Contributions of Functional Magnetic Resonance Imaging in Market Research: Obstacles and Perspectives

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CONTRIBUTIONS OF FUNCTIONAL MAGNETIC RESONANCE IMAGING IN MARKET RESEARCH: OBSTACLES AND PERSPECTIVES

DOPRINOSI SNIMANJA FUNKCIONALNOM MAGNETSKOM REZONANCIJOM ISTRAŽIVANJU TRŽIŠTA: PREPREKE I PERSPEKTIVE

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Abstract

Purpose – The purpose of this research is to determine the way functional magnetic resonance imaging (fMRI), as a research tool in neuromarketing, is used and to analyze important elements of conducting such research, as well as defining all relevant terms regarding neuromarketing and consumer neuroscience.

Design/Methodology/Approach – The research study focused on conducting an fMRI experiment, using the observation method, survey, and interview methods.

Findings and implications – By analyzing all steps in the fMRI experiment procedure and determining how to conduct fMRI research, obstacles in this kind of research were identified to establish what needs to be overcome for proceeding with further studies.

Limitations – Numerous limitations included lack of adequate equipment and software, huge administrative barriers, and finding experts capable of conducting this kind of research.

Sažetak

Svrha – Svrha je istraživanja utvrditi način korištenja funkcionalne magnetske rezonancije (fMRI) kao istraživačkog alata u neuromarketingu te analizirati sve važne elemente njegove provedbe, kao i definirati sve relevantne pojmove vezane uz neuromarketing i neuroznanost potrošača.

Metodološki pristup – Istraživanje je usmjereno na provođenje fMRI eksperimenta pa su korištene metode promatranja, anketnog ispitivanja i intervjuiranja.

Rezultati i implikacije – Analiziranjem svih koraka u provođenju fMRI eksperimenta i određivanjem načina na koji se provodi fMRI istraživanje definirane su prepreke te je utvrđeno što treba prevladati za nastavak daljnjih istraživanja.

Ograničenja – Brojna ograničenja uključivala su nedostatak adekvatne opreme i softvera, ogromne administrativne barijere te pronalazak stručnjaka osposobljenih za provođenje ovakve vrste istraživanja.

Originality – This research study combined the topics of sensory marketing, neuromarketing, and social marketing. Furthermore, it contributes to clearing the path for this kind of research approach in the future, representing a new trend that is here to stay.

Keywords – neuromarketing, consumer neuroscience, fMRI, social marketing, sensory marketing

Doprinos – Istraživanje je kombiniralo teme osjetilnoga marketinga, neuromarketinga i društvenoga marketinga. Nadalje, istraživanje doprinosi raščišćavanju putova za ovakvu vrstu pristupa istraživanju u budućnosti kao novom trendu koji dolazi.

Ključne riječi – neuromarketing, neuroznanost potrošača, fMRI, društveni marketing, osjetilni marketing

1. INTRODUCTION

In social sciences, researchers are facing a problem of gathering exact answers to defined research questions. Now, for the first time in marketing research and given technological advancements, it is possible to get insights into individuals' reactions so precisely as never before. It is about – neuromarketing. The relationship between marketing and psychology is already present in marketing research (Grbac & Lončarić, 2010) and is now being upgraded with links to neuroscience, so neuromarketing can be defined as a sub-area of neuroeconomics that implies the use of methods originally applied in brain research aiming to analyze problems relevant to marketing (Hubert & Kenning, 2008). As Camerer, Loewenstein, and Prelec (2004) described literally, the basis of neuroeconomics (including neuromarketing) can be explained by the phraseme "ask the brain, not the person." Furthermore, the Neuromarketing Science and Business Association [NMSBA] (n.d.a) gave the following neuromarketing description: "unlocking answers without asking." This kind of research approach contributes to shedding light on so-called "black box" of an individual, which always triggers the researchers' interest. Nevertheless, it is very important to stress that this manner of conducting research is extremely complex and the statements, such as finding the "buy button" (e.g., Morin, 2011), should be approached with caution. Firstly, this construct is not in accordance with the marketing concept of business activity because the main marketing goal is to help and contribute to matching products to people (Ariely & Berns, 2010). Secondly, it is about studying something amazing and extraordinary – human brain, which should not be downgraded just like that.

A more detailed analysis explains two close terms: "neuromarketing" and "consumer neuroscience" (Ramsøy, 2014; Hubert & Kenning, 2008). "Consumer neuroscience" implies scientific proceedings and ascertaining of neurophysiological responses of an individual during the decision-making process concerning market transactions. The term "neuromarketing" is relevant to managerial practice and commercial use of neuroscience technologies and knowledge, namely, to the use of these insights in marketing activities on the market. Although the term "consumer neuroscience" translated into different languages may sound a bit unusual, it is very important to deal with this issue and, as Ozretić Došen (2015) does, propose the usage of valid terms with a proper explanation of the distinction between them.

Regarding the development of technology, and in the context of neuromarketing, there are different tools for conducting brain scans. This research study focuses on functional magnetic resonance imaging [fMRI]. The possibilities of this tool for gathering insights inspired the authors to conduct fMRI research and explore new research opportunities.

As noted by Plassmann Venkatraman, Huettel, and Yoon (2015), this field of consumer neuroscience is evolving and with a critical mass of academicians focusing on the goal of conducting this kind of research and disseminating the results, it is expected for "this community to thrive as the field moves forward." Accordingly, it is important to keep up with its findings and prepare the ground for conducting this kind of research to analyze how it works in practice. Thus, the purpose of this research study is to determine the way in which fMRI, as a research tool in neuromarketing, is used and to analyze all the important elements of conducting fMRI experiments, stressing the obstacles that hamper this process. The paper contribution lies in clearing the path for this kind of research approach and overcoming the obstacles blocking it.

Two guiding ideas were followed in the research. The first one was the use of findings to be implemented into the segment of social marketing – particularly education. The second one was inspired by the idea of obtaining knowledge about individuals' reactions (which are difficult to express in words) to specific (mu-

sic and sscent) stimuli. Different stimuli in the environment can provide different reactions in individuals (e.g., the Mehrabian-Russell model explaining that physical surroundings will elicit individual's willingness to interact with or avoid the surroundings) (Donovan & Rossiter, 1982; Kos Koklič, 2019; Vieira, 2013). Therefore, music and scent were analyzed in the context of education, owing to their possible beneficial effects on individuals' alertness and, consequently, on their better following of and participation in lectures. Hence, the paper is focused on: (1) neuromarketing – specifically, the fMRI as a tool of research, (2) social marketing – contributing to education, and (3) sensory marketing – focusing on auditory and olfactory stimuli.

With regard to the methodology applied, besides the analysis of new marketing research methods relating to conducting the fMRI experiment, traditional methods were also used: observation method, as well as survey and interview methods.

The paper consists of five parts. The first one is introduction, followed by theoretical background, in which characteristics of neuromarketing and fMRI are explained. Field research, including field research preconditions, methodology, and findings constitute the central part. Discussion and limitations are presented next. The paper closes with a conclusion and future research propositions.

2. THEORETICAL BACKGROUND

2.1. The neuromarketing concept

The relationship between marketing and psychology is already present in marketing research (Grbac & Lončarić, 2010) and has been upgraded with links to neuroscience (Hubert & Kenning, 2008; Ariely & Berns, 2010). This type of research enhances traditional research methods and provides a better understanding of cognitive processes and affective responses of an individual, namely, the manner in which individuals make decisions (Gountas, Gountas, Ciorciari & Sharma, 2019; Camerer et al., 2004). It provides findings about consumer behavior in a new way and enables analysis of subconscious responses. According to NMSBA (n.d.a), neuromarketing uses neuroscience and studies brain and biometric responses and behavior to reveal subconscious decision-making process, as well as to understand the manner in which consumers think and feel.

It ensures avoiding the problems that researchers encounter in traditional marketing research, such as getting incorrect participants' answers about their preferences because of unawareness of their actual motives and needs or as a result of willing sabotage of researchers' questions (Ariely & Berns, 2010; Marušić & Vranešević, 2001). Hence, neuromarketing implies analyzing and understanding individual behavior in the marketing context, based on the utilization of neuroscience research methods (Hubert & Kenning, 2008; Lee, Broderick & Chamberlain, 2007). As summarized by Lee and others (2007), this field of study could be defined as the use of neuroscientific methods for analyzing and understanding human behavior related to markets and marketing exchanges. The application of neuroscience is one of contemporary key innovations in marketing research which is expected to develop further in the coming years (Ratchford, 2020), making this field worthy of exploration.

As Bechara and Damasio (2005) explain, neurobiological mechanisms underlie market behaviors, indicating that emotions play a key role in the interaction between environmental conditions and decision-making and confirming that the decision-making process is not only logical (as in an ideal model of perfectly rational *homo economicus*) but is also influenced (consciously or unconsciously) by emotions. Hence, many decisions are made on an unconscious level (Ariely, 2009), making many economic research studies more demanding.

The same idea has been emphasized by Kahneman (2013), explaining two systems of

thinking: the fast one – automatic and effortless, and the slow one – focused on complex mental activities and reasoned choices. In the context of dual processing theories and neural imaging, Evans and Stanovich (2013) analyzed decision-making and found that prefrontal and frontal cortical brain regions are involved in a slow processing of mental simulation of future possibilities (hypothetical thinking and considering different problem-solving options), while the limbic system is involved in taking fast, immediate decisions.

Furthermore, this kind of research approach can be beneficial in terms of analyzing individual attention or reactions to stimuli that occur in the environment. In that respect, it is important to explain the so-called bottom-up or exogenous attention, which refers to the situation in which individual attention is "caught" by a stimulus from the environment (unlike the top-down or endogenous attention, which refers to voluntarily aiming attention to search for the stimuli/information with some specific characteristics of interest and resulting from the explicit decision of an individual on where to focus the attention) (Venkatraman et al., 2015; Ciaramelli, Grady & Moscovitch, 2008; Behrmann, Geng & Shomestein, 2004).

Hence, consumer neuroscience can be helpful in the exploration of sensory stimuli and finding out how individuals react to them. Sensory creation of a product brand implies a process that begins with an individual gathering information obtained by all five senses, based on which feelings are created; this is followed by experiences, resulting, finally, in the emergence of an experience related to a product/business entity (Pavlek, 2008). Hulten, Broweus, and van Dijk (2009) explain sensory marketing as a "firm's ability to accomplish a supreme sensory experience with a strategic direction, attracting as many of the human senses as possible" and by focusing on five human senses creating an experience.

Based on that, it is possible to conclude that sensory information is processed mostly via bottom-up processing (Cerf & Garcia-Garcia, 2017) and with the aim of determining individual reactions to specific stimuli. This kind of "ask brain, not person" approach (Camerer et al., 2004) methods could be beneficial in unlocking the answers.

Nowadays, technology provides astonishing possibilities to gain a better understanding of individuals. Some of the tools used by researchers are: functional magnetic resonance imaging, functional near-infrared spectroscopy, electroencephalography, magnetoencephalography, eye-tracking, measurement of physiological responses, face reading, and response time measures (Zurawicki, 2010; Fairchild, Aronowitz, Langleben & Wang, 2018). The positron emission tomography [PET] is also mentioned, but as PET studies include exposure to ionizing radiation (Fairchild et al., 2018) by using fluorodeoxyglucose (glucose molecule artificially attached to an atom of radioactive fluor) (Zurawicki, 2010), this kind of studies should be considered inappropriate if conducted for marketing research purposes.

In addition to ethical issues concerning the use of specific tools, the following general ethical issues should be emphasized. The basis for neuromarketing research has to include primarily the marketing concept of business activity, meaning an orientation on the needs of actual consumers with a view to perceiving and defining marketing as the process of creating the value which customers need (Grbac, 2012). In other words, the main purpose of neuromarketing research should be a better understanding of individuals in the process of decision-making, value creation, and value exchange. Each researcher is responsible for conducting research in line with the highest ethical standards, ensuring that the research with all its reported details is transparent and that all safety standards, protocols, and consent procedures are followed (ICC/ESOMAR, 2016; ESOMAR, 2011; NMSBA Code of Ethics, n.d.b).

2.2. Principles of functional magnetic resonance imaging research

Magnetic resonance is a radiological non-invasive method of imaging that enables a multi-

planar review of the body without exposing an individual to ionizing radiation (Fučkan, 2012a). Magnetic resonance imaging [MRI] uses strong magnetic fields to create images of biological tissue (Huettel, Song & McCarthy, 2009). Studies of the brain structure represent the basis for most of the knowledge about the brain, but structural studies imply barriers preventing the detection of short-term physiological changes. These barriers may be overcome through functional neuroimaging studies by detecting different parts in the brain in which particular mental processes appear and by defining the patterns of brain activation associated with these processes (Huettel et al., 2009). The use of fMRI enables reading out particular physiological process and can be described as an indirect disclose of metabolic brain activity (Pavić & Radoš, 2005). Thus, activation of the particular brain area can be localized very precisely (Posner, 2010; Dimoka, 2012).

The principle of fMRI operating is grounded on the monitoring of blood flow in the brain tissue. This is connected with the so-called Blood Oxygen Level Dependant imaging [BOLD] (Pavić & Radoš, 2005). The principle based on which BOLD imaging operates is that neuronal activation in a specific brain region occurs owing to a specific stimulus. As neurons are activated, oxygen-enriched blood runs towards the activated brain region (Prelec, 2008). Hemoglobin is the transporter of oxygen in red blood cells; oxygenated hemoglobin is diamagnetic (having the characteristics of week repulsion from a magnetic field), while deoxygenated hemoglobin is paramagnetic (having the characteristics of being attracted to a magnetic field, although less so than ferromagnetic objects are). Hemoglobin saturated with oxygen moves towards the activated brain part to a greater extent than "common" blood flow in the brain regions that are not activated by neuronal stimulation. As a result, in the "activated" part of the brain, oxygenated hemoglobin increases and displaces the deoxygenated hemoglobin that was suppressing the MR signal intensity, so BOLD contrast occurs (Huttel et al., 2009). Therefore, fMRI provides excellent insights into the deepest brain structures and individuals' reactions; on the other hand, tasks in fMRI experiments should be simplified and repeated several times to reveal brain reactions.

2.3. Neuromarketing research practices

Based on the fMRI method of research, neuromarketing experiments have raised numerous questions regarding human reactions to different stimuli and decision-making to be analyzed and discussed. Thus, research focuses on (1) using fMRI in neuromarketing research, (2) contribution to social marketing, and (3) using specific stimuli (auditory and olfactory) to elicit a response.

Firstly, motivation and great inspiration for focusing on the use of fMRI was one of the most impressive avenues of research on wine preferences conducted by Plassmann, O'Doherty, Shiv, and Rangel (2008). Their research revealed that participants enjoyed the taste of wine which the information provided to them described as expensive more than that which, according to the information provided to them, is cheaper even though the information referred to the same wine. While this kind of result was expected, brain scan results were stunning. Researchers ascertained that if the information on wine price changes, the activation of the brain regions involved in taste perception (primary taste areas) does not change (when the same type of wine is concerned). However, changes occurred in medial orbitofrontal cortex activation, based on which the researchers concluded that the wine taste was more pleasurable when obtaining information that the wine is more expensive. This constitutes actual proof of how the information obtained changes personal experience. In a way, brain deceived itself (Prelec, 2008), raising numerous questions related to human thinking, reactions, and decision-making. It may apply even more broadly, for instance, to the analysis of the placebo effect in terms of various characteristics of the product and its environment, influencing

perception of the product (Shiv, Carmon & Ariely, 2005; Plassmann & Weber, 2015).

By using fMRI in marketing research for the first time, it is possible to "see" the process of consumer purchasing decisions. Knutson et al. (2007) identified neural circuits that predict purchase, determining that activation of the brain region called *nucleus accumbens* (a part of the limbic system linked to the responses to rewards and gains) reveals customer preferences for the product. Also, when an excessive product price is shown to the participants, insula (the brain region linked, among others, to human response to losses) is activated. This is related to the so-called "pain of paying" phenomena (Prelec & Loewenstein, 1998; Prelec & Simester, 2001). Finally, Knutson, Rick, Wimmer, Prelec, and Loewenstein (2007) determined that the medial prefrontal cortex (a region responsible for conscious appraisal of whether a particular offer is favorable for an individual or not, which is implicated in gains and losses) is activated prior to the purchase decision if a reduced product price is shown and, conversely, deactivated in the case of an excessive product price.

Secondly, the research focus directs neuromarketing research towards the social marketing segment. This segment relates to the application of marketing with the aim of achieving social goals and influencing changes in society by directing public behavior towards generally accepted principles, thus providing welfare to all members of society (Meler, 2003). As regards social marketing, Drapko (2014) emphasizes that social campaigns are selling ideas with the final goal of reshaping the attitude of individuals. Neuromarketing fMRI research in this segment can be directed at creating food labels that promote healthy choices to reduce obesity (Grabenhorst, Schulte, Maderwald & Brand, 2013; Ng, Stice, Yokum & Bohon, 2011) or determining the impact of anti-smoking health warnings on individuals (Liu, O'Donnell & Falk, 2020; Fairchild et al., 2018). Regarding social marketing within this research, the motivation lies in the fact that science, connecting cognitive research and neuroimaging techniques, can also help education (Willis, 2010) that could be more correlated with individuals' needs and wants.

The third area of the research interest concerns sensory aspects of marketing. Sensory aspect implies creating an offer in which, besides visual elements, product is enriched by auditory, olfactory, tactile and, where possible, gustatory elements (Pavlek, 2008; Hasse & Wiedmann, 2018). Krishna (2012) defines sensory marketing as efforts in marketing engaging consumers' senses based on which their perception, judgment, and behavior are affected. Although analyses of environmental stimuli (e.g., temperature, music and sounds, scent, furniture and its arrangement, signs, symbols, decoration style) that affect individual's physiological, emotional and cognitive responses, go back to a long time ago (Bitner, 1992; Donovan & Rossiter, 1982), contemporary neuromarketing methods provide new insights into the stated responses. Different elements regarding stimuli from the environment, such as visual (Stillman, Lee, Deng, Rap Unnava & Fujita, 2020; Stoll, Baecke & Kenning, 2008), auditory (Mostafa, 2012; Plailly, Tillmann & Royet, 2007), olfactory (Plailly et al., 2007; Hertz, Eliassen, Beland & Souza, 2004), gustatory (Okamoto & Dan, 2013), and tactile stimuli (Stilla & Sathian, 2008), even in an online environment (Liu et al., 2020), are analyzed by fMRI research. An individual's perception of the environment frequently occurs at an unconscious level (De Luca & Botelho, 2019), so fMRI enables deep brain structure analysis and differentiating conscious from unconscious processes (Reimann, Schilke, Weber, Neuhaus & Zaichkowsky, 2011). Hence, as emphasized by Petit, Velasco, Cheok, and Spence (2015), consumers evaluate experiences through their senses and neuroimaging tools should be used to get better insights into this process.

3. FIELD RESEARCH

3.1. Preconditions

The main precondition for putting the idea of conducting an fMRI experiment into prac-

tice was to provide the tool for it, i.e., an fMRI scanner. This proved to be a problem because Croatian universities lacked the equipment and specialized laboratories for conducting such research. After analyzing possible options, collaboration between a Croatian university's faculty of economics and business and a private polyclinic was established.

In addition to the equipment, suitable software also had to be provided. Functional imaging is dynamic, meaning that it can "catch" metabolic activity of specific brain regions in response to specific stimuli. With the help from experts in the field of electrical engineering and information technology, the appropriate software was installed to ensure BOLD imaging.[1] As this kind of research requires collaboration of experts from different disciplines, an interdisciplinary team was formed including experts with the economic (marketing) background, medical experts, and experts in electrical engineering and information technology.

Meanwhile, participants were selected and prepared for the experiment. They were students at a Croatian faculty of economics and business. Most of them were interested in marketing research topics, with some actually involved in the activities of the Marketing Department at the faculty in question. Potential participants were interviewed and acquainted with research characteristics, based on which they were to decide on participation in the experiment. All interviewed participants except one, who did not feel comfortable in the MRI environment, opted to participate in the experiment.

The participants were given the *Informed Consent* document, including all details (of which some explained the research objective and purpose, participants' role in the research, assurance of anonymity) and by signing it, they confirmed that they were willing to participate in the experiment. Also, the participants were provided with information on the *MRI Consent Form* explaining the conditions that prevent the participants from undergoing the scan (e.g., metals within body, claustrophobia). As noted by Dimoka (2012), these conditions include certain medical history and use of psychotropic medications. Additionally, the participants were given a note on tattoos and makeup, due to the content of metals and graphite particles in the colors being used, which may cause local tissue heating (Fučkan, 2012a). Finally, the participants were warned not to drink coffee or energetic beverages and not to smoke before undergoing experiment. Furthermore, because of the lateralization of brain function and brain responses to certain stimuli, it is important to know whether the participants are right- or left-handed. The commonly used test for this is based on the Edinburgh Handedness Scale (Oldfield, 1971; Brainmapping, n.d.). Willems, Van der Haegen, Fisher, and Francks (2014) stressed that a more homogeneous sample would provide better results because of smaller variances between the subjects, as well as an increase in statistical sensitivity, but also pointed to the need for including lefthanded participants in studies.

Furthermore, administrative barriers had to be overcome. An *Application for Ethical Approval of Research*, for which approval needs to be obtained, was submitted to the Ethics Committee of the respective faculty of economics and business. It took five months for the approval to be granted, verified, and approved by the Ethics Committee of the same university, but at the faculty of medicine. Since such research had never been conducted there, as far as authors know, at any other Croatian university, obtaining the *Ethics Committee Approval* was extremely complicated not so much on account of the nature research, but for the lack of track record in this kind of research.

3.2. Methodology

The research focused on the process of conducting the fMRI experiment. The observation method was used, so photographs representing visual data of the research flow are included. Survey and interview methods were applied to obtain answers from the participants, and the interview method for gathering insights from the experts.

The scientific problem behind the motivation for research was analyzing the physical environment for giving classes to draw attention of the target group (students). The aim is to increase the individual's attention towards the content heard. The research goal was to analyze whether an individual's exposure to music/scent stimuli would contribute to increased attention. A pragmatic implementation of this idea would relate to, e.g., increasing student attention during classes and encouraging them to participate in classes more easily and actively, especially when attending classes early in the morning (Dikker et al., 2020) or in the time of during the day which, according to the circadian rhythm, is not a good timing for such activities (e.g., late afternoon hours) (Toljan, 2017; Koc & Boz, 2014). This should increase alertness and attention (Lindsley, 1988) of the target audience (students) and, consequently, encourage a higher activity (in the context of participating in classes).

As an auditory stimulus, background music[2] without lyrics was chosen for: its suitability for work environment (Shih, Huang & Chiang, 2012), the fact that music has the ability to reduce stress and anxiety (Bradt, Dileo & Shim, 2013), and findings of previous research that playing music has positive effects on the level of concentration, which could in turn contribute to the performance level (Mori, Naghsh & Tezuka, 2014). As an olfactory stimulus, the peppermint essential oil (*Mentha piperita*, produced by Pranarom), was applied for its potential in helping to reduce mental exhaustion and stress (Wildwood, 2002). This essential oil may also stimulate affective and cognitive responses of an individual, that is, encourage the individual's alertness (Raudenbush, Grayhem, Sears & Wilson, 2009).

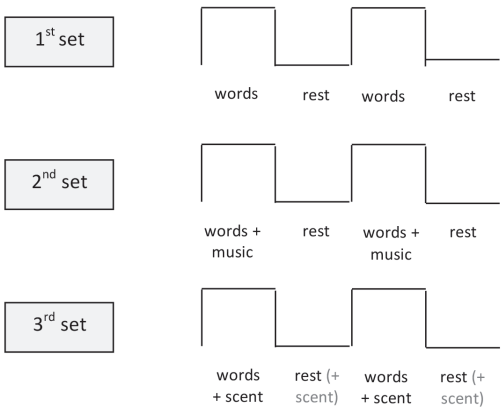
The first step in the experiment consisted in filling out Questionnaire 1, including questions about the participants' demographic profile (gender, age, the year of study), general condition through semantic differential questions about how they felt over the previous month (on a 7-point scale ranging from exhausted to relaxed), and how many hours they slept the night before the experiment. On account of the part of experiment involving olfactory perception, participants were asked whether they were smokers and if they have any kind of breathing problems (proper airway patency).

In order to analyze stimuli (music/scent) which could possibly boost participants' attention during the task (listening to the words) and in line with the research purpose, simple block-design of the fMRI experiment was considered suitable. As pointed out by Huettel et al. (2009), in this kind of experimental design "the trials from each condition are grouped together in time to form blocks" and, as each condition is presented for an extended period of time, comparison is made between them. Based on this, the experiment was designed in line with the guidelines provided and instructions obtained in the interview with radiology expert Fučkan (2012b). The experiment included a series of stimuli and intermittent pauses ("experimental" and "control" parts). Word listening served as the basic stimulus and additional stimuli included firstly background music and secondly scent. The images of participants' brain response to stimulus and the images of participants' brain during pauses were to be compared. Thus, upon consecutive repeats of stimuli and pauses, the differences in the activation of certain brain regions should be detected, revealing which parts of the brain were activated by stimulus. Considering previous research findings (Santos, Moutinho, Seixas & Brandao, 2012; Huettel et al. 2009), the blocks of stimuli and pauses alternated every 10 seconds.

Three sets of scanning were undertaken, with each set creating a combination of stimuli and pauses, so the participants were listening to a series of 6 words, representing a stimulus, over a 10-second period. This was followed by a 10-second pause, upon which the stimulus consisting of the same 6 words being repeated. The second set implied a combination of stimuli and pauses, which again included a series of other 6 words with the addition of background music as a stimulus lasting for 10 seconds, followed by a 10-second pause. The third set included listening to the words and a scent applied as an

additional stimulus.[3] The described experiment design is presented graphically in Figure 1.

FIGURE 1: Experiment design



Source: Authors' own elaboration.

The words used in the experiment were chosen based on consultations with a Croatian language expert; they were equal according to origin (Croatian standard words or foreign ones), number of syllables, and position of emphasis (accented syllable). Three series of six words, similar by the level of difficulty, were formed and each word series was run in three different scanning sets. To change the order in these word series, the sets were designed in the following way: five participants during the first, second and third scanning sets listened to the word series 1, 2, and 3. As to the other two groups, each consisting of five participants, the word series were rotated as shown in Table 1.

TABLE 1: Order of the word series number by set and number of participants included in each set

Number of participants (and participants' code number)	1st set	2nd set	3rd set
5 (1st – 4th, 11th)	1	2	3
5 (5th – 7th, 12th, 13th)	3	1	2
5 (8th – 10th, 14th, 15th)	2	3	1

Source: Authors' own elaboration.

Before entering the MRI room, the participants were interviewed by a radiology technician and were given the *MRI Consent Form* to fill in. The participants were asked to take off any kind of metals (pins on their clothes, piercings) or coins out of their pockets so as not to cause severe consequences. Upon completion of all preparatory procedures, the participants were ready to proceed.

Scanning was carried out at the Polyclinic in April 2013. Fifteen healthy participants – 7 female and 8 male students, who were all volunteers, participated in the research. The participants were aged between 19 and 25 years (mean age = 21.7 years; SD = 1.83). In neuroscience market research, sample size is much smaller than usual in traditional market research. According to ESOMAR (2011) guidelines for neuroscience market research, sample size in this kind of research is much smaller compared to quantitative traditional market research, counting approximately 15 to 30 participants. As fMRI studies should involve at least 15 participants per experiment (Huettel et al., 2009), that same number of participants was adopted for the purpose of this experimental study.

The experiment was conducted using the Philips-Achieva model MRI scanne, strength 1.5 Tesla.[4] Morphological (anatomical) scanning was performed first, followed by functional scanning. The participants underwent three sets of functional scanning. The characteristics of functional scanning were as follows: slice thickness = 5mm, matrix size 64 x 64, number of slices = 29, TR (Time to Repeat) = 3 seconds. Upon scanning completion, images were archived and documented in the Picture Archiving and Communication System.

Once the scanning was completed, images were converted from the DICOM to the Nifti format for further analysis. The foregoing is available by means of the Debabeler program. A total of 2,320 functional images were converted into 80 images in the Nifti format. In other words, 80 dynamics – brain volumes (with 1 volume totaling 29 layers) were obtained. Further images and

data processing were planned to be performed using the Statistical Parametric Mapping [SPM] (n.d.)[5] program, available online free of charge although running in the MatLab program.

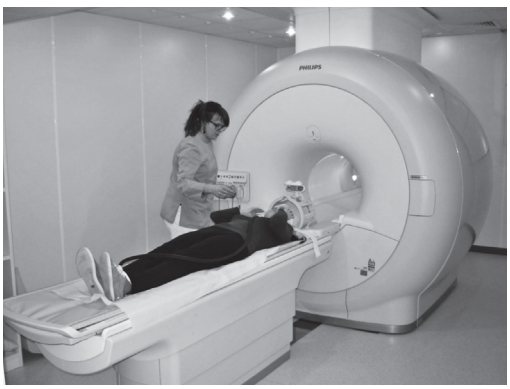
After the participants had passed three sets of scanning, they filled out a "Word remembering test" consisting of three pages. Each page followed each scanning set, including 48 words (all of them prepared based on consultations with the Croatian language expert), of which only 6 were the same words that the participants listened to during fMRI scanning.

3.3. Research findings

3.3.1. Observation

During the fMRI scanning procedure, participants have to stay still. As explained in the document *MRI Consent Form*, scanning is painless, participants should be as relaxed as possible and stay still during the scanning. Head movements may cause artefacts in images, rendering data analysis impossible. Technicians and the research team can hear each participant and see them on the monitor during scanning. Picture 1 shows the radiology technician who, before scanning, confirms the defined research procedure to the participant, checks whether everything is in order, and prepares the coil (a part which helps to receive a signal and gather high-quality images).

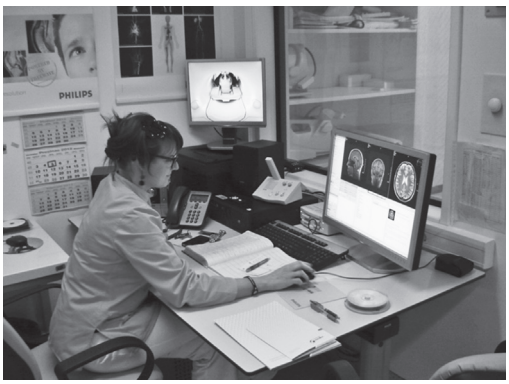
PICTURE 1: Preparation for scanning



Source: Authors' archive.

During the scanning, the control room light was switched off in order so that the participants could not see the researchers or movements in the control room that could distract their attention. An additional observation relates to the fact that the participants were instructed to close their eyes to avoid any visual stimuli. The entire process is monitored from the control room, shown in Picture 2, where the participants are observed on the monitor and through the glass isolating the room for scanning from the control room. Morphological and functional scanning forms are initiated here.

PICTURE 2: fMRI control room

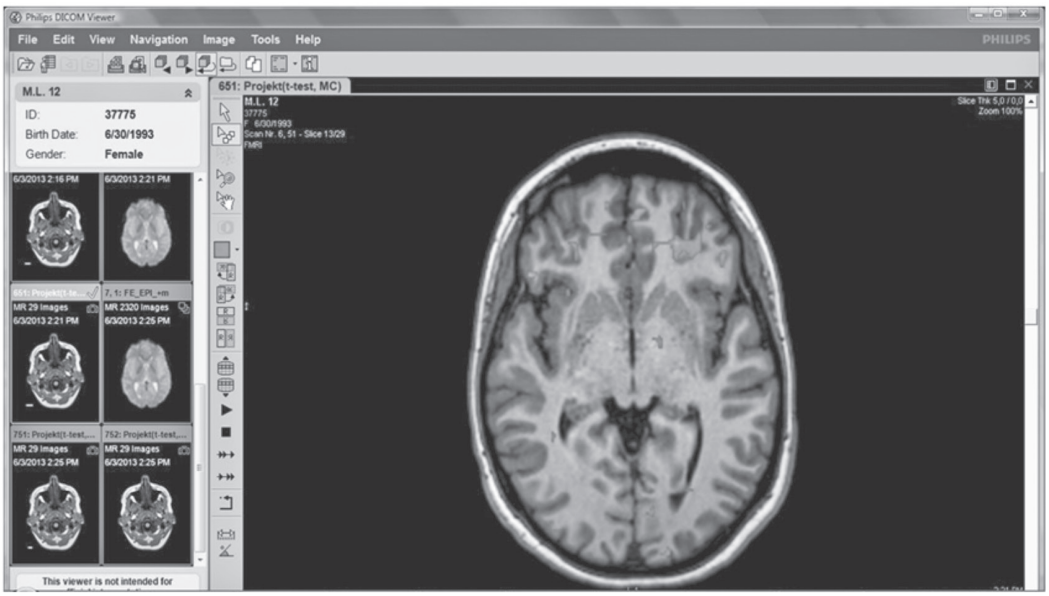


Source: Authors' archive.

During the scanning process and upon its completion, brain images appear on the monitor. Medical technician analyses each image and ensures its archiving. At this stage, it is possible to see a morphological scan of the brain. Morphological scanning is followed by functional processing. Although it is possible to see more active regions of the brain at this stage, as shown in Picture 3, further comparison of the results by means of the software programs foreseen for this activity is yet to follow.

Brodmann's chart and the on-line Brodmann's Interactive Atlas program were used to gain an understanding of the images and analyze the results, while also checking whether the obtained results correspond to earlier expectations and assumptions concerning what parts

PICTURE 3: Example of fMRI brain image in the Philips DICOM Viewer program



Source: Authors' archive.

of the brain would be activated, (n.d.). Programs contributing to a visualization of a certain active area of the brain, such as Talairach Client (n.d.) or MRIcron (n.d.), are also suseful during data processing.

3.3.2. Questionnaire and word remembering test

Based on Questionnaire 1, it was determined that none of the participants, except one (participant no. 7), had any kind of breathing problems (airway patency). Nevertheless, this participant answered that he smelled the scent.

Immediately after passing three sets of scanning, the participants filled out the "Word remembering test." Out of 48 words given for each set, the participants had to pick 6 correct ones (the words which participants actually heard during the experiment). The results are shown in Table 2.

TABLE 2: Correctly recognized words by set

Participant number	1st set	2nd set	3rd set
1st	5	3	6
2nd	6	3	3
3rd	3	1	2
4th	3	0	2
5th	4	5	0
6th	3	5	2
7th	4	5	2
8th	2	1	1
9th	4	2	4
10th	4	1	4
11th	5	3	4
12th	5	1	2
13th	5	1	1
14th	4	2	4
15th	5	4	6

Source: Research results.

In order to obtain a rough picture of results achieved by the participants, the following data are outlined: the average value (mean) of correct answers (recognized words) in the 1st scanning set was 4.13 (SD = 1.06), in the 2nd set it was 2.47 (SD = 1.68), and in the 3rd set 2.87 (SD = 1.77).

After the participants filled out the questionnaire and the word remembering test, a detailed interview followed in which some of the questions were additionally discussed.

4. DISCUSSION AND LIMITATIONS

In conducting an experiment, it is crucial to ensure that all participants are acquainted with the research and the space in which it will be conducted. In this research, before scanning, each participant was shown a presentation of the space in which the research was going to be conducted. Some of them had already been there and had undergone trial scanning. However, some saw the space only when it was shown to them. One participant felt fear and anxiety during the experiment, although she did not expect it. Therefore, it is recommended for all participants undergo pre-scanning preparation in real-life conditions. As stated by Mostafa (2012) and Dong et al. (2005), in their experiments, participants had 15 minutes of so-called pre-scan training session, after which they proceeded to take part in the experiment. It is important that participants are not distracted by any other outside disturbances (e.g., from the control room). During research, it is crucial to ensure that all participants follow the given guidelines and enter the space with no metal objects, such as coins in their pockets, to prevent serious harm to themselves and others and damage to the scanning room equipment.

Although the sample of participants is too small to draw valid conclusions (as the aim of the paper was to conduct fMRI research analysis), it has been observed that the results achieved by the participants in the word remembering test are lower when auditory and olfactory stimuli are included. So, by inclusion of the new stimuli, the participants were potentially disrupted (Domjan, 2012). A participant stated that, at that time a scent was introduced into the space, he did not concentrate on the words at all because his attention was focused on the scent only. Another participant said the scent had distracted her at the very beginning of that scanning set. Although the goal was to increase alertness by using scent, only one participant pointed to being alert as a result. Given the researchers' coping with the installation of equipment and implementation of stimuli, a potential threat was that the participants were sedated instead of staying alert (Goel & Lao, 2006). As regards the analysis of the scent, an important comment standing out was that by the participant who felt fear and anxiety during the research. She said the scent was the only thing that made her feel relaxed and calm. Although brain scan analysis should show the actual state, this is a valuable finding showing that a scent might possibly be used for the purpose of helping patients reduce stress in diagnostic procedures, potentially together with other stimuli, e.g., through the adjustment of lighting or music (Charite, 2015; First Komen, Šepac & Vujičić, 2015).

The next problem involved associations to the words the participants listened to, as a potential distraction that may result in attention decrease. This is confirmed by the participants' comments, showing that different participants had different associations to the words.

Following are the research limitations: the first one relates to the MRI scanner itself. As the University has no laboratory for such research, the first obstacle was finding both a partner for the research and machine available for the scanning.

Also, the noise made by the machine during scanning represented a major disruption in the experiment. The noise occurs owing to rapid gradient coils switching on and off, resulting in its "expansion and shrinkage," heard as loud, rhythmic sounds at different frequencies (Fučkan,

2012a). Although the participants had earphones on to reduce that noise, as well as for listening to the music and words, noise during scanning was very loud. Another limitation concerning hardware was the absence of additional equipment that provides for easier conduct of the experiment (implementation of auditory and olfactory stimuli), due to which the experiment was adapted to given conditions. The third set scanning limitation included the presence of scent over the whole set, also during the word pauses.

Other limitations also included the absence of a formed database of participants. Therefore, the researchers contacted those who were linked to the Department of Marketing at the Faculty and were, thus, potentially interested in participation.

Since this type of research was not conducted at the University before, another limitation relates to the research administrative segment. It took as long as five months to obtain the Ethics Committee approval alone. This was a major administrative problem encountered by the researchers owing to the absence of a routine and established procedures for conducting interdisciplinary research.

Finally, the research limitations also included lengthy preparations, conduct and analysis of the overall research and its results. As the present research was conducted by few individuals, who carried out all the work that is usually performed by much bigger and more coordinated teams, the time necessary for performing the analysis was quite long. It also highlighted a lack of experts capable of interpreting the results of such fMRI research. Moreover, the financial aspect was another major challenge because it is very expensive. Therefore, it might prove rather challenging to continue with similar research without providing adequate experts and funding.

5. CONCLUSION AND FUTURE RESEARCH

Neuromarketing is characterized by the application of neuroscientific methods to answer marketing-related questions. Hence, the use of fMRI for marketing purposes represents an additional tool supporting traditional research to gain a better understanding of consumers in the market, irrespective of whether in the profit or non-profit segment. Not least, it is important to stress the ethical considerations of conducting such research experiments, without jeopardizing participants (e.g., the authors considered PET scanning completely inappropriate for neuromarketing research purposes).

This research was embarked on with a great enthusiasm aiming to analyze the manner in which fMRI research is conducted. The intention was to ensure equipment, gather researchers into an interdisciplinary team, and gain a better understanding or the procedures in such types of research. Potential problems and limitations have been identified and knowledge about all stages of conducting such an experiment, in practice, has been gathered. The experience gained during the research highlighted a need to set up a laboratory at the University level. This implies providing both hardware and software, but also gathering experts from different disciplines who would be involved in similar research. The difficulties encountered point to the for defining and establishing committees and laying down procedures for approving interdisciplinary research. Thus, enormous administrative barriers would be overcome. It is also recommended to consider setting up database of participants for conducting future research.

The recommendations for future research include ensuring proper conditions not only for future research and providing research equipment and software but also capabilities for data analysis. As the research is focused on social marketing, namely, education, future research should focus on ascertaining how neuroscientific findings can help this segment, as well as on identifying its contribution to different fields of social (and service) marketing, such as the aforementioned example of reducing stress in specific situations (e.g., diagnostic procedures).

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Endnotes

[1] The software used was Statistical Parametric Mapping (explained latter).

[2] The musical part played was Ronan Hardiman's *Celtic Dream* from Michael Flatley's *Lord of the Dance* musical musical, based on Irish step-dancing and folklore, which belongs to ambient music that includes elements of electronic and traditional Celtic and Irish music. A rich sound of the Celtic harp brings the main melody, which is in the minor scale and varies throughout the musical composition. Rhythm is accurate and written in the two-beat measure (Šantek, 2020).

[3] The scent stimulus was introduced by means of a cotton pad soaked with five drops of Mentha piperita (peppermint) essential oil, attached to the coil which participants in the MRI scanner had around their head. The set which included the scent was always launched last to avoid its influence on previous sets. Each participant had a set scanning time on a different day to ensure that the MRI room is ventilated and free from the scent when the next participant enters the room. This posed a research limitation, since the scent was present during the rests.

[4] Tesla is a measure unit in the International System of Units, expressing magnetic field intensity (Fučkan, 2012a).

[5] Other programs besides SPM (n.d.) are also available. As mentioned by Dimoka (2012), they includ FSL (n.d.), AFNI (n.d.) and BrainVoyager (n.d.).