Chapter

Multicriteria Algorithm for Multisensory Food Analysis

Alexandre Magno da Rocha Vianna

Abstract

Observation of the multisensory experience using fMRI, EEG and analysis of users' responses using Fuzzy logic. The tabulation of these data aims to verify the responses and quantify them for comparison with a personal opinion survey using the SAATY scale and apply in general terms (opinion response and neural response) in other users belonging to the same group of people. Based on the data and processes of the described applications, a sensory mapping of the observer and verification of "patterns in neurophysiological processes" can be performed with a verbal response, in addition to allowing the understanding of the importance of these patterns for the selection of an option.

Keywords: multisensory, neurodesign, neuroscience, food

1. Introduction

This research is a continuous process of studies started in 2016 at UFRJ under the guidance of Dr. Paulo de Oliveira Reis through LabFuzzy. The proposal deals with the use of neuroscientific technologies to analyze and identify multisensory analogues that can improve the users' experience in the design process. An analysis of how human cognitive processes (related to the acquisition of information such as: learning, attention, memory, language, reasoning, decision making, etc.) linked to people's behavior has been analyzed and applied for some decades. A good example is given by Simon [1], when studying the human cognitive processes linked to decision making. This field was developed and branched out into the decision process linked to the marketing processes.

Subsequently, psychologists Khaneman and Tversky [2, 3] developed the Prospect Theory, demonstrating a profit and loss perspective model and the cognitive impact related to this event, which demonstrated that people tend to value much more avoiding losses than generating gains. An important milestone along this path occurred in 1980, when the first full-body magnetic resonance imaging (MRI) occurred in Scotland, a major advance compared to X-rays. In the middle of the following decade, functional magnetic resonance imaging (fMRI) recorded, for the first time, images of the brain in activity, during and after stimuli, showing the activation of the regions involved in certain tasks without the need to use ionizing radiation and exogenous contrast. Like traditional MRI devices. This model brings a new perspective in the view of consumption that, from the 90's, is widely treated in marketing processes. Lindstrom [4] through research on thousands of brains, analyzed a large part of the processes related to attractiveness and consumption behavior.

This chapter proposes the use of multidisciplinary concepts and tools between Creative Economy, Neuroscience, Mathematics and design for the observation of multisensory experience. The author of this chapter [5] enters this universe through the Design of furniture for offshore ships, where in addition to the functional character the internal environments need to attend to the psychological of the employees who remain there for months. Colors, shapes, spaces, art, everything has to be thought with a view to physical and emotional health. From that moment on (2006), a methodology for designing products and images with a focus on the user experience starts to be constructed through multisensory analogs, that is, information sensorialized by the observers that arouse certain reactions and that can be applied to the 5 senses. This methodology was used in the industrial sector and in micro and small companies (healthy food, PET, drinks, food, etc.) and patterns that can be recognized and mapped to generate certain reactions in the consumer were observed. As of 2017, with the acquisition of fMRI and EEG software and equipment, the Fuzzy Logic started to be used to quantify the mapped responses that started to be studied and tested in applications related to food and beverages.

Presentation of the techniques used for research in this chapter:

- Functional magnetic resonance (fMRI) analysis mentioned above,

- Electroencephalogram (EEG): used to record the electrical activity of the brain that is diagnosed by means of neural oscillations or brain waves, beta, alpha, theta and zeta.

- Hormonal dosage of saliva: just as the blood test can identify hormones and other elements, the analysis of saliva focuses on those present at the time of collection).

Other techniques can be used in data collection such as: Galvanic skin conductance (SCR), Skin temperature analysis by infrared thermography (ING), Heart rate (HVR), Facial expression recognition (FER), Implicit association test (IAT), retina mapping (eye tracking) and other less common.

For the research to be presented, techniques such as functional magnetic resonance analysis (fMRI), electroencephalogram (EEG), hormonal dosage of saliva were used, in addition to other techniques such as focus group and SAATY scale. The objective is to search the data for neurophysiological patterns that can generate a division between satisfactory and unsatisfactory neurobehaviors, that is, unfavorable reactions occur when data is presented and favorable reactions occur in the same way. The construction of these favorable or satisfactory reactions can be applied widely (a city, a public space, an enclosed space) or in very small areas (an environment, an object, a product, a service experience or even physical) or digital image). The point in question is the result that must be designed so that the user has an intended experience and keeps it in his memory. This analysis will be done using the techniques obtained above to identify in users, areas of the brain that have been stimulated and to identify these patterns, to be determined in each element of the project.

To understand what this observer seeks, it is necessary to go through the motivation theorists: Freud [6], Maslow [7] and Herzberg [8] who explain the subjectivity of human thought and how it correlates with social cycles and their own experience with what is observed, generating "satisfactory and unsatisfactory" profiles, rationalizing their environment and their sensorializations. Freud develops his thinking about the subjectivity of human choices, through his literatures: The unconscious, which traces a trajectory of ideas of the subjective factors of our choices. This thought was addressed with the example of "motivation for choosing an object" that occurs due to factors such as color, weight, size, texture, shape, etc. which are linked to the interpretation of each of these details through subjective memory, as well as the "object as a whole", as well as, all "emotional charge" contained in its interpretation in our past and its relationship with the present moment.

Maslow in his work "Motivation and Personality" describes the "Hierarchy of needs" which is widely known as the "Maslow's Pyramid". According to him, the individual feels the desire to satisfy his needs, according to the stage or level. Therefore, the motivation to fulfill these wishes comes gradually, generating a certain predictability of needs and desires according to several sociodemographic (age, income, geographic area, etc.) and behavioral (ambitious, heavy users, etc.) factors as well as in the cycle of life of a person or group of individuals. Herzberg, talks about the "2-factor theory" that defends the idea that there are satisfactory and unsatisfactory motivators in the work environment and that it is used in marketing management Kotler [3] for the marketing universe interpreting these concepts for products, services, people, environments, etc. From there, it is necessary to understand what makes the observer have a pleasant experience and enter the universe of experience design. The one by Csikszentmihalyi [9] brings in his works about Flow (concept defined as the great experience, or the psychology of the great experience, is linked to the challenge and reward zones of the brain and related to learning) the aspects that are related to the experience engaging and charming enough to pass the time and even forget some of the most basic needs like eating. To reach this level of immersion, Norman's work [10] and his concepts on design bring terms to specify levels of experience of the observer that go beyond the visceral or subconscious level, to the reflective level, but this reflection is based on their habits, which in turn, is at the behavioral and instinctual level, which is basically the automatic and subjective area linked to our experience. An individual's experience contains memories and emotional charges linked to the result of similar previous situations and which, in turn, are the result of our emotions Krippendorff [11].

The projected emotions will be mainly in search of the observer's pleasure and satisfaction as ways to reach the state of Flow and in this context the pleasures of Jordan 4 [12] relate aspects of functionality and usability to these states. The author assumes that pleasures are the result of the hedonic and practical emotional benefits associated with a product and that needs related to the usability of that product can be satisfied in 4 forms of pleasure (physiological pleasure, social pleasure, psychological pleasure and ideological pleasure). These authors reflect the concepts and tools for the investigation and manifestation of multisensory experiences. Another literature such as Logic Fuzzy Tanaka [13] is needed to measure the observer's reaction to the possibilities. In Fuzzy Logic, a multiple-value chain can be generated in which the logical values of the variables can be any real number between 0, corresponding to the false value, and 1, corresponding to the true value, for example. In contrast, in Boolean logic, the logical values of variables can be just 0 and 1, a or b, etc. this means that there are several possibilities between true and false and these possibilities can be found and determined if they correspond to the analyzed objective with the greatest probability, possibility and or plausibility. In this way, measurable variables can be found and an analysis system designed to measure these experiences created Ross [14]. One should not only take into account the tabulation of these data, but obtain them to measure the reaction of the observer and verify through the emotional dimensions of Carter [15] the impact that will provide for them to reach a certain objective, be it to obtain better performances or simply for entertainment.

It works like this, people determine verbally when asked about a particular experience or random information, but the verbal response does not always represent the cognitive response. In addition to the truth, there are exaggerations, minimizations and lies. This happens for several reasons and more often than we imagine Feldman [16]. However, by analyzing the cognitive response by means of Functional Magnetic Resonance (fMRI), Electroencephalogram (EEG), hormonal dosage of saliva and other previously necessary techniques, it can be verified if certain areas of the brain have been affected and what is the biological response. For example, when smelling a food being made on the spot, the olfactory cortex in the temporal lobe will be stimulated and information will be sent to areas such as the frontal lobe cortex (association with similar previous experiences), limbic system of the diencephalon (Memory) and response through neural peptides available in the hippocampus Silverthorn [17]. Other areas can be stimulated and hormones such as ghrelin for example, also known as "hunger hormone", are a peptide produced mainly by epsilon cells in food and by the pancreas when on an empty stomach, which then acts on the lateral hypothalamus and in the arched nucleus, generating a sensation of hunger. These areas of the brain can be observed by means of magnetic resonance in conjunction with specific areas (nucleus accumbens, geniculate body and certain areas of the visual cortex) making it possible to observe the option for a particular dish in a restaurant, in addition to determining the intensity of these reactions through EEG (stress, engagement, interest, excitement, focus and relaxation). One can go further, and check the levels of Ghrelin, Serotonins and Dopamines (through the analysis of saliva), understanding the levels of hormones and peptides Dispenza [18], responsible for hunger, pleasure and well-being. It can be measured against a quantity when you see, taste, touch, smell, etc. in each of the restaurant's dish options, following the previous example. When determining the preference standards of the tested group (which should represent consumers and target customers through personas, for example), it is possible to select a better menu, presentation of dishes, images for campaigns, restaurant environment, employee uniform, memorabilia and etc.

The complexity of the new consumer market requires an investigative method that clearly demonstrates how to design experiences for a group, capable of generating a positive impact, focusing on the necessary elements and increasing performance, minimizing unnecessary and incorrectly applied costs. The application of an investigative method linked to the relationship between the public and a medium or product is related to the sociocultural profile of these people in the sense that their parameters of relationship with the external world and interpretations of this world come from the knowledge acquired throughout life, where a large part of their cognitive stimuli and co-relationships happen through the environment where they live and relate daily.

1.1 Stages of development

Phase 1. Qualitative Research: The generation of personas is necessary to define a group that can represent the general public.

Phase 2. Explanatory research (cause and effect): The processes of attention, retention and memory, occur in different areas of the brain and transmit information to the body through hormones and peptides that are used as a basis to measure whether the data obtained in the experiment is positive or negative (EEG, fMRI and saliva analysis).

Phase 3. Experimental Research. Observation of the user's brain during the experiment.

2. Experiences

The experiences presented below were evolutions and variations of this methodology in the area of food. Because it is a sector that can awaken the 5 sensory channels, even though the 3 main ones are vision, smell and taste. The first test was developed using the image of 3 foods (as we can see in **Figures 1**–**3**), where a more juicy image was presented (**Figures 1** and **2**) and even an image with desaturated and manipulated foods to look unpleasant (**Figure 3**). The objective of having 3 such different variations, was to verify if the neural and verbal response coincided in options that seemed to be practically unanimous and if the result of the algorithm would follow this path, **Figure 1** was selected as the most tasty and **Figure 3** the least tasty as we expected.

Subsequently, 3 hamburger options were tested (**Figures 4**–**6**) this time, the test was to understand whether the launch of a new hamburger option with reference to the artisanal hamburger trend in Brazil (**Figure 6**) would be accepted among the more consolidated options on the market (**Figures 4** and **5**). This time, the acceptance of the new option was rejected by the participants in the verbal analysis (**Figure 8**), but an interesting feature was observed in the EEG analysis (**Figure 7**). According to the software data, the level of "interest" in the participants increased when this option was presented, which led me to invite them to a focus group to try to understand this discrepancy between verbal and neural analysis. The response of the participants in most cases was that they had an interest in trying the option in

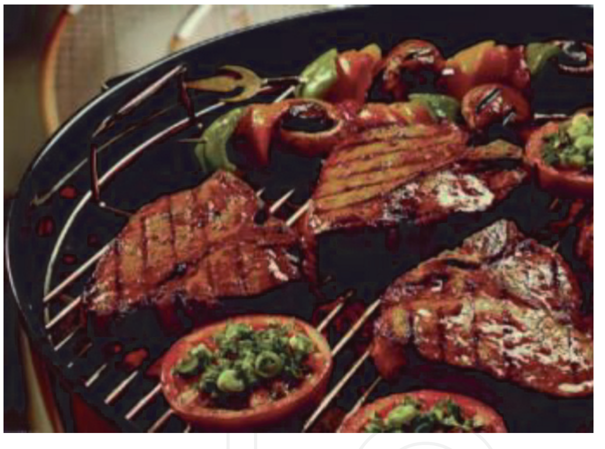

Figure 1.
Image of barbecue with grilled fruits.

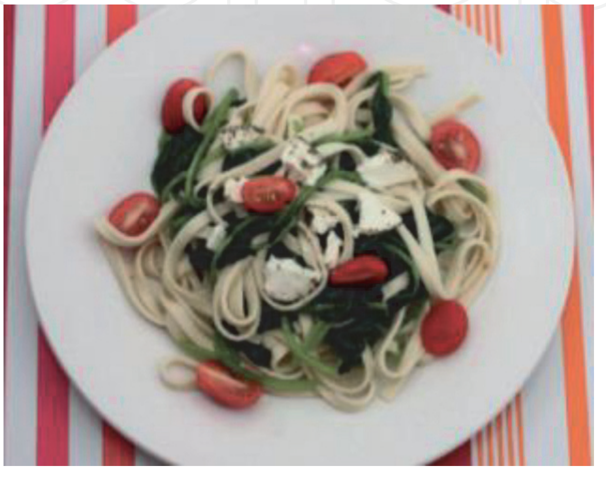

Figure 2.
Pasta with fruits.

Figure 3.
Plate of fruits, fungi, sausage and bacon with sauce (with manipulation of the saturation of the colors to look disgusting).

Figure 4.
Hamburguer A.

Figure 5.
Hamburguer B.

Figure 6, but they were not willing to "pay" for that option, the options in **Figures 4** and **5** being better known, that is, even in no information has ever been given on option values, whether there would be any payment, etc., the participants' response had a direct connection with the fact that they preferred to stick to traditional options rather than try a new one (taking into account automatically) the financial factor and the fact that they prefer to stick to already known tasty options

Figure 6.
Hamburguer C.

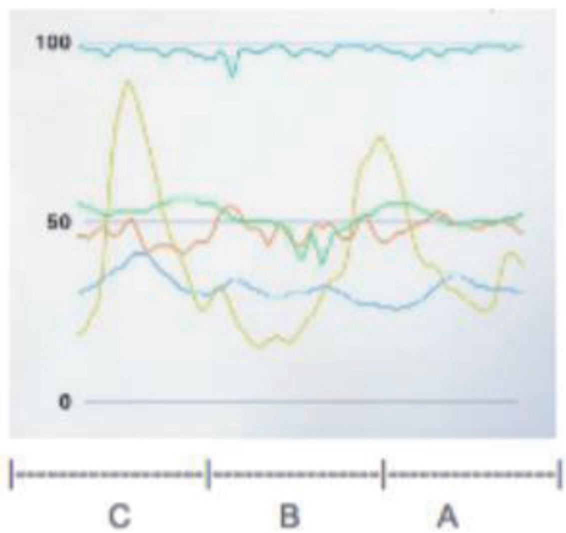

Figure 7.
EEG Interest is the yellow wave.

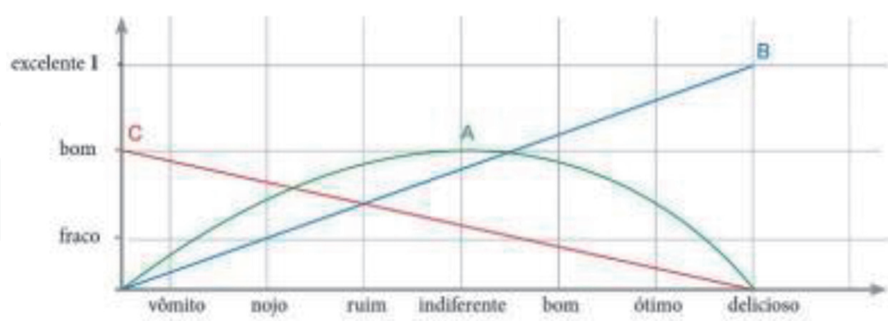

Figure 8.
Although the waves show high interest in options C and A, the verbal chart portrays them as the worst options.

than to take a chance on a new flavor that is likely not to be as tasty, according to Prospect theory).

The following analysis (**Figures 9–11**) was performed without the hormonal dosage of saliva, however, EEG analyzes were introduced in a more protagonist way. This decision was made in order to better observe the experience because it is understood that when it comes to food, when eating a salad or a chocolate, most of the stimulated areas observed through the fMRI equipment are the same. But the preference for the second option (chocolate) is probably greater in most people,

Figure 9.
Analysis site of coffee samples.

Figure 10.
Sample A.

Figure 11.
Sample B.

simply because the brain prefers more fatty foods due to its high energy consumption (it consumes approximately 20% of the energy produced by the body). Therefore, the analysis of waves and neural frequencies, as well as the attributes presented by the EEG software, are faster to interpret. In addition to this facilitation, it is possible to compare the results verified by the fMRI images (brain waves are represented in different colors, with 1 color for each frequency - **Figure 15**). Another way of comparing the 3 techniques presented (fMRI, EEG and hormonal dosage of saliva) is precisely through the hormones found during the experiments, as well as their quantity. The hormones, wave frequencies and analysis of the EEG software, demonstrate differently the possible emotional states of the participants and can be compared with each other.

2.1 Analyzed areas

Lateral geniculate body and prefrontal cortex: attraction for appearance. The appearance of food is more important than taste in many cases, even when food is prepared with the same ingredients and cooking methods. When we see something we shouldn't be eating, the brain sends an alarm. You can be fooled by stimuli of the smell of good food and the sound of frying, for example, which stimulate the production of ghrelin.

Accumbens Core: Food generates dopamines and serotonins and the tastier the better (our brain tends to prefer foods with more fat). It is related to pleasure.

Olfactory cortex: smell is one of the oldest senses and its stimulus is received in the olfactory bulb that directs the stimulus to the olfactory cortex, limbic system, motor cortex and others.

Visual cortex: related memory and visual processing.

Prefrontal cortex: related to planning complex behaviors and thoughts, expression of personality, decision making and modulation of social behavior.

2.2 Personas selection

In the case of a complex analysis, the cut used so far is that of qualitative research, seeking to analyze a series of people who can represent the target audience with quality. An adopted methodology uses a method of crossing supply and demand matrices Cosenza [19] to identify the distances between the different product alternatives in meeting the needs of its customers according to the profile demanded by them.

2.3 Phase identification (coffee experience)

- Personas. Selection.
- People who represent personas (**Figures 9–18**).
- Subscription.
- Sensory scale (linguistic variables and neural response).
- Multicriteria algorithm for sensory analysis. fMRI and EEG. SAATY scale for verbal response (1, 2, 3, 4, 5, 7, 9).
- Observation of the impacted area.
- Fuzzification and defuzzification of results (normative maximization).
- Answer 1: Selection of the option.
- Answer 2: evaluation of the experience at a rational and emotional level.

Figure 12.
Sample C.

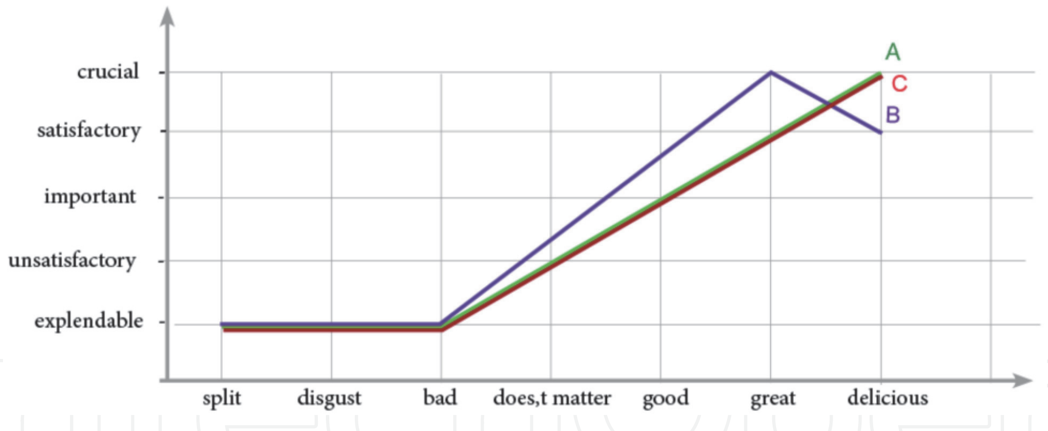

Figure 13.
Verbal Response graph, Sample A, B and C.

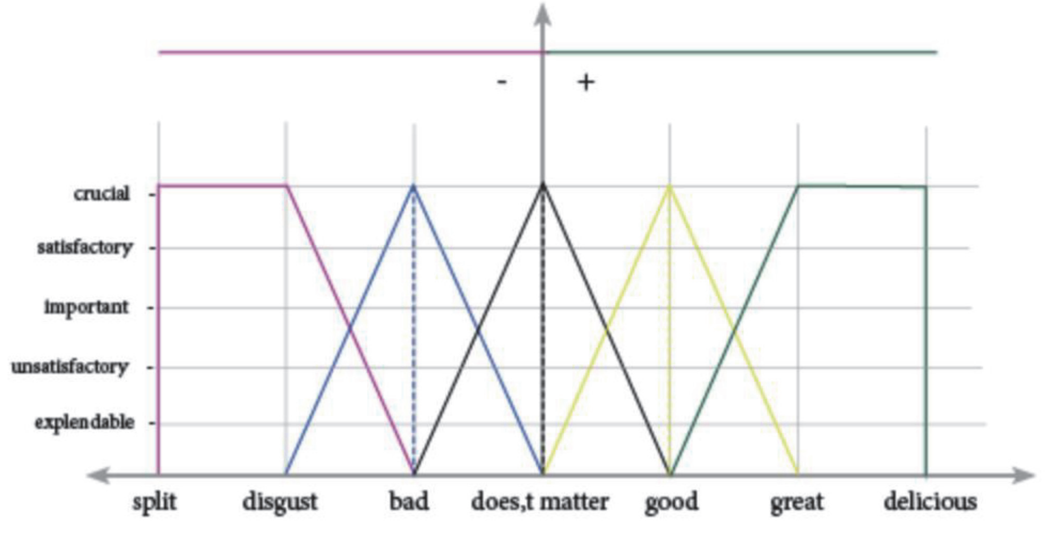

Figure 14.
Verbal Attributes description fuzzy matrix.

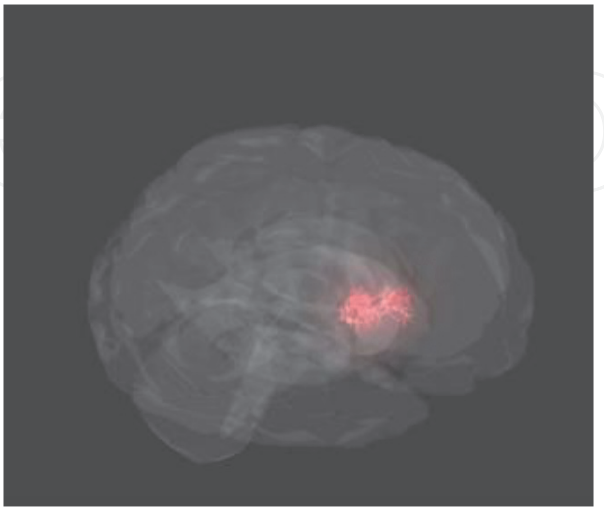

Figure 15.
fMRI.

Step 1: Preparation of the drink. Sensory analysis was performed using 3 coffee samples. For the preparation, a conventional home coffee maker was used. The coffee samples were prepared using coffee and mineral water. Each infusion was

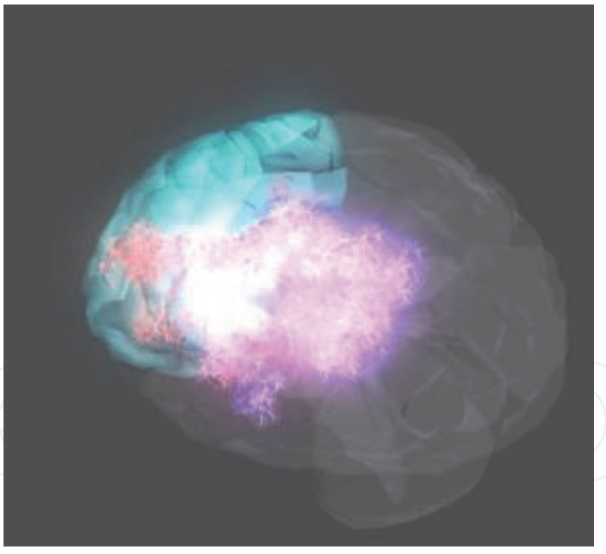

Figure 16.
fMRI area.

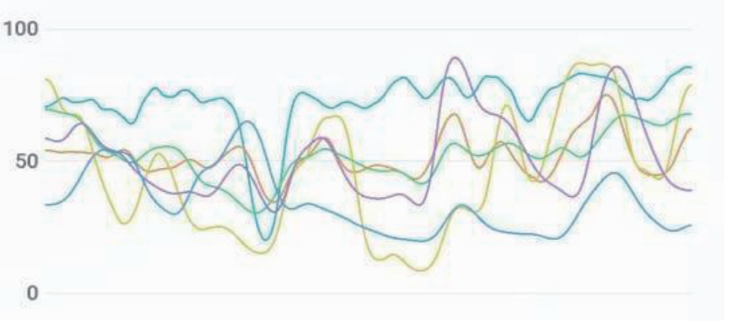

Figure 17.
EEG image.

Figure 18.
EEG results.

prepared with a maximum of 500 mL of each sample and stored in thermos, remaining in place for a maximum of 90 minutes. The evaluation for aroma and flavor was made using 30 mL of each coffee sample served in transparent cups at an average temperature of 60 °C without the addition of sucrose. Between each sample, participants were served water at room temperature to wash the taste buds. Appearance was assessed using the conventional presentation (transparent cups and saucers) and transparency exists so that participants can see the color and texture of the drink. Visibility and light conditions of a common night in ambient lighting. For this experience, the environment used was an open area with room temperature and filming and protection equipment (mask, alcohol gel and gloves, in addition to receiving 1 person at a time in intervals of 3 to 4 hours between each participant to clean the place) The alone are served 2 times each, so that in each one the data of EEG + scale of SAATY and fMRI + saliva are collected.

Step 2: The equipment will be placed on the user and the user will taste the coffee and rate each sample using the SAATY scale, while the EEG data is generated. For measurement, the EPOC + equipment from the company Emotiv and the EEG software EmotivPro were used, which in addition to presenting the data for each frequency, generates the interpretation of these signals as stress, focus, motivation, engagement, relaxation, interest and excitement (**Figures 17** and **18**).

Step 3: The user will try it a second time, while the fRMI analysis is done. For measurement, the EPOC + equipment from Emotiv and the fMRI software BrainViz were used. During the test, 6 samples were taken from each user. Before drinking coffee, after the first sip and after the end of each cup. The saliva analyzes were stored to be sent to the laboratory.

Step 4: Movies and photos of people were stored in HD and cloud, as well as films from fMRI and EEG. Gel alcohol, masks and gloves were available at all times for participants with an isolated disposal site of at least 3 m.

Step 5: The linguistic terms of the SAATY scale (2.4 results) were developed and approved by food professionals such as restaurant owners, buffets, cheffs, housewives who cook for their families and even by a purchasing chef in a large chain. Supermarkets in the state of Rio de Janeiro in Brazil. The fMRI analyzes were made by the author with the cutout presented in brain response to food [20] and after adaptation, presented to specialists in neuroscience and consumer psychology at USP and UNIFESP for validation. EEG analyzes are taken from the software. The traditional EEG reading presents the frequencies in real time, however the software presents a reading (patented by the manufacturer) through the frequencies that generates responses of: interest, motivation, stress, engagement, focus and excitement.

Step 6: The data collected through fMRI, EEG and hormonal dosage in saliva are inserted in Matrix 2: Brain and hormones. The fMRI data is collected by analyzing the video of the brain at a speed of 30 frames per second, counting the moments of stimulus of the areas: Lateral Geniculate Body, Visual Cortex, Nucleus Accumbens, Olfactory Cortex, Frontal Cortex and standardized to be on a scale from 0 to 100, as is the answer presented by the EEG software. Inserted in the matrices, the data is processed through the algorithm created for this project and receives a final score (2.4.3 Verbal Analysis × Neural Analysis).

Step 7: Comparative analysis. After analyzing the samples of each participant, we have the verbal and neural score for each sample. These notes are compared in order to understand the preferred option of the participants in an individual and general way.

Step 8: Conclusion interview. After the analysis and conclusions, the participants of the experiment are invited to an interview where the variables involved and the preferences of the group are debated to verify points that influence the preference and which responses generate these variables. As we could see in the hamburger experiment (**Figures 4–6**), some answers can be contradictory, but this was not the case for this third experiment with the 3 coffee samples.

2.4 Results

The attributes selected for the option selection:

- Spit: Any reaction linked to the exclusion of food from the mouth;
- Disgust: I don't even want to try it;

- Bad;
- Indifferent: it is not bad, but it is also not good;
- Good: satisfied with the taste;
- Great - satisfied with the taste, he would eat again;
- Delicious - delicious.

2.4.1 Sensorial scale of verbal attributes

Before interpreting the data, a classification vector was constructed using the sets below (Dispensable: 1 to 3; Unsatisfactory: 3 to 4; Important: 4 to 5; Satisfactory: 5 to 7 and Crucial: 7 to 9). Where the attributes for grades 1 to 9 of the verbal scale (SAATY) are developed.

Set 1: Dispensable
if 1 < or = x, then u (x) = 1
if 2 < ou = x < ou = 3, then u (x) = − x + 3

Set 2: Unsatisfactory
if 2 < ou = x < ou = 3, then u (x) = x - 2
if 3 < ou = x < ou = 4, then u (x) = − x + 4

Set 3: Important
if 3 < ou = x < ou = 4, then u (x) = x - 3
if 4 < ou = x < ou = 5, then u (x) = − x + 5

Set 4: Satisfactory
if 4 < ou = x < ou = 5, then u (x) = x - 4
if 5 < ou = x < ou = 7, then u (x) = − x + 7

Set 5: Crucial
if 5 < ou = x < ou = 7, then u (x) = x - 7
if 7 < ou = x < ou = 9, then u (x) = 1

At the same time that the participant responds verbally, his brain is analyzed in fMRI, checking if the areas responsible for the feeding process, such as salivation, digestion and etc. are stimulated, and for how long the stimulus occurs in each area. To measure whether the participant's interest, involvement, excitement, focus, relaxation and stress, EEG equipment was used. Some of these states are linked to the production of hormones such as serotonin, endorphins and dopamines, among others, which are related to pleasure. These data generate an interference model to establish the criteria of the Fuzzy set of pertinence and can be crossed to generate a score for each experience with each coffee, which can be measured and compared.

In the table below, we can identify the sensation (column sensations) according to the linguistic terms (2.4 Results). The grades for each sample A, B and C are presented in the respective columns and the importance for the objective is applied by the researcher according to the sets above (which represent each grade).

The notes in **Table 1** are represented in the graph below (**Figure 13**). The graph in **Figure 14** represents the description of the Fuzzy Matrix, between the "linguistic terms" and the importance for the objective.

Sensations	Sample A	Sample B	Sample C	Importance for the objective
Split	1	1	1	Dispensable
Disgust	2	2	2	Dispensable
Bad	3	3	3	Dispensable
Doesn't matter	4	4	4	Unsatisfactory
Good	5	5	5	Important
Great	7	9	7	Satisfactory/crucial/satisfactory
Delicious	9	7	9	Crucial/satisfactory/crucial
Linguistic terms of importance for the objective: dispensable, unsatisfactory, important, satisfactory and crucial.				

Table 1.
Verbal scale.

2.4.2 Sensorial scale of neural attributes

To interpret the neural matrix data, a new classification "Vector" is required, this time between 0 and 100, which was represented by the sets below (Dispensable: 10 to 30; Unsatisfactory: 30 to 40; Important: 40 to 50; Satisfactory: 50 to 70 and Crucial: 70 to 90 or greater). Where the attributes for the notes analyzed through the fMRI are developed (where we check 30 images per second to define how long each stimulus takes place, as well as making mathematical adjustments for quantification (each sample was tasted for 1 min, therefore, having the same time interval of each sample and the time in which each area was stimulated, we can interpret this data as a number between 0 and 100 that will fit perfectly in the neural matrix and in the Vector for interpretation of the algorithm (**Table 2**).

Set 1: Dispensable (g) = 10
c (g) = x

Set 2: Dispensable (g) = 20
10 < n < or = 20, n (g) = x + 10

Set 3: Dispensable (g) = 30
20 < r < or = 30, n (g) = x + 20

Set 4: Unsatisfactory (g) = 40
30 < i < ou = 40, n (g) = x + 30

Set 5: Important (g) = 50
40 < b < ou = 50, n (g) = x + 40

Set 6: Satisfactory (g) = 70
50 < o < ou = 70, n (g) = x + 50

Set 7: Crucial (g) = 90
70 < d < ou = 90, n (g) = x + 7

Stimuli	Sample A	Sample B	Sample C	Importance for the objective
Lateral geniculate body	76	86	64	Satisfactory/satisfactory/important
Visual cortex	52	80	58	Important/satisfactory/important
Nucleus accumbens	90	80	88	Crucial/satisfactory/satisfactory
Olfactory cortex	71	86	70	Satisfactory/satisfactory/satisfactory
Frontal cortex	76	80	76	Satisfactory/satisfactory/satisfactory

Stimuli	Sample A	Sample B	Sample C	Importance for the objective
Stress	51	51	43	Important/important/unsatisfactory
Excitement	45	36	22	Unsatisfactory/dispensable/dispensable
Engagement	71	73	77	Satisfactory/satisfactory/satisfactory
Focus	52	48	34	Important/unsatisfactory/dispensable
Interest	51	55	65	Important/important/important
Relaxation	34	31	30	Dispensable/dispensable/dispensable

Linguistic terms of importance for the objective: dispensable, unsatisfactory, important, satisfactory and crucial.

Table 2.
Neural stimuli.

The notes for stress, excitement, engagement, focus, interest and relaxation stimuli are interpreted and sent by the software. Below in **Figures 15** and **16**, we can see the fMRI images and the areas stimulated with different frequencies (**Figure 16**). In **Figure 17**, we can analyze the EEG data during the process of the experiment with one of the coffee samples, thus being able to understand peaks and falls of the stimuli, as well as identify what happened in the experiment that may have been responsible for the changes in the graph. **Figure 18** shows the results of the EEG software, it can be seen that the colors of each attribute are represented in the graph of **Figure 17**.

In **Figure 19**, we can see the graph of the Neural response and its interpretation is very similar to the graph in **Figure 13**, where the terms of importance for the objective are on the vertical axis and the stimulated areas, as well as the EEG attributes are positioned to give us a visual representation of the difference between samples for one participant.

2.4.3 Verbal analysis × neural analysis

The standardization of notes through vectors and the importance for the objective, aims to transform the numbers on a scale, where the largest number is the most pertinent, that is, the higher the number found in the analysis of the algorithm, the greater the relevance of that one. Sample regarding the participant's preference for the sample.

Sample A
Verbal = 1.4474 | Verbal Analysis Winner
Neural = 1.9886

Sample B
Verbal = 1.4447
Neural = 2.0515 | Neural Analysis Winner

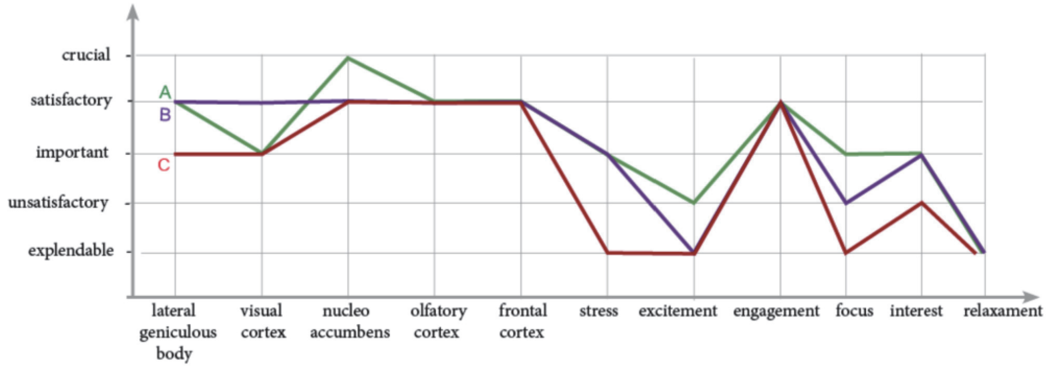

Figure 19.
Neural response graph, sample A, B and C.

Sample C
Verbal = 1.4447
Neural = 1.9834

2.4.4 Comparison between samples

Sample A | Verbal / Neural
(1.4474 + 1.9886) / 2 = 1.7178

Sample B | Verbal / Neural
(1.4447 + 2.0515) / 2 = 1.7481 | Winner of Verbal / Neural Analysis

Sample C | Verbal / Neural
(1.4447 + 1.9834) / 2 = 1.7140

3. Conclusion

A tie can be observed if verbal analysis is considered, but neural analysis showed preference for Sample B. For one more test, the average between the verbal/neural scores of each sample was made in order to be able to compare them to each other, giving Sample B the winner again. Considering previous experiences and those scheduled for the coming years, the multicriteria algorithm is developed according to the number of linguistic terms, areas to be analyzed and the number of participants. The linguistic terms vary according to the segment (food, perfumes, etc.) and experts must always be used so that the terminology reproduces the objectives of the experiment. In this case, the verbal scale was discussed and approved by professionals from different areas related to food and beverages, such as restaurant chefs, sommeliers, food and beverage entrepreneurs, as well as empirical specialists (people who cook for home or small businesses) and professional of a supermarket chain in Brazil. The neural matrix was built based on models and studies by CARNELL S. and Emotiv's EEG software.

3.1 Future reviews

This same data can be used to analyze peaks and falls individually and to understand what factors can be determined by these effects. Analysis of each element of a layout, product or service such as colors, images, typography, packaging, internal and external experience, etc. Thus, the same experience can be analyzed at satisfactory and unsatisfactory peak times, identifying them and using the information both to avoid unsatisfactory, and to praise and build their offers and experiences based on the observer's satisfaction, both for a product/service and for an environment/experience.

Author details

Alexandre Magno da Rocha Vianna
DNAhub Neurodesign, Rio de Janeiro, RJ, Brasil

*Address all correspondence to: alexandre@dna-neurodesign.com

References

[1] Simon H 1975, Prx00EA;mio Turing da ACM, juntamente com Allen Newell, pelas suas "contribuix00E7;x00F5;es bx00E1;sicas x00E0; Inteligx00EA;ncia Artificial, x00E0; Psicologia de Cognix00E7;x00E3;o Humana, e ao processamento de listas".

[2] Kahneman D, Tversky. Prospect Theory: An Analysis Of Decision Under Risk. Econometrica, Vol. 47, No. 2. 1979, pp. 263x2013;291. DOI: 10.2307/1914185

[3] Kotler P, Keller K, Administrax00E7;x00E3;o de Marketing. New Jersey: Pearson Prentice Hall. 2012, 12a ed.

[4] Lindstrom M. A Lx00F3;gica do consumo, 2016. Brasil: Harper Collins. ISBN-10: 8595082669

[5] Alexandre Magno da Rocha Vianna. Multicriteria Algorithms for Multisensory Design. Human Interaction, Emerging Technologies and Future Applications III. IHIET 2020. Advances in Intelligent Systems and Computing, vol 1253. Springer, Cham. DOI: 10.1007/978-3-030-55307-4_12

[6] Freud S 1915, The Unconscious, (Rio de Janeiro: Imago) vol 1, 98-136p; 1915.

[7] Maslow A H. Motivation and Personality. 1970, Nova Iorque: Editora Harper x0026; Row, Publishers. ISBN 0-06-041987-3

[8] Herzberg F, Mausner B, Snyderman B. The motivation to work. Transaction Publishers. New Brunswick (USA) and London (UK). Reprint Routledge, 2017. ISBN 1351504428, 9781351504423.

[9] Csikszentmihaly L's 1. Flow. The Psychology of Optimal Experience. HarperCollins Publishers, Inc 1996

[10] Norman D. Emotional Design: Why We Love Or Hate Everyday Things. 2005, New York: Basic Books.

[11] Krippendorff K 2004, Intrinsic Motivation and Human-Centered Design. Pennsylvania: University of Pennsylvania, Departamental Papers ASC. 10.1080/1463922031000086717

[12] Jordan P. Designing Pleasurable Products. Cleveland: CRC Press, 2000. ISBN-10: 0415298873

[13] Tanaka K 2003, Introdux00E7;x00E3;o aos conjuntos nebulosos. Tradux00E7;x00E3;o de Osvaldo R. Saavedra (GSP-DEE x2013;UFMA). DOI: 10.1002/3527601821.

[14] Ross T. Fuzzy Logic With Engineering Applications. 2010, Wiley: John Wiley x0026; Sons 3rd Edition. DOI: 10.1002/9781119994374

[15] Carter Rita. Mapping the mind. Edited by Cambridge University, 2000

[16] Robert S. Feldman, James A. Forrest x0026; Benjamin R. Happ (2002) Self-Presentation and Verbal Deception: Do Self-Presenters Lie More?, Basic and Applied Social Psychology, 24:2, 163x2013;170. DOI: 10.1207/S15324834BASP2402_8

[17] Silverthorn D U. Fisiologia Humana, uma abordagem Integrada 5x00B0; Ed. 2010.

[18] Dispenza J. Evolving your brain and the science of creating personal reality. 2007. ISBN-10: 0x2013;7573-97789

[19] Cosenza C A N. Toledo O M. Um caso de aplicax00E7;x00E3;o da Lx00F3;gica Fuzzy x2013; o Modelo Coppe-Cosenza de Hierarquia Fuzzy. XXIII Encontro Nac. de Eng. de Produx00E7;x00E3;o - Ouro Preto, MG, Brasil, ENEGEP 2003.

[20] CARNELL, Susan. SCHUR, Ellen. What Twin Studies Tell Us About Brain Responses to Food Cues. 2017.