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COMPARING BRAIN ACTIVITY OF ENTREPRENEURS AND NON-ENTREPRENEURS DURING CREATIVE THINKING AND OPPORTUNITY RECOGNITION

YARATICI DÜŞÜNME VE FIRSAT TANIMLAMA ESNASINDA GİRİŞİMCİLER VE GİRİŞİMCİ OLMAYANLARIN BEYİN AKTİVİTELERİNİN KARŞILAŞTIRILMASI*

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Abstract

The main purpose of this study is to try to explain entrepreneurship within the framework of brain-based entrepreneurship approach (neuroentrepreneurship). In our study, we examined creative thinking and opportunity recognition, which are two characteristics that are frequently used to define entrepreneurs. Data were collected using Electroencephalography (EEG). The sample of the research consists of 35 participants (entrepreneurs and non-entrepreneurs). Research data were analyzed with WINEEG and SPSS programs. The findings of the research indicate that there are differences between the brain activity of entrepreneurs and non-entrepreneurs during creative thinking and opportunity recognition. In addition, it has been observed different neural networks in the brains of entrepreneurs, especially during opportunity recognition.

Keywords: Neuroentrpreneurship, Creativity, Opportunity Recognition

Öz

Bu çalışmanın temel amacı, beyin temelli girişimcilik yaklaşımı (nörogirişimcilik) çerçevesinde girişimciliği açıklamaya çalışmaktır. Çalışmada, girişimcileri tanımlamak için sıklıkla kullanılan iki özellik olan yaratıcı düşünme ve fırsat tanımlama incelenmiştir. Araştırma verileri Elektroensefalografi (EEG) kullanılarak toplanmıştır. Araştırmanın örneklemini 35 katılımcı (girişimci ve girişimci olmayan) oluşturmaktadır. Araştırmada elde edilen veriler WINEEG ve SPSS programları kullanılarak analiz edilmiştir. Araştırmanın bulguları, yaratıcı düşünme ve fırsat tanımlama esnasında girişimcilerin ve girişimci olmayanların beyin aktiviteleri arasında farklılıklar olduğunu göstermektedir. Ayrıca özellikle fırsat tanımlama esnasında girişimcilerin beyinlerinde farklı sinir ağlarının kullanıldığı gözlemlenmiştir.

Anahtar Kelimeler: Nörogirişimcilik, Yaratıcılık, Fırsat Tanımlama

GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı

Bu çalışmanın temel amacı girişimciliği geleneksel girişimcilik araştırmalarından farklı olarak beyin temelli girişimcilik yaklaşımı çerçevesinde açıklamaya çalışmaktır. Bu amaçla girişimcilik literatüründe girişimcileri diğerlerinden ayırt etmeyi sağlayabilecek iki önemli unsur olan yaratıcı düşünme ve fırsat tanımlama konuları ele alınmış ve EEG kullanılarak girişimciler ile girişimci olmayanların beyin aktiviteleri incelenmiştir.

Araştırma Soruları

Araştırmaya yön veren sorular şu şekildedir: 1. Yaratıcı düşünme esnasında girişimcilerin ile girişimci olmayanların beyin aktiviteleri arasında fark var mıdır? 2. Fırsat tanımlama esnasında girişimcilerin ile girişimci olmayanların beyin aktiviteleri arasında fark var mıdır?

Literatür Araştırması

Nörogirişimciliği farklı açılardan ele alarak alana katkı sağlayan teorik çalışmalar bulunmaktadır (Krueger ve Welpe, 2008; Singh ve Ronch, 2011; Martin de Holan, 2014; McMullen vd., 2014; Colosio vd., 2017; Day ve Boardman, 2017; Guillory vd., 2017; Martin de Holan ve Couffe, 2017; Perez-Centeno, 2017a; Perez-Centeno, 2017b; Perez-Centeno, 2017c; Shaver vd., 2017; Sud, 2017; Treffers, 2017; Ward vd., 2017; Aydın ve İrmiş, 2018; Heydari vd., 2020; Korpysa, 2020; Massaro vd., 2020; Nofal vd., 2021; Ballı ve Aycı, 2021; Girişken ve Çakar, 2021). Ancak bu alanda fırsatların belirlenmesi ve risk alma (Zaro vd., 2016), karar verme (Ortiz-Teran vd., 2013; Laureiro-Martinez vd., 2014), girişimcilik bağı (Lahti vd, 2018), girişimcilik tutkusu (Shane vd., 2019), sezgisel biliş ve girişimci uyanıklığı (Moore vd., 2021) gibi sınırlı sayıda araştırma bulunmaktadır.

Yöntem

Araştırmada yaratıcı düşünme ve fırsat tanımlama esnasında katılımcıların beyin aktivitelerini gözlemleyebilmek için iki farklı deney tasarımı oluşturulmuştur. Veriler 19 kanallı EEG cihazı ile toplanmıştır. Araştırmanın örneklemi girişimci ve girişimci olmayan 35 katılımcıdan oluşmaktadır. Elde edilen veriler WINEEG programı kullanılarak ön işlemlerden geçirilmiş ve verilerin sinyal analizleri yapılmıştır. Araştırma sorularını test etmek için (gruplar arasında istatistiksel olarak anlamlı bir farklılık olup olmadığını belirlemek için) Mann-Whitney U testi kullanılmıştır.

Sonuç ve Değerlendirme

Araştırma bulguları girişimciler ile girişimci olmayanların beyin aktivitelerinin yaratıcı düşünme ve fırsat tanımlama esnasında farklı olduğunu göstermektedir. Araştırmada elde edilen önemli bulgulardan biri fırsat tanımlama esnasında girişimcilerin beyinlerinde temporal bölgede gözlemlenen aktivasyondur. Girişimcilerin fırsatları tanımlarken girişimci olmayanlardan farklı olarak belleklerinden destek aldıkları görülmektedir.

1. INTRODUCTION

In recent years, curiosity and interest in the biological basis of entrepreneurial thought, emotion and behavior has increased. One of the biologically based approaches is neuroentrepreneurship. Neuroentrepreneurship is a multidisciplinary field in which the entrepreneurial cognition and entrepreneurial behavior are tried to be explained by making use of the knowledge that neuroscience has about the human brain and the methods and techniques used by neuroscience. The characteristics that differentiate the entrepreneur from other individuals and the cognitive processes underlying the entrepreneurial behavior are tried to be explained with a brain-based understanding. Subjects such as which brain region and/or activity can be associated with entrepreneurial alertness; whether there is a difference between the brain activities of entrepreneurs and non-entrepreneurs during divergent thinking (creativity); and what kind of brain activity occurs in which part of the entrepreneur's brain during opportunity recognition constitute research questions of neuroentrepreneurship. Research techniques such as survey, interview, observation, focus group, case analysis are replaced by techniques EEG, fMRI, MEG, PET. In research carried out with the use of these techniques, the source of data is not directly human, but the human brain.

There are theoretical studies that contribute to the field by considering neuroentrepreneurship from different perspectives (Krueger & Welpe, 2008; Singh & Ronch, 2011; Martin de Holan, 2014; McMullen et al., 2014; Colosio et al., 2017; Day & Boardman, 2017; Guillory et al., 2017; Martin de Holan & Couffe, 2017; Perez-Centeno, 2017a; Perez-Centeno, 2017b; Perez-Centeno, 2017c; Shaver et al, 2017; Sud, 2017; Treffers, 2017; Ward et al., 2017; Aydın & İrmiş, 2018; Heydari et al., 2020; Korpysa, 2020; Massaro et al., 2020; Nofal et al., 2021; Ballı & Aycı, 2021; Girişken & Cakar, 2021). However, there are few research in this field such as identification of opportunities and taking risk (Zaro et al., 2016), decision making (Ortiz-Teran et al., 2013; Laureiro-Martinez et al., 2014), entrepreneurial bond (Lahti et al., 2018), entrepreneurial passion (Shane et al., 2019), intuitive cognition and entrepreneurial alertness (Moore et al., 2021).

There are several reasons why we consider entrepreneurship from a brain-based perspective. The first and main reason is the assumption that, under certain conditions, the brain activity of entrepreneurs should be different from other individuals. In the entrepreneurship literature, it is stated that entrepreneurs are different from other individuals in terms of emotions, thoughts and behaviors. The center of all emotions, thoughts and behaviors is the brain. In this case, the characteristics that make entrepreneurs different from other individuals should also be observable at the level of brain activity. Research supports this assumption. The activity and neural networks that observed during opportunity identification, risk taking (Zaro et al., 2016) and making decision (Ortiz-Teran et al., 2013; Laureiro-Martinez et al., 2014) differ between entrepreneurs and non-entrepreneurs. Investigating these differences in the brain can provide a better understanding of entrepreneurship.

Secondly, studies on entrepreneurs mostly focus on entrepreneurial characteristics, skills and abilities. However, whether entrepreneurs are different from others (the expectation that entrepreneurs are different from other individuals) or why they are entrepreneurs (the effect of factors such as sociological, economical, cultural, genetic, psychological) is still not completely answered. Drucker (2017) states that entrepreneurship is not a personality characteristic, there are entrepreneurs who have different temperaments and characters. Similarly, Hatten (2012) draws attention to the existence of entrepreneurs with different personality characteristic and coming from different backgrounds. According to Baron (1998), efforts to identify entrepreneurs with personality tests are unsuccessful. He argues that entrepreneurs are different in terms of cognitive processes. Creativity and opportunity recognition, which are important stages of the entrepreneurial process (Moore, 1986; Morris, 1998; Lumpkin & Lichtenstein, 2005; Bygrave, 2010; Qin et al., 2020; Ardichvili et al., 2003: 106; Eckhardt & Shane, 2010: 49, Shane et al., 2012) is a cognitive process (Shane & Venkataraman, 2000; Gaglio & Katz, 2001; Baron, 2002; Marie De Carolis & Saparito, 2006; Baron, 2007; Koellinger et al., 2007; Tang et al., 2012; Chell, 2013). Therefore, by investigating the entrepreneur's brain, we examine whether creativity and opportunity recognition are cognitive processes that explain entrepreneurs.

The third reason is the change in the position of the entrepreneur in the entrepreneurship process. The entrepreneurship process has ceased to be a process in which a person (entrepreneur) is the subject and has become a process that takes place at the team and organizational level. The entrepreneur does not have to have capital, take risk or manage the process. For instance, a person with an innovative idea can reach angel investors by way of online platforms and realize his idea by receiving investment support for the idea/product/process he has developed. Creativity and opportunity recognition are critical stages to start this process. Examining the brain activity of entrepreneurs during creativity and opportunity recognition can be a guide to increase entrepreneurial activities.

In our study, we discussed creativity and opportunity recognition from both entrepreneurial and neuroscience perspective. We used EEG to collect data. The research findings indicate that there are significant differences especially during opportunity recognition.

2. CREATIVITY FROM THE PERSPECTIVE OF ENTREPRENEURSHIP AND NEUROSCIENCE

Creativity can be defined as a cognitive activity which enables an original and new approach to an existing situation (Solso et al., 2018), the capacity of a person to think of possibilities by realizing her/his own potential and imagination (Chell, 2013), and a process that emerges with the combination of different components (Amabile, 1997; Andreasen, 2019; Sternberg &Lubart, 1996).

Creativity is an important personal variable that is effective in the creation of new ideas and recognition of opportunities, which are the first stages of the entrepreneurial process (Moore, 1986; Morris, 1998; Lumpkin & Lichtenstein, 2005; Bygrave, 2010; Qin et al., 2020). It is known that there

are significant similarities between creative individuals and entrepreneurs (Whiting, 1988; Fillis & Rentschler, 2010; Tang et al., 2018). Entrepreneurs are expected to approach problems from different perspectives in order to generate new ideas, identify opportunities and find solutions that reveal their creativity. For this reason, it can be said that every entrepreneurial activity includes creative thinking. From this point of view, it can be stated that every entrepreneur is creative. However, every creative thought is not an entrepreneurial activity, and every creative person is not an entrepreneur.

It is seen that there are many branches of science that try to explain creativity, which is a versatile and quite complex process. The idea that this extraordinary capacity of the human mind will both shed light on the history of humanity and provide important benefits in the future (Dietrich & Kanso, 2010) increases the interest in the neurophysiology foundations of creativity. Neuroscience techniques such as EEG, fMRI and PET are used to explain the neurophysiology of creativity. There are many studies conducted with EEG and fMRI related to creativity in the literature. Creativity or divergent thinking have been associated with reduced theta power and increased alpha power in frontal cortex (Mölle et al., 1996), dimensional complexity in frontal, central and parietal regions (Mölle et al., 1999), increased beta power (Razumnikova, 2004), alpha synchronization in the frontal region of the brain (Fink et al., 2006), strong alpha synchronization in the parietal regions (Fink & Neubauer, 2006), increased EEG coherence in alpha2, beta2 and gamma (Shemyakina & Dan'ko, 2007), increased alpha power in frontal regions (Jauk et al., 2012). Therewithal, Andreasen (2019) thinks that creativity is related to unconscious free association. She states that the frontal, parietal and temporal regions are active during unconscious free association. According to her, the more connections between neurons are formed in the brain, the more original ideas emerge (Andreasen, 2019). The findings indicate that it is not possible to explain creativity with a single brain region or activity. However, many factors such as the methods used in research, experimental design, and the type of variables are seen as a factor in the differentiation of research results.

The first question of the research was formed based on the assumption that entrepreneurs are creative individuals and the brain activities of creative individuals and non-creative individuals are different.

Research question 1: Is there a difference between the brain activity of entrepreneurs and non-entrepreneurs during creative thinking?

3. OPPORTUNITY RECOGNITION FROM THE PERSPECTIVE OF ENTREPRENEURSHIP AND NEUROSCIENCE

Opportunity recognition is an important stage of the entrepreneurial process (Morris, 1998; Ardichvili et al., 2003; Eckhardt & Shane, 2010; Shane et al., 2012) and an important characteristic that defines the entrepreneur (Shane & Venkataraman, 2000; Kavanagh & Hisrich, 2010; Bygrave, 2010; Loue & Baronet, 2012). Opportunity recognition is a cognitive process and is related to perception

(Shane & Venkataraman, 2000; Gaglio & Katz, 2001; Baron, 2002; Marie De Carolis & Saparito, 2006; Baron, 2007; Koellinger et al., 2007; Tang et al., 2012; Chell, 2013). In order to talk about an opportunity, there must be a noticed or perceived stimulus or set of stimuli. As Baron (2002) expresses, determining "what it is that entrepreneurs perceive or think they perceive" is very important in order to explain the opportunity recognition. Drucker (2017) states that anything in nature cannot be seen as a resource until a way of use is found to add economic value to it. Baron and Ensley (2006) remark that opportunities are only a potential until they emerge in the human mind. Therefore, entrepreneurs are people who can turn anything in the environment into opportunity, that is, people who have minds that will transform them into tangible products, services, technologies, processes, and who actively monitor and process changes in the environment are entrepreneurs. For this reason, the discovery, identification and recognition of opportunities is one of the important issues in the field of neuroentrepreneurship.

There is few research on opportunities in the neuroentrepreneurship literature. Zaro et al. (2016) conducted a study with the EEG technique to examine the brain activities of entrepreneurs and non-entrepreneurs during opportunity identification. As a result of the research, it has been shown that activation occurs in the left frontal, medial and left midtemporaparietal region in the brains of non-entrepreneurs during opportunity identification. On the other hand, in entrepreneur brains activation was observed in the right frontal and posterior temporal region, in a different right frontal region, and in the left and right temporal regions. Laureiro-Martinez et al. (2014) compared entrepreneurs and managers by measuring their brain activities during exploitative and explorative decision-making, using fMRI technique. According to the results of the research, a stronger activation was observed in frontopolar cortex associated with explorative choice in the brains of entrepreneurs.

In the process of perceiving and using the opportunities that form the basis of entrepreneurship (Gaglio, 2018), entrepreneurs are seen as the people who determine these opportunities to create and present value (Ardichvili et al., 2003). Shaver and Scott (1991) express that economic conditions, social networks, teams and incentives are important for a business, but none of them creates a venture without an entrepreneur. As Gaglio and Winter (2017) stated, it is necessary to investigate: whether the mental schema of an entrepreneur and a non-entrepreneur is different; secondly, whether entrepreneurs use this information differently from non-entrepreneurs, and finally whether unique features of the mind, such as content and uses, are influential in identifying more and qualitatively superior opportunities. In the light of this information, the second question of the research was formed based on the assumptions that entrepreneurs are individuals who define opportunities and there is a difference between the brain activities of entrepreneurs and non-entrepreneurs during opportunity recognition.

Research question 2: Is there a difference between the brain activity of entrepreneurs and non-entrepreneurs during opportunity recognition.

4. RESEARCH METHOD

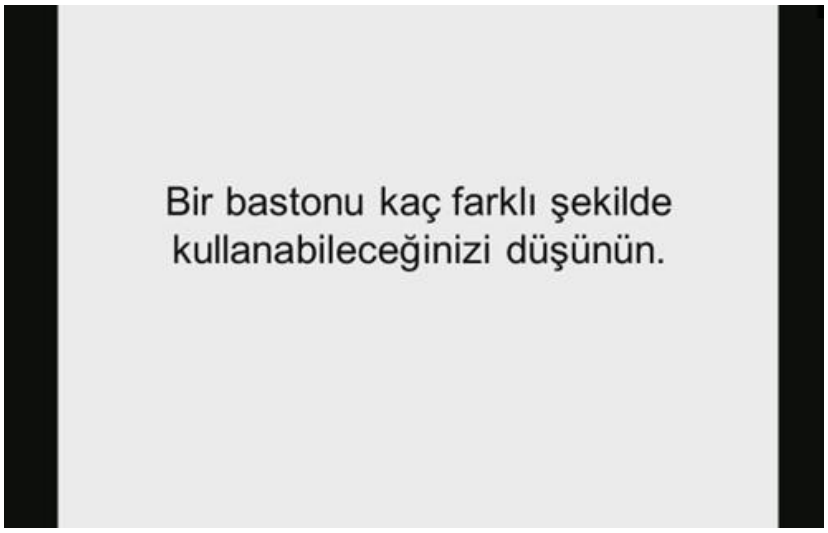
4.1. Methodology

Electroencephalography (EEG) technique was used to collect data in this study. EEG is a technique that allows the spontaneous electrical activity of the brain to be recorded from the scalp with surface electrodes or from brain structures with electrodes placed on the skull with stereotaxic method (Özesmi et al., 2000). EEG signals reflect the electrical neuronal activity of the brain (Malik & Amin, 2017). This electrical activity is due to the activity of a large number of neuron groups (Bora & Yeni, 2012) and is associated with different brain regions and functions. These activities in the brain can be measured with the help of electrodes. In our research we used Mitsar 201 EEG with 19 channels to collect data. The device sampling frequency is 2000 Hz and the signal conversion is 24-bit resolution. The electrodes were placed according to the international 10-20 system. Data were obtained from 19 electrodes: Fp1, Fp2, F3, F4, Fz, C3, C4, Cz, T3, T4, T5, T6, F7, F8, P3, P4, Pz, O1, O2.

The research was carried out in two stages. The first stage is about the creative thinking. Creativity is associated with a divergent thinking style, which is open-ended and includes many possible solutions but does not require a correct answer (Goldstein, 2013). Divergent thinking requires the ability to produce various interesting, appropriate and fluent answers to a given question or task (Andreasen, 2019). Numerous tests have been developed to examine and measure creativity in the field of psychology. One of these tests is the Alternative Uses Test (AUT) developed by Guilford. The test includes a very simple method in which a person is asked how many different ways he can use an object. In the studies of Arden et al. (2010) and Dietrich and Kanso (2010) in which they examined the studies on creativity using fMRI and EEG techniques in the literature, it is seen that the alternative use test is a frequently preferred technique in explaining the neural basis of creativity. For this reason, Guilford's Alternative Uses Test was preferred to examine the brain activity during creative thinking in this research.

The test, which was prepared in video format for simultaneous recording of brain activity, was projected onto the computer screen and shown to the participants (Figure 1). Before starting the EEG recording, the participants were informed about the EEG recording and the instructions were explained. In the test, participants were asked to think about in how many different ways they could use a cane. EEG was recorded for 180 seconds during the test. In order to determine the reading time of the question, we performed a stopwatch test on people who not participate in the research. The time to read the question was calculated as 5 seconds and this time was not included in the data analysis.

Figure 1. Creativity Test (Alternative Uses Test - AUT)*



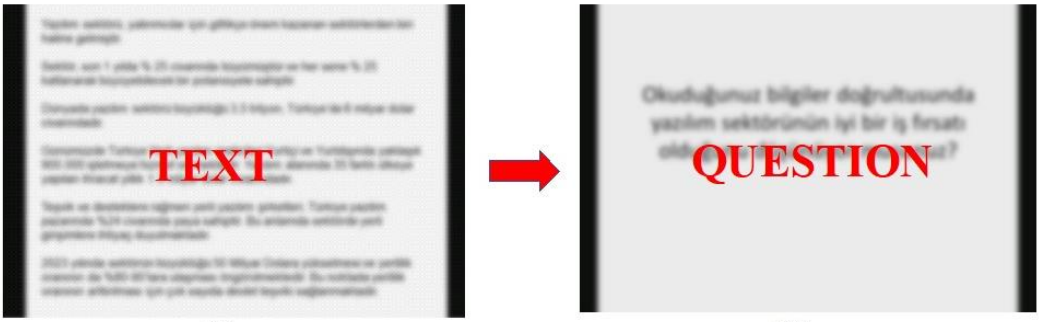
*Research text: "Think about in how many different ways you can use a cane."

Opportunity recognition is the second stage of this research. Opportunity recognition is related to both perception and thinking processes, as Baron (2002) states. Opportunity recognition can be a part of the creativity (divergent thinking) process. However, divergent thinking and convergent thinking occur together in the development of new products and ideas (Yeşilyurt, 2020). Convergent thinking is expressed as a way of problem solving and logical thinking. Therefore, opportunity recognition refers to the evaluation of a situation and the process of generating a solution (opportunity or not opportunity). In the light of this information, we designed an experiment to examine the brain activity during opportunity recognition.

Opportunity recognition is a process. We can explain opportunity recognition that processing information of transforming the current conditions in the market into business opportunities when the supply-demand relationship is known. In order to reach the conclusion of "opportunity" or "not opportunity", the information must be processed mentally by the individual. In other words, the process of assessing whether a situation is an opportunity or not occurs in the brain. The aim of this research is to determine what kind of activity occurs in their brains and what kind of neural network is used while the conditions in the market are defined as opportunity (or vice versa) by entrepreneurs and non-entrepreneurs. A text was created for this experiment. Then a question was asked to the participants within the information given in the text, and they were asked to think about the question. While creating the text entrepreneurship literature and the opinions of the entrepreneurs who will not participate in the research were taken into account. The meaning and structure of the text were controlled according to communication techniques. Before preparing the text, we researched emerging sectors that have investment attractiveness and where opportunities are clearly visible in the market. Afterwards, we asked the entrepreneurs what they thought about these sectors. We did not include these entrepreneurs in our experiment. Considering the supply-demand relationship, the growth rate of the sector and

incentives in terms of opportunity recognition, it was decided that the appropriate sector was software. Before the text about the sector was prepared, we interviewed entrepreneurs who not be included in the experiment, and asked what criteria they evaluated investment opportunities in a sector. It has been determined that information such as the growth rate of the sector, its size, export amount, incentives, domestic investor market share are important for opportunities. This information has been converted into short, clear and understandable expressions in terms of the effectiveness of communication. The experiment was prepared in video format and shown to the participants via a screen. The instructions were explained to the participants before the EEG recording. Participants were first asked to read the text on the screen (60 seconds) and then to think about the question on the screen (Figure 2). EEG was recorded for 180 seconds during the test. The time to read the text was calculated by the stopwatch test. Reading time was not included in the data analysis.

Figure 2. Design of Opportunity Recognition Experiment



4.2. Research Participants

The sample of this research consists of 17 entrepreneurs and 18 non-entrepreneurs. Only "founders" who have founded their own businesses are included in this research. Entrepreneurs operate in mining, logistics, construction, agriculture, animal husbandry, tourism, architecture, security, textile, software, consultancy, landscaping and advertising. The non-entrepreneurs in this research are those who have not engaged in any entrepreneurial activity before, who do not have an entrepreneurial history and who are not a manager. Non-entrepreneurs work in a public institution or in a business. These institutions operate in the fields of education, zoning, cement, construction, communication, health and security. Variables such as age, education, gender, illness, trauma, drug use can cause differences in brain structure and functioning. For this reason, only men between the ages of 30-50, university graduates, without any neurological or psychiatric disease were included in our research. They also do not use any neurological or psychiatric drugs. Since the dominant hand is associated with the dominance of different hemispheres of the brain, only right-handed users were preferred. We had a preliminary interview with the participants who met the criteria. We gave information about the research. Before the EEG recordings, the participants were informed about caffeine, alcohol consumption and drug use before the experiment while making appointments. In addition, it was stated that they should not use

gel, spray and similar hair stylers when coming to EEG recordings. Before the study, each participant was asked to read the ethics committee approval and information letter and to sign the voluntary consent form.

4.3. Ethical Approval

Ethical approval of this study was received from Pamukkale University Social and Human Sciences Research and Publication Ethics Committee (13.11.2019), (13-04). In addition, the participants were informed about the research method and content, and an "informed consent form" was taken from all participants.

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5. RESULTS

Wineeg and IBM SPSS Statistics 22 programs were used to analyze the data collected in the research. Differences between groups were tested with the Mann-Whitney U test.

Two participants (due to attention problems, etc.) were excluded from the research after EEG recordings, and EEG data of three participants were not included in the analysis due to the problem in the EEG recordings. The analyzes of the EEG data in the experiments were carried out on the data obtained from 15 entrepreneurs and 15 non-entrepreneurs.

The data were purified from artifacts (caused by physiological and technical reasons) with Independent Components Analysis (ICA) before the analysis. Then, artifact marking was performed and limited to 50 μV for slow waves and 50 μV for fast waves in all channels. We used the spectral analysis which is a kind of signal analysis method. Spectral analysis provides the digitization of frequency components in EEG recordings as power with Fast Fourier Transformation (FFT) method (Turanlı, 1994). Spectral analysis reveals which frequencies the time series is associated with and its dependency structure (Erdemir, 2000). As a result of spectral analysis, various data such as power distribution graphs, topographic maps of the brain, power spectrum tables belonging to bands can be obtained.

Frequency bands for the analysis were determined as delta 1-4 Hz, theta 4-8 Hz, alpha 8-14 Hz, beta1 14-20 Hz, beta2 20-30 Hz, gamma 30-40 Hz. Power values and frequency values in six frequency bands (delta, theta, alpha, beta1, beta2, gamma) obtained from each electrode were calculated.

5.1. Findings on Creativity

As a result of the analysis of the EEG data statistically significant difference ($U=56.5$, $p=0.020$) was found in theta band (F3 electrode) in terms of power values during creative thinking (Table 1). It was observed that the theta power was higher in the left frontal region of the brain of the non-entrepreneurs.

Table 1. Power Values Mann-Whitney U Test Result

E-μV	Group	N	Rank Average	Rank Sum	U	Z	p
F3-θ	Entrepreneurs	15	11.77	176.5	56.5	-2.32	0.02
	Non-Entrepreneurs	15	19.23	288.5			

θ: Theta $p<0.05$

Moreover, in terms of frequency values, a statistically significant differences were found in theta, beta1, gamma and beta 2 band (Table 2). Frequency values are higher in the beta1 band in the left frontal region and in the beta1 band in the right temporal region in the brains of entrepreneurs. In the brains of the non-entrepreneurs, higher frequency values were observed in the theta band in the left frontal region, in the gamma band in the right central region, and in the beta2 band in the left occipital region.

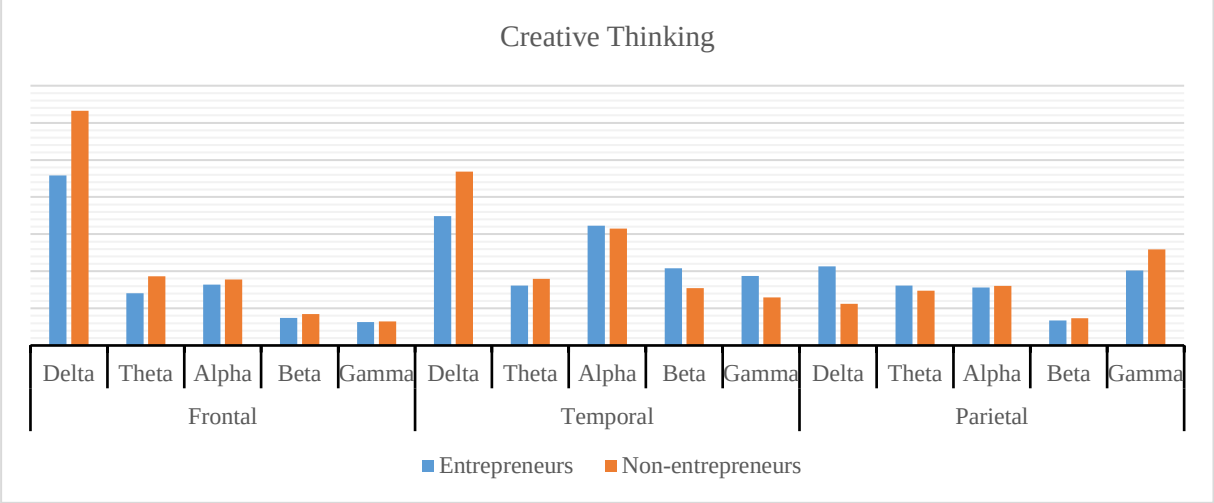
Table 2. Frequency Values Mann-Whitney U Test Results

E-F	Group	N	Rank Average	Rank Sum	U	Z	P
F1-θ	Entrepreneurs	15	11.80	177	57	-2.41	0.016
	Non-Entrepreneurs	15	19.20	288			
F3-β	Entrepreneurs	15	18.87	283	62	-2.12	0.034
	Non-Entrepreneurs	15	12.13	182			
C4-γ	Entrepreneurs	15	12.17	182.50	62,5	-2.08	0.037
	Non-Entrepreneurs	15	18.83	282.50			
T4- β	Entrepreneurs	15	19.07	286	59	-2.24	0.025
	Non-Entrepreneurs	15	11.83	179			
O1- β	Entrepreneurs	15	11.93	179	59	-2.24	0.025
	Non-Entrepreneurs	15	19.07	286			

θ: Theta, β: Beta, γ: Gamma $p<0.05$

After analyzing the brain activities during creative thinking on the basis of electrodes, it was examined whether there was a significant difference between the groups in terms of power values in the frontal, temporal and parietal regions. First, we grouped electrodes. We used Fp1, Fp2, F3, F7, Fz, F4 and F8 electrodes for the frontal region, T3, T4, T5 and T6 electrodes for the temporal region, and P3, Pz and P4 electrodes for the parietal region. The frontal and temporal regions were regrouped on the basis of the left and right hemispheres. According to the test results, there was no statistically significant difference between the groups (Figure 3).

Figure 3. Comparison of Power Values Measured in Frontal, Temporal and Parietal Areas During Creative Thinking



5.2. Findings on Opportunity Recognition

It was seen that there was a statistically significant difference between the groups in theta, alpha, delta power during the opportunity recognition (Table 3). Compared to the entrepreneurs, it was observed that theta and alpha powers in the right frontal region, theta power in the left temporal region, and delta and theta power in the right temporal region were higher in the brains of the non-entrepreneurs.

Table 3. Power Values Mann-Whitney U Test Results

E-μV	Group	N	Rank Average	Rank Sum	U	Z	P
F8- θ	Entrepreneurs	15	12.07	181	61	-2.14	0.033
	Non-Entrepreneurs	15	18.93	284			
F8- α	Entrepreneurs	15	12.33	185	65	-1.97	0.049
	Non-Entrepreneurs	15	18.67	280			
T3- θ	Entrepreneurs	15	12.00	180	60	-2.18	0.029
	Non-Entrepreneurs	15	19.00	285			
T4- δ	Entrepreneurs	15	11.60	174	54	-2.43	0.015
	Non-Entrepreneurs	15	19.40	291			
T4- θ	Entrepreneurs	15	12.20	183	63	-2.05	0.040
	Non-Entrepreneurs	15	18.80	282			

δ: Delta, θ: Theta , α: Alpha $p<0.05$

A statistically significant difference was found between the brain activity of entrepreneurs and non-entrepreneurs in beta2, gamma and beta1 bands in terms of frequency values during opportunity recognition (Table 4). It was observed that the frequency values of the brains of the entrepreneurs in the research group were higher in the Beta2 band in the right frontal region and in the Beta1 band in the

right temporal region. It was observed that the frequency values in the gamma band were higher in the brains of non-entrepreneurs in the left frontal, middle parietal and left occipital regions.

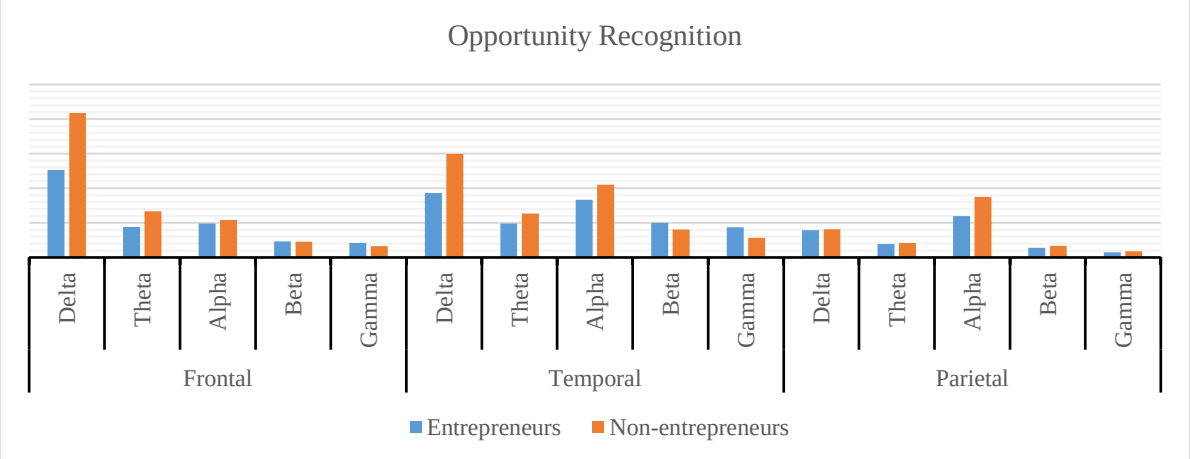
Table 4. Frequency Values Mann-Whitney U Test Results

E-F	Grup	N	Rank Average	Rank Sum	U	Z	P
F2- β	Entrepreneurs	15	18.80	282.00	63	-2.06	0.040
	Non-Entrepreneurs	15	12.20	183.00			
F7-γ	Entrepreneurs	15	12.13	182.00	62	-2.10	0.036
	Non-Entrepreneurs	15	18.87	283.00			
Pz-γ	Entrepreneurs	15	12.33	185	65	-1.98	0.048
	Non-Entrepreneurs	15	18.67	280			
T6-β	Entrepreneurs	15	19.17	287.50	57.5	-2.30	0.022
	Non-Entrepreneurs	15	11.83	177.50			
O1- γ	Entrepreneurs	15	11.97	179.50	59.5	-2.21	0.027
	Non-Entrepreneurs	15	19.03	285.50			

β: Beta, γ: Gamma $p<0.05$

Brain activitiy during opportunity recognition were analyzed on the basis of electrodes, and then it was tested whether there was a significant difference between the groups in terms of power values in the frontal, temporal and parietal regions. Values were calculated for each frequency band by grouping Fp1, Fp2, F3, F7, Fz, F4 and F8 electrodes for the frontal region, T3, T4, T5 and T6 electrodes for the temporal region, and P3, Pz and P4 electrodes for the parietal region. In order to examine the values in the frontal and temporal regions, the electrodes in these regions were regrouped on the basis of the left and right hemispheres. According to the test results, there was no statistically significant difference between the groups (Figure 4).

Figure 4. Comparison of Power Values Measured in Frontal, Temporal and Parietal Areas During Opportunity Recognition



6. DISCUSSION

In this research we compared brain activity of the entrepreneurs and non-entrpreneurs during creative thinking and opportunity recognition. It was observed that the power values in the theta band in the left frontal region were different during creative thinking. This region is associated with functions such as motor planning, visual episodic recall, object processing, and emotional interpretation. The increased theta power in this region is explained by reduced executive functions (Field et al., 2019). During creative thinking, executive functions are less in the brains of non-entrepreneurs compared to entrepreneurs. In research on creative thinking, it is seen that creativity is associated with high amplitude low frequency waves such as theta and alpha in the frontal region, which occur during relaxation and rest, where cognitive activity is low. The main reason for this is that low amplitude high frequency waves such as beta and gamma seen in the frontal region related to executive functions are associated with functions such as analytical thinking, logical decision making and planning. It is thought that the brain should be in a relaxed state while creative ideas are being formed, therefore, high-level cognitive functions are suppressed during creative thinking (Carter, 2013). In the light of this information, our research findings are consistent with the literature.

In our research, differences were observed in the left prefrontal, right central, left occipital, left frontal and right temporal regions in terms of frequency values during creative thinking. The difference in theta values in the left prefrontal region can be interpreted as the fact that entrepreneurs focus more on the subject during the task (Field et al., 2019). Higher values in the gamma band in the right central region and in the beta2 band in the left occipital region in the brains of non-entrepreneurs and in the beta1 band in the left frontal and right temporal regions in the brains of entrepreneurs were observed. Observation of higher values in beta and gamma bands indicates that more cognitive activity occurs in those regions. When it comes to a task related to executive functions, it is considered normal to observe the beta wave especially in the frontal regions. Because these waves which are associated with high-level cognitive functions such as problem solving, active thinking, reasoning and planning (Eagleman, 2018), are the task of the frontal region which is also related to thinking and planning (Tanrıdağ, 2018).

It is seen that theta and alpha power in the right frontal region, theta power in the left temporal region, and delta and theta power in the right temporal region are higher in non-entrepreneurs' brain during opportunity recognition. This indicates that the brains of entrepreneurs have higher cognitive functions during opportunity recognition in the right frontal, left and right temporal regions compared to non-entrepreneurs' brain. The increase in delta, theta and alpha powers in the frontal areas demonstrate that the functions in these regions are suppressed or low cognitive activity. The high-amplitude waves that occur in the temporal area indicate that the problems are interpreted (Field et al., 2019).

Considering the frequency values recorded from the electrode regions during opportunity recognition, it is seen that beta values obtained in the right prefrontal region and right temporal region

during opportunity recognition in the brains of entrepreneurs are higher than non-entrepreneurs. Findings indicate that entrepreneurs get support from both the prefrontal region (which is associated with higher-level cognitive functions) and temporal region (related with long-term memory) while defining the opportunity. Differences in beta waves demonstrate that entrepreneurs are trying to solve the problem with higher cognitive capacity and also, they use their existing knowledge to recognize the opportunity. Similar findings are seen in the research on opportunity identification (Zaro et al., 2016). In their research higher activation has been observed in the right frontal and right temporal regions during opportunity identification in entrepreneurs' brains. This situation can be explained by the statement of Morris et al. (2011) "It is argued that the entrepreneur and venture emerge as a function of ongoing experience, with the venture creating the entrepreneur as the entrepreneur creates the venture.".

7. CONCLUSION

Based on the research findings, different brain activities take place and different neural networks are used during creative thinking and opportunity recognition in the brains of entrepreneurs and non-entrepreneurs. One of the important findings obtained in this research is that entrepreneurs used their memories during opportunity recognition. As mentioned in the opportunity recognition literature, entrepreneurs make use of their existing knowledge and past experiences (Ardichvili & Cardozo, 2000; Shane & Venkataraman, 2000; Ardichvili et al., 2003) when defining whether a situation in the environment is an opportunity.

It is thought that the findings obtained in this research will be supported by different studies in the field of neuroentrepreneurship or will be enriched with different findings. The number of studies in the field of neuroentrepreneurship is still very limited. However, the entrepreneurship literature offers many research subjects to researchers who want to study in this field. Risk taking is one of the most used characteristics in the literature to distinguish entrepreneurs from others. Risk taking can be investigated with appropriate experimental design. Entrepreneurial alertness associated with perceptions is another important subject to be examined. Perception is a suitable subject to be researched by neuroscience techniques. In addition, experiments with different control groups are also important. For example, the decision-making skills of entrepreneurs and managers in risky situations can be compared. Explaining how the entrepreneur's brain works and its differences will help to clarify many issues that could not be answered about entrepreneurship. Moreover, research on brain activity of entrepreneurs will guide the improvement of interrelated processes such as the number of entrepreneurs, the quality of the entrepreneurial idea, and success of the entrepreneurship. For example, our research findings indicate that existing knowledge is important for opportunity recognition. Getting to know the entrepreneur's brain and having more information about it can guide the reorganization of the content of entrepreneurial education. The brain-based explanation of the variables that determine the quality of the entrepreneurial idea will make it easier for investors to invest in the right entrepreneurial ideas. However, the limits in

this field should be well known. Each of the studies should be seen as important steps taken on this path. But it should be known that such studies are not one-time studies that can give results in a short time. It is necessary to conduct a lot of research examining the brain activity of entrepreneurs and to obtain a larger sample size.

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