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Neuroentrepreneurship a new paradigm in the management science

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Abstract

The primary objective of the paper is to present the essence of the new paradigm in the management science, which is neuroentrepreneurship. This objective determined the paper's layout. In the first part, the theories of entrepreneurship are presented, including the context of research on entrepreneurship. In the second part, the techniques of cognitive neuroscience are described, which are used to determine the impact of thought processes on the recognition and use of a business opportunity by an entrepreneur. This part also analyses the new paradigm of management sciences, i.e. neuroentrepreneurship. In this respect, the most important achievements of science in diagnosing the impact of neuronal impulses on the entrepreneurial process are presented.

Keywords: entrepreneurship; entrepreneur; neuroscience; neuroentrepreneurship;

1. Introduction

Nowadays, entrepreneurship is a multidimensional and multi-pragmatic science. This is due to the fact that scientists from different fields and disciplines use different research methods and techniques to explain the essence of entrepreneurship, which is the effect of different research perspectives. In many studies, entrepreneurship is viewed from the perspective of an active human being - an entrepreneur who aims at discovering yet unknown market opportunities [1]. In this research line, entrepreneurship is examined in terms of entrepreneurs' attitudes,

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behaviour and characteristics [2]. To this end, researchers analyse entrepreneurship by means of techniques and methods derived from cognitive and behavioural sciences. In the cognitive science approach, entrepreneurship is considered in the context of the entrepreneurial mindset and heuristic theories [3]. An important aspect in this respect is the identification of cognitive mechanisms that allow the entrepreneur to make decisions faster and more effectively [4]. From the behavioural point of view, scientists analyse the decision-making process through the prism of entrepreneur's behaviour and competence. In the approach of cognitive theories, however, entrepreneurship is examined from the perspective of social theories focused on thought patterns [5]. Thus, according to the functionalist paradigm, the decision-making process of entrepreneurs is conditioned by cognitive neuroscience [6]. Following this trend, when identifying the essence of the neurological basis for entrepreneurs' decision making and decoding the decision-making process, the scientists try to distinguish the determinants conducive to decision making concerning utilisation of business opportunities. Moreover, scientists analyse the essence of cognitive processes taking place in the entrepreneur's brain, which help to overcome uncertainty, examine the process of seizing entrepreneurial opportunities basing on neural impulses, and, finally, try to create neurocognitive models that are designed to explain the phenomenon of entrepreneurship [7].

Regardless of the scarcity of relevant studies, scientists increasingly often postulate to include neuroscience in cognitive processes that are related to the exploration of a new paradigm, i.e. neuroentrepreneurship. They primarily advocate the study of cause and effect relationships related to the functioning of the entrepreneur's brain which affects their risk-taking capacity [8], their entrepreneurial intentions and competences[9], their skills to adapt to the conditions existing in the environment as well as the processes of pursuing business opportunities. [10].

In view of the above, as well as the fact that research on the new neuroprofessional paradigm is still at an early stage of development, it seems appropriate to try to analyse the role of this paradigm in explaining the entrepreneurial process. Thus, the most important theoretical aspects of entrepreneurship, as well as methods and techniques of cognitive neuroscience which are used to identify entrepreneurial processes, will be presented in the further part of the article. Considerations on the above issues will be the basis for presenting the most valuable achievements for both science and practice in terms of explaining the essence of neuroentrepreneurship.

2. The essence of entrepreneurship

The complexity of issues and research related to the exploration of entrepreneurship is a reason why scientists are constantly looking for one common definition. Basing on the accomplishments of the pioneers of the entrepreneurship theory, we may state that entrepreneurship in terms of classical discourse should be analysed in the context of human activities undertaken in pursuit of market opportunities and human capacity to bear risks [11]. The desired effect of these activities is that the entrepreneur makes a profit resulting from the process of transferring his resources from areas of lower productivity to areas of higher productivity [12].

In the neoclassical discourse, entrepreneurship is seen as creative destruction that determines the process of disrupting routine by an entrepreneur and implies a process of change in the existing structure [13]. As a consequence, innovation is created, which is the basis for entrepreneurial activities. At the same time, researchers define innovation as the entrepreneur's purposeful, organised, systematic and rational action aimed at creating new products, services, processes or new markets [14].

Beside classical and neoclassical discourses, entrepreneurship is also analysed in the literature as a function of human qualities [15]. What is emphasised in this respect is the importance of entrepreneurial qualities that shape entrepreneurial behaviour in the process of making internal changes (relating to a given human being) and external ones relating to the environment in which a given individual lives. The most frequently listed qualities include: dynamics of action, leadership skills, ability to see opportunities, ability to act in conditions of risk and uncertainty, creativity, independence, ability to adapt, internal motivation, extraversionality, compliance, meticulousness, and openness to experience. With the above qualities in mind, it is worth noting that regarding the first quality, i.e. the dynamics of action, researchers characterise entrepreneurship through the prism of an active entrepreneur who shows initiative and constantly seeks new solutions in ways to improve methods or processes taking place in a given organisation. Also underlined is the importance of the second feature, mainly the entrepreneur's leadership skills [16]. This quality is understood as a process of prioritising objectives and values in the organisation and, at the same

time, setting out a plan how to reach these objectives. Another quality is the ability to see opportunities, which is reflected in an individual's constant pursuit of new opportunities in the environment. The capacity of a person to act, and in particular to overcome risks and uncertainties, is also essential, as well as the skill to adapt to the changing environment and internal motivation which is necessary for the entrepreneur to act persistently and effectively in order to gain benefits [17]. It should not be forgotten that an important entrepreneurial quality is extraversionality which concerns entrepreneurs who are optimistic and establish contacts easily. What is more, researchers claim that one of the vital entrepreneurial qualities is meticulousness, meaning the observance of existing laws and regulations by entrepreneurs and their willingness to learning from the experience of others as regards problem-solving.

Each of the qualities outlined above affects the diversity of entrepreneurial behaviour, and in particular the ability to take risks, develop motivation and locate an internal sense of control. On the basis of the presented entrepreneurial qualities, a concept of entrepreneurial passion was created [18]. According to the scientists, entrepreneurial passion is intrinsically linked with positive feelings of an individual (joy, optimism, love), which, on the one hand, constantly motivate him/her to act and, on the other hand, make it possible to overcome barriers related to entrepreneurial activity At the same time, the authors of this concept distinguished three types of entrepreneurial identities: an inventor, a founder and a developer. The first type refers to the entrepreneurial unit, which becomes a creator of change through innovation. The second one is reflected in the starting a business in order to commercialise innovations and take advantage of emerging opportunities. The third type is related to the desire to develop an operating company [19].

With regard to the above considerations, it should be noted that entrepreneurship is identified with the process of pursuing entrepreneurial opportunities which the literature on the subject divides into four types: imitative, allocative, exploratory and creative [20]. The imitative ones are a common type of entrepreneurial opportunities recognised by an entrepreneurial person. By observing how the opportunities are used by other organisations, an entrepreneur al unit implements good practices in this respect, thus reducing the risk of making a mistake and minimising the costs of operation. The second type of opportunities is related to the inadequacy of the environment which encourages the process of relocating resources from low to high performance areas. In this sense, entrepreneurship is identified with decisions to allocate resources in areas that ensure more effective and cost-effective use. Taking into account exploratory opportunities, an essential element in this category of opportunities is an individual's sensual perception based on experience, knowledge and information that he/she has. Another important element is inductive thinking, which makes the process pursuing entrepreneurial opportunities more realistic. The final type of creative opportunities refers to the process of exploring opportunities by an entrepreneurial individual. It is possible thanks to multiple attempts, experiments and mistakes made by a given individual in the course of actions. Thus, creative opportunities arise only when the organisation allows them to happen [21].

Beside the presented concepts, today entrepreneurship is also analysed in the context of the company's operation. In this respect, the literature most often identifies entrepreneurship in accordance with three criteria, namely:

- organisation’s innovativeness,
- organisation’s development,
- organisation’s growth .

In the first perspective, entrepreneurship is seen in a similar way as in neoclassical discourse in the context of creating radical innovations in an organisation . In such an approach, the process of creating innovation is, on the one hand, a result of the entrepreneur's creative inspiration and, on the other hand, it is a pattern to follow for other individuals. In this respect, it should also be borne in mind that in the literature on the subject, entrepreneurship has been increasingly often identified with incremental innovations, which mean minor improvements of processes taking place in the organisation [22].

As regards another criterion, i.e. the development of the organisation, entrepreneurship identified with a set of actions aimed at improving the performance of the enterprise in a given environment [23]. This envelopes all practices that the organisation implements in order to develop not only in respect of its competitors but also its self-development.

In the last category, i.e. the growth of the organisation, entrepreneurship is analysed through the prism of sales value dynamics, market share dynamics, asset value growth and employment growth.

An important scientific discourse within which entrepreneurship is analysed is the context of entrepreneurial management. In this perspective, Drucker's concept of entrepreneurial management is quite often promoted. This concept refers to the activity of an entrepreneurial entity who implements innovations not only of technical and product-oriented nature (hard innovations), but also of social nature (soft innovations). The latter type of innovation refers directly to entrepreneurial management which is conditioned by the type and size of the organisation [24].

According to Drucker's theory the following types of entrepreneurial management can be distinguished: entrepreneurial management in a large enterprise, entrepreneurial management in a small start-up and entrepreneurial management of a public institution [26]. According to the researcher, in a large enterprise, on the one hand, it is easier to create and implement innovations due to having considerable (in comparison with other entities) financial resources. On the other hand, entrepreneurship has no natural, spontaneous character, as it is determined by the application of certain management rules. Thus, the existing bureaucracy and conservatism in a given organisation significantly constrains its entrepreneurial capacity. However, according to Drucker, a large organisation can be a source of entrepreneurial activity thanks to well-managed teams. A necessary condition is to establish the structures that facilitate the implementation of staff's ideas and suggestions. At the same time, an important factor conditioning the emergence of innovations in a large organisation is the building the employees' awareness of the fact how important is the impact of innovations on the growth and competitiveness of the company [27].

Another category is entrepreneurial management of a small start-up. Drucker emphasises that start-ups are characterised by their ability to constantly search for and exploit market opportunities. Their owners are well aware that effective and sustainable operation on the new market largely depends on finding a product or service niche. Moreover, the author of the presented theory underlines that it is typical of small enterprises - as opposed to large entities - to be highly flexible, as well as to have efficient teams of employees. Thus, Drucker, as regards small organisations, does not recommend separating specific structures of employee teams which are designed to create and implement innovations. He believes that all employees of a small enterprise together with its owner should be permanently ready to create innovations when performing tasks related to the current activity of their organisation.

The last type of entrepreneurial management analysed by Drucker is public institution management. The researcher is aware that there are barriers in the public organization that hinder innovative activities. These barriers include: the lack of social acceptance for radical modifications to the institution's operation as well as the fact of funding the activity from the state budget. Despite these constraints, he believes that a contemporary public institution is obliged to implement entrepreneurial type of activity. As a result of the implementation of a new management system targeted at modernising the established norms and principles, the organisation will tailor its existing activity to market reality. Moreover, Drucker proposes that, while setting their goals, institutions should be guided by the so-called principle of economisation, which translates into profit-maximising activities whenever it is possible [28].

Taking into account the above types of entrepreneurial management, it should be stated that regardless of the entity, it is the entrepreneur and the employee who are the driving force of the adjustment process, on which depends whether a given management process will evolve in the direction previously set. Thus, entrepreneurship is a quality that enables the stakeholders of this process to be creative and flexible. Therefore, entrepreneurship is reflected in the ability to monitor one's market environment and the ability to analyse the current situation, to predict future market trends, as well as to implement ideas in practice, both by the entrepreneur and their employees.

To summarise the reflections to date on the essence of entrepreneurship, it should be stated that entrepreneurship in many definitions and contexts, whether in the context of entrepreneurial management, entrepreneurial qualities or company operation is identified with the pursuit of an entrepreneurial opportunity. In such an approach, entrepreneurship is conditioned by sensitising the entrepreneurial human being to market and social changes as well as to these changes inside the organisation that help the entrepreneur use them to achieve their goals.

3. Neuroentrepreneurship

As a result of the development of technologies for measuring brain activity, cognitive neuroscience has become increasingly important in recent years. The essence of cognitive neuroscience is to study the impact of thought processes on the implementation of individual tasks and taking diverse initiatives [29]. In this context, science has proven that the individual cerebral hemispheres are responsible for important mental impulses that condition the process of pursuing opportunities. In the course of their research, scientists have found that the left hemisphere of the human brain is responsible for the accumulation of knowledge and enables an individual to behave according to well-established patterns. The right hemisphere, on the other hand, is oriented towards the search and discovery of innovations [30]. The above assumption has become an impulse for scientists to explore the knowledge about the influence of the human brain on the formation of human behaviour and attitudes, including the entrepreneurial ones [31]. Therefore, the use of various cognitive neuroscience techniques to explain the essence of entrepreneurial activities has become increasingly common [32]. One of these techniques is the brain neuroimaging technique (EEG). The popularity of this method is mainly due to its relatively high availability and low requirements for testing conditions. It is a non-invasive method, which measures the bioelectric brain function using electrodes placed on the surface of the scalp. This measurement is possible through the electrodes placed on the skin [33]. Thanks to them it is possible to examine changes in brain activity over time and to analyse responses to external stimuli. In order to obtain the best possible signal quality, special conductive substances are usually used in the form of gel or liquid electrolyte when applying the cap with electrodes. This further reduces the share of artefacts in electroencephalogram recording. In this respect, it is worth bearing in mind that electrodes not only record the electrical activity of the brain, but also collect the signal generated by other sources of electricity, located in a given room [34]. For this reason, research laboratories are equipped with an electrostatic screen (the Faraday box), whose task is to limit the interference of similar factors that may distort the electroencephalogram.

When analysing electroencephalography in terms of its usability, it should be borne in mind that it has a high temporal resolution, while its weak point is the inability to determine which areas of the brain are responsible for specific actions. To a large extent, this inaccuracy depends on the selection of appropriate electrodes, which register thought impulses and waves in a human brain. It often happens that this measurement is not accurate enough. Despite this shortcoming, this technique is widely used in neuromarketing where, by registering and analysing human brain waves, scientists can determine the level of emotional involvement of a given person exposed to diverse stimuli when, e.g. watching an advertisement or a product offer presentation [35].

As far as the development of cognitive neuroscience technique is concerned, an interesting method has been developed based on functional magnetic resonance imaging (FMRI). Resonance imaging provides images of cerebral structures with much better resolution than in electroencephalography [36]. Instead of the output values that are sent to other areas of the brain, functional magnetic resonance imaging measures the input values that are processed in the brain. As the result, the images produced as a result of the magnetic resonance can be used to identify what information and impulses determine a specific human action [37]. The biggest advantage of this method is a high accuracy of measurement and a huge number of collected data, which can be analysed and used as a basis for conclusions. Compared to electroencephalography, this method permits a more complete and accurate reading of brain functionality [38]. However, it should also be borne in mind that it has a much poorer temporal resolution, which may be insufficient to study the dynamics of certain cognitive processes.

Another technique applied in cognitive neuroscience is the measurement of spatial distribution of visual attention, i.e. eye tracking [39]. This method allows researchers to identify the key elements of the image that attract human attention the most. By using this technique, it is possible to precisely determine on which elements of the visual area the tested person focuses his or her attention and for how long individual components of the image have been watched. The spatial distribution of visual attention can be measured either in laboratory or in the environment in which the person functions on a daily basis [40]. It is also worth adding that in contrast to neuroimaging and functional magnetic resonance imaging techniques, the results of eye tracking studies can be expressed in a numerical form. In this respect, it is helpful to analyse descriptive statistics, by means of which it is possible to determine the time, frequency and number of visual fixations, i.e. the moments when the visual gaze is maintained on a single location. Furthermore, it should be borne in mind that the eye tracking is a non-invasive method that can measure many key parameters related to brain activity while solving various cognitive tasks. It helps to show how,

by analysing the eye activity (the focus map), various strategies of problem solving can be examined. The results obtained by means of the eye tracking method may be an extremely valuable source of information helping to understand cognitive mechanisms, as well as to determine strategies when solving problems of varying degrees of difficulty [41].

Another quite common technique used in cognitive neuroscience is the Galvanic Skin Response. The method allows to measure eclectic changes on the skin surface under the influence of a given stimulus[42]. The measurement of the skin-galvanic response is carried out by determining the value of the electrical resistance of the skin, which is dependent on the level of its hydration, and this in turn is the result of the body's response to external stimuli. Testing is carried out by passing a low voltage current between two electrodes placed on the subject's skin. This current is described by two main components, i.e. skin conductance level (SCL) and skin conductance response (SCR). SCL is a current that is responsible for slow signal changes and is measured in second or minute intervals. Its baseline value depends on the individual characteristics of the subject, therefore, when comparing results between units it is necessary to normalize data. The second, complementary type of current is the phasic component, or the skin conductance response. This current is responsible for a rapid change of the signal occurring in response to a specific stimulus, the signal peak. It is described by a number of indicators, i.e. amplitude or arousal time, which depend on the type of activation [43].

With regard to the above techniques, it should be noted that scientists are increasingly advocating the use of cognitive neuroscience methods in explaining the brain activity of an entrepreneur in the decision-making process [44]. At the same time, they believe that modern research on entrepreneurship cannot ignore the fundamental components of the entrepreneur's performance in their environment, one of those components being the functioning of the entrepreneur's brain [45]. In this respect, however, science world is divided, as some researchers share the view that the use of cognitive neuroscience methods and techniques in explaining entrepreneurial processes is groundless. This is mainly due to the fact that neuroscience is unable to understand processes related to the essence of entrepreneurship, which is based on quite considerable uncertainty and complexity. Furthermore, according to some scientists, the results of neuroscience experiments can significantly distort the substance of the entrepreneurial process [46]. Despite some criticism regarding the application of neuroscience to explain entrepreneurial processes, scientists more and more often refer to studies on the role of entrepreneur's senses on the process of pursuing business opportunities. This new paradigm in science is referred to as neuroentrepreneurship. This trend assumes that the process of recognising and seizing business opportunities is stems from the theory of entrepreneurial cognition, which in turn highlights the environment as the main source of the entrepreneur's pursuit of business opportunities [47]. At the same time, it is assumed that in spite of being recognised by the entrepreneur, this opportunity would not be used if the so-called neural impulse [48] did not appear. This impulse triggers thinking processes that take place in cerebral hemispheres. The right brain hemisphere is responsible for thinking processes that are not consciously controlled. These processes are based on intuition and associative memory. The left hemisphere, on the other hand, is where thinking is focused and conscious. Thanks to the synergy of processes in both hemispheres, the entrepreneur gains the exploratory and creative abilities as regards allocation of physical and intangible resources [49].

Due to the facts that research on neuroentrepreneurship was initiated a few years ago, the publications on the subject are still scarce in literature. With this in mind, the table below gives an overview of the main achievements in this field.

Table 1. Neuroentrepreneurship .

Authors	Applied cognitive neuroscience technique	Findings
Ortiz-Terán (2013)	EEG	• Entrepreneurs make decisions faster than others through better synergy of the brain hemispheres; • Entrepreneurs have a better ability than others to feel in control, to be visually sensitised and to respond to external stimuli, which promotes faster and more efficient use of entrepreneurial opportunities.
Laureiro-Martínez (2014)	fMRI	• Entrepreneurs are characterized by a higher than managerial efficiency when pursuing entrepreneurial opportunities. This is

		due to the more powerful processes taking place in the front polar cortex (FPC); • Entrepreneurs make more effective decisions than managers thanks to feedback from neural impulses; • The processes associated with the utilisation of entrepreneurial opportunities are conditioned by neural impulses which are responsible for the sense of anticipating a reward for the undertaken action. On the other hand, the processes associated with seeking an entrepreneurial opportunity are conditioned by neural impulses that are responsible for the sense of control; • Processes associated with the search for opportunities, as opposed to taking advantage of opportunities, lead to the entrepreneur's greater emotional involvement.
Zaro (2016)	EEG	• The right hemisphere of the entrepreneur's brain is responsible for seeking new entrepreneurial opportunities, while in the case of non-entrepreneurs it is the left hemisphere; • With regard to risk capacity, it has been found that there are no significant differences in the functioning of the hemispheres of entrepreneurs and non-entrepreneurs, as the process of risk-taking occurs the right hemisphere. However, research has shown that entrepreneurs, unlike others, are capable of performing a detailed risk analysis.
Bernoster (2018)	EEG	• The neuroplasticity helps shape entrepreneurial attitudes, sense of control, entrepreneurial intentions, entrepreneurial norms and the entrepreneurial orientation of an individual.
Shane (2019)	fMRI	• Neural impulses occurring in the entrepreneur's brain determine the presence of a positive correlation between the entrepreneur's passion for entrepreneurship and the entrepreneur's ability to invest time and money in their business; • The greater the entrepreneur's passion, the stronger the capacity to take risks and seize business opportunities.
Lahti (2019)	fMRI	• Neural stimuli experienced by entrepreneurs minimise the impact of negative emotions, such as the sense of fear and anxiety related to their functioning in the environment; • Owning an enterprise determines the entrepreneur's sense of certainty and responsibility; • Entrepreneurs feel similar emotions to parents caring for their children, i.e. a sense of belonging, agency and security.

Own work based on: [50]; [51]; [52]; [53]; [54]; [55].

4. Discussion and conclusions

On the basis of the above considerations, it is clear the role of neuroscience in explaining the entrepreneurial process is important from the point of view of developing an entrepreneurial discourse. Conclusions from neuroscience research confirm that entrepreneurial intentions and actions are the result of feedback between the neural impulse and thought processes occurring in the right and left hemisphere. Moreover, science has also diagnosed that stimulating entrepreneurship is possible through emotions that condition specific entrepreneurial behaviour and attitudes in the decision-making process.

Although the knowledge about the human brain functioning is still fragmentary and multithreaded, it must certainly be said that the development of cognitive neuroscience confirms that entrepreneurship is the result of a dynamic feedback between neuroplasticity and the stimuli that affect it. Moreover, neuroplasticity indicates the key role of support and action in the development of entrepreneurial attitudes of the entrepreneur. It is the neurotransmitters that flow from emotions that stimulate decisions and actions taken by entrepreneurs. It should also be stressed that an entrepreneur's brain can and should be trained like muscles. Thus, according to the research findings, a given person's entrepreneurial traits and behaviour can be developed thanks to the multiple repetitions of behaviours and thoughts (2). More importantly, it has been proven that the brain of an entrepreneur can also change under the influence of purely mental activities, e.g. meditation or cognitive-behavioural therapy.

It should be noted that cognitive neuroscience has made a distinction between two cerebral hemispheres in terms of modes of thought, i.e. system 1 and system 2. The former is responsible for fast thinking that automatic, without

or with little effort, and unconscious. This system is the core of associative memory and includes intuitive and automatic thought. In the latter system thoughts are formed slowly and consciously. This system distributes the necessary attention between activities that require mental effort and is responsible for continuous monitoring of one's behaviour.

To recapitulate, researchers are constantly carrying out studies that broaden their knowledge of the brain nature and processes. However, despite the limitations stemming from multithread character of research on entrepreneurship and the complexity of studies on the functioning of the human brain, cognitive neuroscience techniques should be more and more frequently used to analyse the process of recognising and seizing entrepreneurial opportunities. It is obvious that new research may appear at any time, also the ones refuting today's state of knowledge, e.g. on the influence of the entrepreneur's cerebral hemispheres and neurotransmitters on their decision making. Despite this constraint, it seems obvious that the advances in neuroscience should be an obligatory perspective for research on the personal characteristics and behaviour of entrepreneurial people. This is due to the fact that, thanks to the findings of cognitive neuroscience research, the theory of entrepreneurship is being enriched with issues related to neuro stimulants of entrepreneurial decision making, which results in a better insight into the phenomenon of the entrepreneurship process.

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