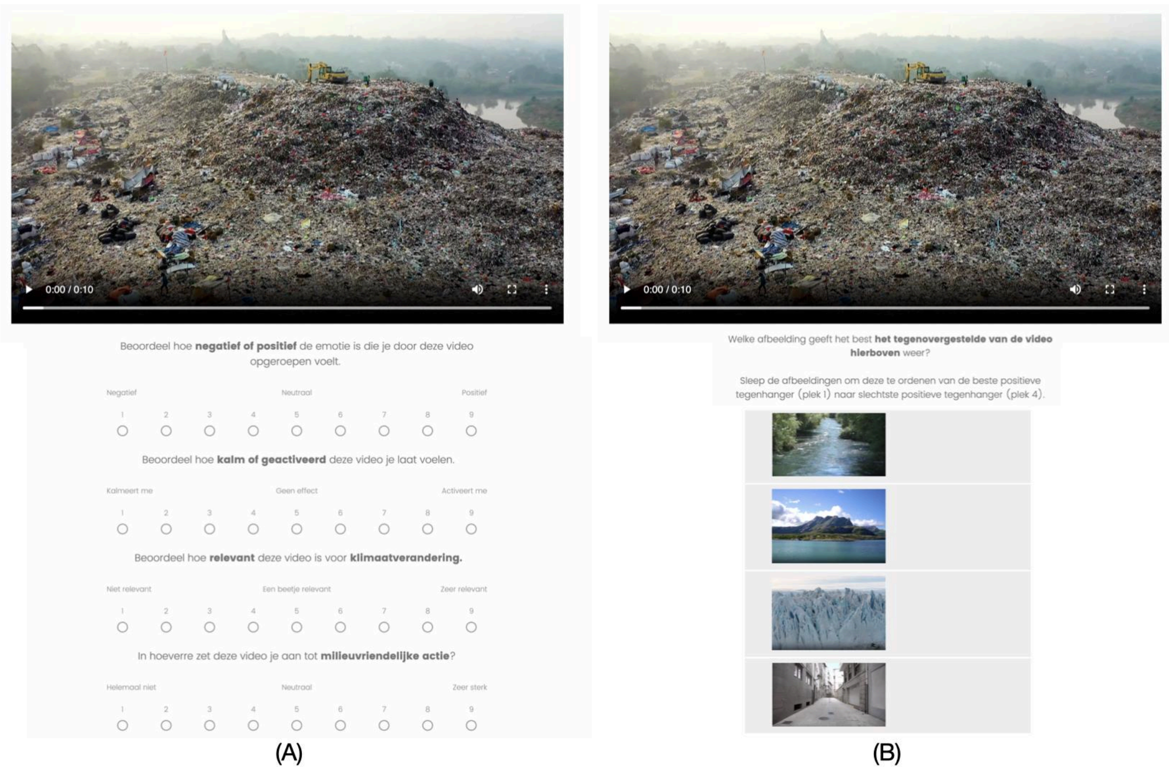

Figure 4: Examples of questions in pilot study on Climate Change-Related video

Note. (A) Example question for assessing four dimensions valence, arousal, relevance and the extent to which the video evoked action, (B) Example question for rating the screenshots on a 4-point scale based on visual and conceptual congruence with the negative video.

Figure 5: *Final set of 15 videos used in the main study*

Note. (A) The pairs of positive and negative videos that were selected from the pilot study. (B) Neutral videos used in the experiment that were selected from the pilot study.

2.3.3 Electroencephalography

We assessed the brain activity using EEG to examine responses when participants viewed supermarket products before and after the EC phase. EEG signals were recorded with the NeuroElectrics Enobio8 system, which records with a sample rate of 500 Hz at eight electrode channels positioned at various brain areas according to the 10-20 system: the frontal (Fpz, F3, F4, F7, F8), temporal (T7, T8), and occipital areas (Oz). Reference electrodes were placed on the earlobe, and Signa Gel was used to ensure conductivity between the electrodes and the scalp. EEG data were captured using iMotions software (iMotions [9.3], 2022).

2.3.4 Eye tracker (Tobii Pro X3-120)

A study by Zhao and Koch (2012) addressed the importance of including the monitoring of eye movements during a study with visual stimuli. An eye-tracker was used to verify participants' attention to the presented stimuli. This monitoring of eye movements improves the reliability of findings by ensuring that participants remain focused during the experiment. The current study used the Tobii Pro X3-120 eye tracker (Tobii AB, 2019). This eye-tracker tracked the eye movements and confirmed participants' visual engagement with the stimuli. A check was conducted to verify whether each participant maintained attention on the stimuli throughout the study by assessing whether their eyes were fixed on the stimuli displayed on the screen. For all participants whose data were used in the study, the eye tracking quality scores, obtained from iMotions, was calculated

2.4 Data analysis

The EEG data analysis started with standard preprocessing to ensure clean data. This included bandpass filtering (a zero phase-lag band-pass butterworth filter) 1 - 100 Hz, notch filtering (a zero phase-lag butterworth notch filter) 50 Hz. Stimulus-length epochs were segmented into 1-s segments with 50% overlap. Since the exposure time for each product was 6 seconds, this resulted in a maximum of 11 segments per product exposure. For artifact rejection, segments containing ocular, muscle or other artifacts were identified and removed automatically according to the following thresholds: a voltage step exceeding 30mV/ms, exceeding a maximal difference of values of 150 uV over 200ms, or activity lower than 0.5mV throughout 100ms. Segments with more than 5% missing data or a peak-to-peak amplitude over 120 µV were rejected.

The 1-second segments were tapered using a 100% Hanning-window (1s long) and subjected to a discrete Fast Fourier Transformation with a resolution of 1Hz. For two frontal electrodes in the left and right hemispheres (F3 and F4), the alpha (8-12 Hz) power was calculated per epoch using the Welch method. Segments with power values exceeding 4 standard deviations from the mean were removed. Observations were discarded when there were less than 3 1-s segments included for the exposure. The 1-second segments were tapered using a 100% Hanning-window (1s long) and subjected to a discrete Fast Fourier Transformation with a resolution of 1Hz. For two frontal electrodes in the left and right hemispheres (F3 and F4), the alpha (8-12 Hz) power was calculated per epoch using the Welch method. Segments with power values exceeding 4 standard deviations from the mean were removed. Observations were discarded when there were less than 3 1-s segments included for the exposure. In total, 131 exposures were excluded from the data, across 53 participants, each having 80 exposures (40 products pre-EC and 40 products post-EC). These excluded exposures were spread across the data of 32 participants.The obtained powers were averaged over all segments for each stimulus exposure. FAA was calculated by [$FAA=\ln(\alpha F4)-\ln(\alpha F3)$]. Finally, FAA values were averaged per participant and product exposure pre- and post-EC. Greater left frontal activity (lower alpha power in the left than in the right electrode) results in higher FAA scores, suggesting positive, approach-related emotions. Conversely, greater right frontal activity (higher alpha power in the left than in the right electrode) results in lower FAA scores, which are associated with negative, withdrawal-related emotions (Briesemeister et al., 2013; Coan & Allen, 2004; Harmon-Jones & Gable, 2018; Campbell et al., 2023).

FAA scores were analyzed using Afex ANOVA from the R package Afex (Kassambara, 2023). All assumptions of the ANOVA were tested: normality was assessed using a QQ plot and the Shapiro-Wilk test, homoscedasticity was tested with Levene's test, and Mauchly's test was used to assess sphericity. A significance level of less than 0.05 was used to determine statistical significance.

The repeated measures ANOVA was used to evaluate the impact of evaluative conditioning with three types of climate-related videos on FAA scores during exposure to supermarket products.

The first factor was conditioning type (Condition 1: positive videos, Condition 2: negative videos, Condition 3: neutral videos, Condition 4: no video). The other factor was time (pre-conditioning vs. post-conditioning). The dependent variable was the FAA score, measured while participants viewed the supermarket products.

3. Results

3.1 Descriptive statistics

The mean environmental belief, as measured by the NEP, was 3.54 (*SD* = 1.17). Scores were based on a 5-point Likert scale, where higher scores indicate stronger pro-environmental beliefs. These results suggest that the group of participants, on average, displayed moderate environmental beliefs, with some variability. This variation is particularly relevant for the study, as individuals with higher NEP scores may be more sensitive to the evaluative conditioning (EC) intervention, while those with lower scores may be less receptive to change their attitude. Furthermore, all products are purchased by at least 54% of the participants, showing consumer engagement across all 15 product categories (*M* = 75.22%, *SD* = 12.59). Further details are shown in Appendix Table 1. According to the eye tracking data, all participants included in the study paid close attention to the product images, with an average eye tracking quality score of 88.28% and a standard deviation of 18.5.

3.2 Effect of Evaluative Conditioning

In this section, we analyzed the impact of evaluative conditioning with three types of climate-related videos on FAA scores during exposure to supermarket products. The first factor was conditioning type (Condition 1: positive videos, Condition 2: negative videos, Condition 3: neutral videos, Condition 4: no video). The other factor was time (pre-conditioning vs. post-conditioning). We also analysed the interaction-effect of condition and time. The dependent variable was the FAA score, measured while participants viewed the supermarket products. Results of this analysis are displayed in Figure 6.

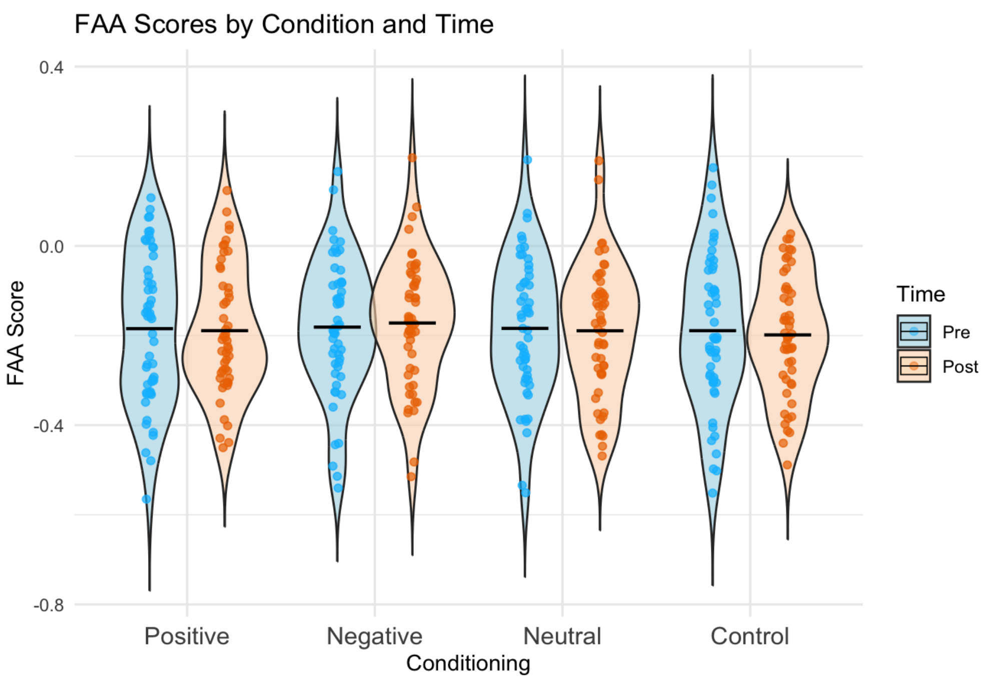

Figure 6: Violin plot showing all participants' mean FAA scores in response to 5 supermarket products, grouped by the conditions: Positive, Negative, Neutral and Control.

The effect of condition on FAA score

No significant main effect was observed for the different types of evaluative conditioning [F(3, 150) = 1.079, *p* = 0.359, η^2 = 0.03]. This indicates that there was no significant difference in FAA scores across the different conditions.

The effect of time on FAA score

For the different timepoints no significant main effect was observed [F(1,150) = 0.882, *p* = 0.352, η^2 = 0.03]. This indicates that there was no significant difference in FAA scores before and after conditioning.

The interaction effect of condition and time on FAA score

For the interaction effect of condition and time no significant main effect was observed [F(3,150) = 0.440, *p* = 0.725, η^2= 0.01]. This indicates that interaction of condition and time had no significant effect on the FAA scores.

3.3 Recall of the product-video pairings

After the EC phase, participants were asked whether they still remembered which product was associated with each video. On average, 83% of the participants were able to correctly recall the product-video pairings. The correct recall rates varied slightly across different video types, with 64.2% of the participants recalling the product-video pairings correctly for negative videos, 71.7% for positive videos, and 73.2% for neutral videos.

4. Discussion

This study investigated the potential effect of evaluative conditioning (EC) using climate-related videos on FAA scores during exposure to supermarket products. We hypothesized that EC could shift consumers' preferences toward sustainable products, with this shift reflected in FAA scores, particularly through increased left frontal activity (higher FAA scores) following exposure to both positive and negative climate-related videos. This increased activity would suggest that FAA may serve as a valuable neural indicator not only for assessing emotional responses to stimuli but also for uncovering the motivational forces driving consumer behavior. Based on our findings, we can not confirm our hypothesis.

First, we found no significant effect of conditioning type on the FAA scores, suggesting that different types of EC did not influence the FAA scores. Consequently, the hypothesis that exposure to negative and positive videos would result in higher FAA scores must be rejected. Second, there was no significant effect of time on the FAA scores, indicating that EC did not affect FAA scores over time. Lastly, we found no significant interaction effect between conditioning type and time on the FAA scores. Based on these findings, this study cannot conclude that FAA serves as a reliable neural indicator of consumer preferences, specifically in the context of supermarket product packaging.

The absence of an observed effect in FAA scores may be attributed to certain limitations in our study. One possible explanation is that participants may not have associated the product with the video they viewed. If this was the case, the video's influence would not be reflected in FAA scores when participants viewed the product images. However, when we looked at the explicit recall of the product-video pairings, an average of 83% of participants correctly remembered the pairings of the products and videos. This suggests that the coupling was successfully established through the EC. Future research could explore other methods to implicitly assess whether the coupling in the EC phase was established, such as the Implicit Association Test (IAT). Additionally, other methods could be used to examine whether the conditioning changed the participant's emotional valence and motivation associated with the product.

Another limitation of this study concerns the perceived realism of the consequences shown in the videos associated with the packaging. For instance, it is relatively plausible that a plastic package is linked to a video showing ocean pollution. However, other consequences may have been perceived as less realistic by participants. An example is the video of a koala walking through a burning forest, which might have been paired with a carton of milk. Purchasing this milk is not a direct cause of the forest fire, potentially reducing the video's impact or the perceived relevance of the pairing. Future studies could address this limitation by selecting more realistic cause-and-effect scenarios that are directly related to consumer behavior, enhancing the ecological validity of the study.

The pairing of products with videos in this study was intended to mimic a commercial. However, this approach may lack ecological validity, as the participants first viewed a climate related video and then a separate image of a product. This sequential presentation does not fully replicate the experience of a real commercial, where products are often integrated directly into the video. For future studies, incorporating the product into the video itself could enhance the realism and provide a more realistic representation of how advertisements influence consumer behavior. However, this approach presents challenges in maintaining the randomization of pairings. Namely, to achieve complete randomization of product and emotional video, a stimulus would have to be created for each possible product-video combination, incorporating all climate-change-related content, which would be a highly time-consuming and difficult process. Nevertheless, the use of Artificial Intelligence could be explored as a potential method to simplify the creation of the video stimuli and be able to maintain the randomization of pairings while at the same time maintaining ecological validity.

One additional limitation is that the number of exposures during the conditioning may not have been sufficient to stabilize the learning effect. A possible explanation is that participants were not exposed to the stimuli enough times, this could have resulted in variability in the results. Furthermore, previous studies have shown mixed findings regarding the impact of exposure times on learning effects. Hofmann et al. (2010) found no significant correlation between the number of trials and the strength of the EC effect across different measures. Similarly, other studies using EC have failed to find an effect of the number of exposures, even when varying exposure from as few as 4 to as many as 24 trials (Hu et al., 2017; Kurdi & Banaji, 2019). Future research should investigate how the number of exposures potentially influence learning effects. Longitudinal designs could also provide insights into how learning effects differ over time and whether stabilization occurs at different exposure times.

While previous research suggests that FAA may serve as a neural indicator of consumer preferences, it may be too simple to assume that a single neural metric can fully capture the complexity of such decision-making processes. Consumer preferences for sustainable products are influenced by a variety of emotional, cognitive, and contextual elements, which may not be fully captured by FAA scores alone. For example, Davidson (1992) highlighted the role of frontal asymmetry in emotional and motivational processes, but later studies have raised questions about its consistency across different contexts (Smith et al., 2016). Research by Harmon-Jones et al. (2009) suggested that FAA reflects not only emotional valence but also motivational tendencies, which are highly context-dependent. Similarly, Sabu et al. (2022) explored the validity of FAA and emphasized that its interpretation is often influenced by methodological and contextual factors, complicating its use as a standalone metric. Furthermore, Telpaz et al. (2015) demonstrated the potential of FAA to predict preferences and purchase intentions, but noted the need for additional neural measures to fully understand consumer behavior. These inconsistencies in past findings, along with the results of the current study, highlight the ongoing challenges in interpreting FAA as a reliable indicator of preferences for sustainable products in supermarket contexts.

To our knowledge, this is one of the first studies to link FAA scores to the effects of EC. Therefore, the findings cannot be directly compared to previous studies, highlighting the need for further research into the neural effects of EC. Future studies should investigate whether frontal regions are part of a broader neural network involved in processing emotional valence and motivation during EC. Understanding this network's role could provide deeper insights into how EC influences pro-environmental behavior (PEB) and consumer preferences. Such research would give insight into whether FAA serves as a distinct neural marker or functions within a more complex brain system driving these behaviors.

In conclusion, this study contributes to the understanding of how to promote PEB and helps to design more effective strategies for encouraging behavior change in the context of climate change. While the findings did not confirm a direct link between EC and changes in FAA scores, the study highlights important considerations for future research into the neural mechanisms underlying consumer preferences. The results emphasize the complexity of using FAA as a standalone neural indicator, suggesting that frontal regions are part of a broader neural network involved in processing emotional valence and motivation.

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6. GenAI Disclosure Statement

During the process of writing my thesis and collecting the data, I used GenAI tools to help with various aspects of my work. GenAI really supported me during the process, I think it improved the overall quality of my thesis.

Identifying relevant literature

To perform my literature review at the start of my research, I used GenAI tools to help identify appropriate academic sources. I combined these tools with other search engines such as Google Scholar and PubMed, this resulted in a clear overview of the existing literature.

Improving my writing

To improve my academic writing I used GenAI tools to refine my text. During the writing I used it for the overall structure, clarity and coherence of the text. But also for more specific tips on improving the sentence structure, and grammar checking.

Enhancing my R code for data analysis

During the data analysis phase, I used GenAI tools to improve my R code. These tools came up with suggestions for optimizing the code, and gave solutions for errors that occurred. Thereby, making my analysis more efficient and accurate.

By using GenAI in these aspects of my thesis, I was able to improve the quality of my thesis while still maintaining a thoughtful and critical view to its use and suggestions.

7. Appendix A Information Letter

Information letter

General information

Title: Change in affective responses after informative videos

Principal Investigator: Nikki Leeuwis, nikki@unravelresearch.com

Co-investigator: Tom van Bommel, tom@unravelresearch.com

Co-investigator: Dr. Maryam Alimardani, m.alimardani@tilburguniversity.edu

Introduction

Thank you for signing up for neuro-research at Unravel Research. We're a neuromarketing company where we investigate implicit reactions to communications. This experiment is carried out in collaboration with Tilburg University. In this message you will find everything you need to know to be well prepared to come to our living room lab (Burgemeester Reigerstraat 78 Utrecht). Before you can participate in this research, you will sign a consent form in which you agree to participate and confirm that you have read the information in this document. So please read this carefully to know what the study entails.

Purpose of the study

The purpose of this research project is to understand responses to product images and how information about climate change coupled to these products might change these responses. To evaluate these effects, we will measure your brain activity and eye movements. In this way, we can see what attracts attention and what parts are perceived as positive or negative. You will also be asked some questions about your demographics, buying behavior and environmental attitudes. In this way, we aim to understand the attitudes and behavior regarding (un)sustainable product decisions.

Study procedure

When you have signed the informed consent, you can proceed to the experiment. You will complete a questionnaire about your current shopping behavior before you participate in the EEG study. An EEG is a device that uses electronic signals from your brain to tell when something is difficult, fun or confusing. We cannot read your thoughts or send thoughts into your head, we only look at a very low level if you process the stimulus to be confusing, attractive or cognitively complicated. Setting up the EEG takes some time: sometimes it can take up to half an hour.

If the EEG is fitted properly and eye tracking is sufficiently calibrated, the examination will begin. In this experiment, product images will be coupled to positive or negative videos of climate change. Please note that these do not reflect in any way a truthful connection. The researcher will further explain what to expect before the experiment starts. You can ask the researcher for help at any time by using the bell in the lab. When you have finished, the researcher will remove the EEG from your head and explain something more about the research. Sometime after your participation in the experiment, a second questionnaire will be sent. The incentive will be transferred within two weeks after the termination of the experiment.

All of your data will be pseudonymized, which means that your name will be detached from the datafile. The informed consent is the only link between your name and the pseudonym used in the datafile. This document will be separately stored in a locked safe that is only accessible by the researcher of the experiment. The pseudonym under which we store your data is only traceable to your name by the researcher.

Duration of the experiment

The study should take you around 60-120 minutes to complete. You will receive monetary incentive accordingly (€20 per hour).

Conditions and Risks

You are expected to be at least 18 years of age and to provide consent for

participation. Participation in this experiment does not deliver any direct disadvantages. The data derived during this experiment might contribute to an enhanced understanding of human behavior in regard to (un)sustainable choices. The physiological sensors used in this study are non-invasive, and tasks are not considered to cause any deception. Other than gender and age, you will not be expected to answer any demographical questions. Additionally, we will collect your general environmental attitude and health consciousness using a questionnaire. In the future, we might re-use pseudonymized data for research, however this will not be traceable to you. Data will be encrypted and stored for 10 years.

Confidentiality and Privacy

Your identity will be kept strictly confidential. Once all data is collected and your responses evaluated, all documents will be pseudonymized and there will be no way of personally identifying your data in any reports of the completed study. The pseudonymous data will be archived on DataVerse, which is a data storing platform supported by Tilburg University where data can be made available to future researchers with permission. There are no constraints in sharing of the data. The data and results of this experiment are jointly owned by Tilburg University and Unravel Research, the company Nikki Leeuwis works for. Both parties (TiU and Unravel) agree that the data are managed by Nikki Leeuwis and she will manage access over the dataset.

Voluntary Participation

Your participation in this research is voluntary. You have the right to decline to participate and withdraw from the research at any moment, without any negative consequences, and without providing any explanation. You have the right, in principle, to request access to and rectification, erasure, restriction of or object to the processing of the personal data until the moment that data is definitely pseudononymized (three weeks after the end of the study). For more information: www.tilburguniversity.edu/privacy.

Contact Information

This study has been approved by the TSHD Research Ethics and Data Management Committee. If you have any questions or want further information concerning this study, please contact the Principal Investigator, Nikki Leeuwis (nikki@unravelreseach.com).

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the “Research Ethics and Data Management Committee” of Tilburg School of Humanities and Digital Sciences via tshd.redc@tilburguniversity.edu.

Consent

It is assumed that if you participate in this experiment, you have provided consent to participate. However, you have the right to refuse to participate or to withdraw your participation at any time by simply closing the survey. In the next page, you will sign the "informed consent form". You may print this consent form to have a copy for your records. Please do not hesitate to ask any questions you may have before signing this form.

8. Appendix B Informed Consent Form

By signing this form, you acknowledge that:

- You have read and understood the information sheet.
- Your participation in the study is voluntary.
- You are aware that you may choose to withdraw from the study at any time without providing a reason.
- You are 18 years of age or older.
- You are informed about any potential benefits and risks associated with participation in the experiment.
- You give us permission to process your anonymized data.
- You give us permission to process your physiological data (EEG and/or GSR and/or heart rate).
- You give us permission to process data related to Eye Tracking (eye movements).
- You give us permission to store the collected data for a period of ten years.
- You agree that all collected data (in anonymized form) may be shared with other researchers.

9. Appendix C Consumer Engagement Rate

Percentage of Respondents Who Buy Each Product	
Product	Percentage
Apple	92.45%
Beer	84.91%
Croissant	69.81%
Baguette	88.68%
Tuna	69.81%
Avocado	84.91%
Walnuts	66.04%
Blueberries	67.92%
Wraps	88.68%
Milk	75.47%
Chickpeas	62.26%
Mango	66.04%
Pineapple	54.72%
Eggs	96.23%
Fruit Juice	60.38%

Table 1*:* Percentage of participants that indicate to purchase the different product types in the supermarket.