

Working Paper

'It Takes Three to Tango': Brain, Cognition and Entrepreneurial Enhancement

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‘IT TAKES THREE TO TANGO’: BRAIN, COGNITION AND ENTREPRENEURIAL ENHANCEMENT

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ABSTRACT

In the global clash for unveiling the ‘innermost secrets’ of the brain, the field of neuroscience is the most fitting contender. Neuroscience is not quite ready to win the war for now, but it is assuredly equipped to win some battles. Notwithstanding that entrepreneurship is fundamentally a brain-driven phenomenon, entrepreneurship research based on neuroscience’s tools cannot be counted on the fingers of more than one hand. Grounded on a prior literature review that investigates the state of neuroscience’s use in entrepreneurship research, this position paper reflects on the future implications that the utilization of neuroscience brings to entrepreneurship research and cognition. To articulate this exercise, I present the so-called five ‘winds of disruption’ to signal where to go next in the study of entrepreneurship from a brain-driven perspective. Next I spell out four ways to maximize neuroscience’s inputs into entrepreneurship research. Furthermore, I synthesize the value of three neuroscience-based tools to rear and boost ‘entrepreneurial enhancement’, the ultimate challenge in the orbit of entrepreneurship research.

Keywords Entrepreneurial neuroscience, neuro-entrepreneurship, entrepreneurial enhancement, cognition, brain-driven entrepreneurship, entrepreneurial enhancement

JEL-Classification L26, M13, O33

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1 INTRODUCTION

As Benjamin Franklin observed, ‘When you are finished changing, you are finished’. The development of the field of entrepreneurship since its birth has been led by a variety of fields: from economics to social sciences to management studies (Lohrke & Landström, 2010). Recently investigations into how entrepreneurs think, more often known as ‘entrepreneurial cognition’, have become one of the major research instigators among entrepreneurship scholars. Entrepreneurial cognition research, however, presents methodological (Omored, Thorgren, & Wincent, 2015) and theory-building hindrances (Kraus, Meier, & Niemand, 2016; Pérez, 2017b) which neuroscience could bolster.

The cognitive focus of this field coupled with recent advances of neuroscientific technologies and methods is pushing the winds of change in various directions; it is a signal that has already been decoded by some entrepreneurship scholars (Blair, 2010; de Holan, 2014; McMullen, Wood, & Palich, 2014; Nicolaou & Shane, 2014; Pérez, 2017a; Smith, 2010). I call this ‘the new emerging wave’: the brain-driven entrepreneurship research era, or simply the ‘brain era’.

This new aeon will invigorate and replace the study of what entrepreneurs are or have (attributes) and what they do (behaviors) based on what entrepreneurs think, how they think, why they think the way they do and how they came to think that way (de Holan, 2014), aided by the ‘magic’ of neuroscience techniques and methods.

I am warned that attempting to predict where the future lies for entrepreneurship research is no easy task because one could very easily go astray (Wiklund, Davidsson, Audretsch, & Karlsson, 2011). Thus in this position paper, based on a prior review on the state of brain-driven entrepreneurship research (Pérez, 2017a), I undertake a reflective exercise to elaborate on the future contribution of neuroscience to entrepreneurship research and cognition in particular.

Tangibly, this position paper builds upon three outputs: First, I reveal the five winds of disruption that neuroscience will implant into entrepreneurship and cognition research. Second, I introduce four ways in which neuroscience adds value to entrepreneurship in order to improve and develop it. Finally, I elaborate on three neuroscientific tools that will be particularly instrumental in the fulfillment of the ultimate goal of entrepreneurship research: ‘entrepreneurial enhancement’.

2 THE CONSTRAINT OF ENTREPRENEURIAL COGNITION RESEARCH EFFORTS

The progress made in entrepreneurial cognition research is valuable, fascinating and growing in full swing. Randolph-Seng, Mitchell, and Mitchell (2014) report that current research developments on this topic laser-focus on four themes: theory, entrepreneurial affect, entrepreneurial neuroscience and entrepreneurial thought.

Some of the late research developments within the issues highlighted by Randolph-Seng, Mitchell, et al. (2014) shed light on the transition from static to dynamic cognitive research (Randolph-Seng, Mitchell, et al., 2014); link cognitive factors, such as intentions and motivations, to goal setting (Carsrud & Brännback, 2014); highlight the role that entrepreneurial behavior plays as one of cognition's most observable outcomes (Bird, 2014); touch upon the intersection of non-conscious cognition, entrepreneurial intentions and intuition (Randolph-Seng, Williams, & Hayek, 2014); allege that the affective/cognitive connection exerts influence across time and levels of analysis (Foo, Murnieks, & Chan, 2014); and draw attention to various types of affective/cognitive forces depending on their enduring versus episodic nature and their plane of influence (Grégoire, 2014).

Other researchers who propose a culturally-situated model that relates entrepreneurial emotions/passion and cognition/self-efficacy to explore how these factors affect venture performance (Drnovsek, Slavec, & Cardon, 2014) claim that entrepreneurs' brains are physiologically the same but different in terms of their experiences and knowledge (Baucus, Baucus, & Mitchell, 2014). They also elucidate the formation and successful implementation of opportunity beliefs (McMullen et al., 2014), propose new ways of thinking about advances in large-scale codification processes (media, for example) and in network formation (markets and social structures) (Forbes, 2014) and allude the formative role of language in shaping the ideas of entrepreneurs (Clarke & Cornelissen, 2014).

It is palpable that these research advances are noteworthy; nonetheless they hold methodological, theoretical and technological hindrances that could be strengthened by neuroscience. These drawbacks are summarized by Omorede et al. (2015): 'some cognition topics that are interesting to advance are also methodologically challenging, because it is difficult for people to reflect on their own conscious processes. Studies of the brain and procedures such as brain scanning are suggested as a next step' (p. 766).

The 'next step' is challenging because it not only necessitates that neuroscience move 'fast and furious', but because the incorporation of neuroscience tools and methods will tweak the way in which the field of entrepreneurship is researched, reflected, taught, practiced and fostered. The 'creative

destruction' that the use of neuroscientific tools and approaches will produce in the ambit of entrepreneurial research and cognition is necessary and, to a large extent, impending.

3 THE FIVE DISRUPTIVE WINDS OF NEUROSCIENCE IN THE FIELD OF ENTREPRENEURSHIP

The horse, one of the most remarkable prime movers on earth, ruled 19th century urban life and rural culture in both Europe and North America. Then along came the combustion engine; however, it took the automobile nearly 50 years to dislodge the horse from farms, public transport and wagon delivery systems (Nikiforuk, 2013).

Neuroscience methods and techniques might not be perfect, as neuroscience is not as seamless as the prototype of the first combustion engine, but its potential (Blair, 2010; de Holan, 2014; Nicolaou & Shane, 2014; Smith, 2010) to impact the field of entrepreneurship is promising.

I foresee five winds of disruption through which neuroscience is to alter the path of entrepreneurship research and cognition. These winds of change will reshape the field of entrepreneurship from the stances of research, education, pedagogy, practice, philosophy, technology and policy-making. Again, similar to how the transition from the use of horses to the combustion engine took half a century, the transition between traditional entrepreneurship and brain-driven entrepreneurship research (Pérez, 2017a) will take some time. The first wind of disruption is to influence the way research is done in entrepreneurship. The second is to shift existing pedagogies to educate students and aspiring and existing entrepreneurs. The third wind of change is to transform the practice of entrepreneurship. The fourth is to reshape the philosophical roots of the field, whilst the fifth wind of disruption is to modify the strategies and measures to foster entrepreneurial development.

3.1 Disrupting the philosophical grounds of entrepreneurship research

The faint philosophical grounds of entrepreneurship will also be shaken when fused with neuroscience. This disruption pushes the transition from a 'traditional' to a 'brain-based philosophical' view of entrepreneurship. As the brain gives rise to consciousness, emotions, thoughts and the most basic human functions, there is a need for entrepreneurship scholars to address social and ethical questions specifically raised by brain research (Evers, 2017).

The field is still scrambling to gain philosophical legitimacy. In addition to furthering its acceptance, entrepreneurship scholars must face the neuroscience wave. On one hand, ontological, ethical and epistemological grounds concerning the nature of entrepreneurship are in their infancy in their growth toward a philosophy of entrepreneurship (Hjorth, 2014). On the other hand there is agreement that an axiological view of the field is needed (Kyrö, 2015).

For instance, various studies mainly reflect on the ethical principles (Staniewski, Słomski, & Awruk, 2015) and norms of behavior for specific entrepreneurial moral dilemmas (Hannafey, 2003) and the epistemology of entrepreneurship (Alvarez & Barney, 2010; Diamond, 2012; George & Marino, 2011; Karatas-Ozkan, Anderson, Fayolle, Howells, & Condor, 2014), but the philosophical implications of the use of neuroscience in the field of entrepreneurship from the perspective of researchers, entrepreneurs, policy makers and students remain uninvestigated.

Such inertia will be slowed because brain-driven entrepreneurship research, as any other study that collects data from the brain, raises important ethical and social challenges, such as issues surrounding data protection or 'dual use', that must be considered if we are to reap the benefits of this research whilst avoiding putative pitfalls (Evers, 2017).

Neuroscience devices do not enter the subconscious but provide information on the brain areas activated against a stimuli; they do not invade an individual's private world and their interests but rather create a way to find objective answers to questions (Olteanu, 2015).

As a result new ethical issues are arising in terms of safety, social competition and changing the human condition (Fuchs, 2006). For instance, brain enhancement raises the question of whether we want to change the human condition by manipulating our subjective experiences, cognitive abilities and personality traits (Fuchs, 2006).

Following the recommendations of Olteanu (2015), I portray some of the ethical standards that brain-driven entrepreneurship scholars are to face as an aftereffect of this disruption: identifying the national and international laws relevant for their study, including the national ethics committee whose consent is required; identifying vulnerable populations who should be protected from brain research; requiring that subjects sign agreement papers, after understanding the effects of participating in such a study, as research procedures involve brain activity monitoring; being cautious of reverse inference while analyzing the brain regions involved in the research to assure internal validity; and identifying cases in which results may be misused and abused and act accordingly to protect society and vulnerable populations.

3.2 Disrupting the way in which entrepreneurship is researched

The practice of entrepreneurship research will be affected by neuroscience because the 'social-sciences' research paradigm currently in force will evolve into a 'naturalistic' research approach, urged to borrow methodological insights from 'medical research' and move towards the increasing adaptation and application of clinical-like studies.

The research of entrepreneurship has been driven mainly by methods derived from social sciences (quantitative, qualitative, mixed methods, and so on) which have been majorly oriented to evaluate the past of the entrepreneurship phenomena: How and why did it happen?

Nevertheless, the promise of neuroscience goes beyond the exploration of the past and rather points to the careful and controlled building of the future: Why should we aim for it? and how can we make it happen? This is something that Japanese neuroscientists call 'brain management'.

Put simply, fueled by neuroscience the field is to move from a retrospective to a prospective research approach. Whereas in retrospective studies data is collected from the past, either through records created at that time or by asking participants to remember their exposures or outcomes, prospective studies follow participants forward through time, collecting data in the process (Thiese, 2014).

For instance, the use of neuroscience to enhance entrepreneurial learning could be addressed from the angle of the so-called interventional clinical studies.

Interventional study designs, also called experimental study designs, are those where the researcher intervenes at some point throughout the study (Thiese, 2014). The objective of an interventional clinical study is to compare treatment procedures within a patient population, which should exhibit as few internal differences as possible, apart from the treatment (Neugebauer, Rothmund, & Lorenz, 1989). Possible therapies include a drug, an operation, the therapeutic use of a medical device such as a stent, physiotherapy, acupuncture, psychosocial intervention, rehabilitation measures, training or diet (Röhrig, du Prel, Wachtlin, & Blettner, 2009). Applying these inputs to entrepreneurship research implies the implementation of interventional study designs to test, monitor and fine-tune neuroscience-based therapies to, for example, elucidate, stimulate and enhance skills development among a variety of target populations: aspiring and existing entrepreneurs, entrepreneurship students and others.

Forasmuch as interventional studies are by nature experimental, they fit within the current need of the field for experimental methodologies (Shane, 2003). Therefore in addition to their prospective role, the adoption of a naturalistic approach will help lessen the internal validity problem of empirical research in entrepreneurship (Foo et al., 2014; Krueger & Welp, 2014) and upgrade the role of entrepreneurship researchers to research scientists.

3.3 Disrupting the fashion in which entrepreneurship is taught

There is agreement among scholars, practitioners and policy makers that entrepreneurship education¹ should meet the social and economic needs of all stakeholders involved: pupils, students, families, organizations and countries (Fayolle, 2013). However, the brunt of existing efforts to ‘train’ students and aspiring entrepreneurs is minor and insufficient. Studies on this matter reveal two key weaknesses: excessive focus on short term and subjective impact measures, such as entrepreneurial attitudes and intentions, instead of longer ones, such as venture creation and business performance; (Henry, Hill, & Leitch, 2005; Pittaway & Cope, 2007) and lack of research that links entrepreneurial outcomes to specific pedagogical methods (Pittaway & Cope, 2007).

The mitigation of these weaknesses gains momentum because of the recent links that have been established between neuroscience and the contexts in which teaching and learning take place (Beauchamp & Beauchamp, 2012), as well as because of a late scholarly interest on the subject of entrepreneurial learning (Loi, Castriotta, & Di Guardo, 2016).

Now greater than ever there is little doubt that neuroscience may add value to educational practice. Studies of brain activity can elucidate learning processes (Weigmann, 2013) which may disentangle entrepreneurs’ learning processes and help to swell what Loi et al. (2016) calls ‘training effectiveness’.

Despite that a recent study undertaken by the European Commission concludes that entrepreneurship education has a positive impact on a variety of outcomes (EC, 2015), more research-based reviews reconfirm the above mentioned weaknesses (Nabi, Liñán, Krueger, Fayolle, & Walmsley, 2016) and overall small but positive effects on the development of entrepreneurial intentions, but they also warn that results have to be interpreted with care (Bae et al., 2014; Martin et al., 2013). The above advocates that, for the most part, the epicenter of entrepreneurship education efforts since its genesis has been placed on ‘training’ students with unconvincing results.

If the question is how, when, and why students develop entrepreneurial competencies (Lackéus, 2015); if we regard entrepreneurship education as ‘content, methods and activities that support the development of motivation, skill and experience, which make it possible to be entrepreneurial, to manage and participate in value-creating processes’ (Moberg et al., 2014, p. 14); if the goal is to harmonize entrepreneurial competences with 21st century skills, such as creativity, problem solving, social competence and resilience, then this wind of change is looming because neuroscience is proving its faculty to adjust the daedal mental processes behind learning (Katwala, 2016).

¹ This study regards entrepreneurship education as ranging from a relatively short training course that focuses on core entrepreneurship knowledge and skills related to starting a particular business (Martin, McNally, & Kay, 2013).

The amalgamation of a brain-driven perspective on entrepreneurship education holds the capacity to upgrade the efficiency and Thrane, Blenker, Korsgaard, and Neergaard (2016) relationships between existing didactics and pedagogies and, while doing so, add value to the attainment of ‘entrepreneurial enhancement’.

3.4 Disrupting the means to achieve entrepreneurial performance

Think of entrepreneurs getting their ‘therapies of entrepreneurial enhancement’ in laboratories or hospitals. Surprised? Don’t be; it is going to happen. A fourth wind of disruption mobilized by neuroscience lies in its capacity to elucidate and stimulate brain-driven mechanisms to boost the development and enhancement of entrepreneurial learning, resulting in a substantial entrepreneurial outcome², a feat not attempted thus far.

For the most part existing efforts within the spectrum of entrepreneurship education are primarily concentrated in the training of potential and possible new entrepreneurs, that is students at various levels of education who voluntarily (aspiring entrepreneurs) or involuntarily (other than the former) are exposed to a variety of entrepreneurship education programs. However, when it comes to entrepreneurship education schemes to support existing entrepreneurs, or individuals who did not pass through any sort of entrepreneurship training but are already immersed in any entrepreneurial activity, these efforts are marginal and little is known on its effect.

The closest research on the impact of entrepreneurship education to entrepreneurial performance among existing entrepreneurs is contradictory, focused more on intentions than outcome and mostly addressed to students than real entrepreneurs. For instance, on the one hand a quantitative review claims a positive correlation between entrepreneurship education and entrepreneurship outcomes (Martin et al., 2013); on the other hand it is underlined that entrepreneurship education’s effect on students’ self-assessed entrepreneurial skills is insignificant, and the effect on the intention to become an entrepreneur is even negative (Oosterbeek, Van Praag, & Ijsselstein, 2010).

This is an area in which neuroscience will have a major say, particularly to the benefit of millions of worldwide necessity entrepreneurs who lack the skills (Webb & Fairbourne, 2016) and economic know-how (Jeremi, 2014) to make a successful transition from survival to growth mode, from traditional (and informal) sectors to modern sectors (Caliendo & Kritikos, 2010; Desai, 2011).

It is known that necessity and opportunity entrepreneurs (Cheung, 2014) differ in terms of their cognitive and non-cognitive skills-set (Calderon & Lacovone, 2017); what remains as a challenge is

² Entrepreneurial outcome relates to financial success (Karlan & Valdivia, 2011).

how to effectively nurture, measure and boost the development of these skills among non-entrepreneurs, entrepreneurship students, aspiring entrepreneurs, existing entrepreneurs and principally necessity entrepreneurs and even opportunity entrepreneurs.

Neuroscience is best equipped to address this challenge because most of the differences between necessity and opportunity entrepreneurs are linked to the nature of their ‘mindset’, which ultimately lies in their brains, the area of neuroscience adroitness. Besides memory, a cognitive skill that has already been recognized as crucial to entrepreneurial excellence (A. R. Baron, 2013), I envision that neuroscience via the conjugated use of neuro-feedback, brain-training and brain stimulation is capable of helping the development of other knowledge structures equally relevant to entrepreneurship, such as attention, speed of processing information and pattern recognition, owing to its knack for affecting the three tenets of information processing: encoding (what is extracted from available input), retrieval (what is recalled and integrated into judgement) and weighting (what is assigned greater and lesser importance) (Balcetis & Granot, 2015).

3.5 Disrupting the efficiency of public policy measures for entrepreneurship promotion, development and enhancement

Public policies aimed at the fostering of entrepreneurship are chiefly based on three measures: output³, attitude⁴ and framework indicators⁵ (Ács et al., 2014). The problem with these indicators is that they are primarily retrospective and aggregated, therefore incomplete for policy-making purposes.

Brain-driven research strongly relates to public policy because it makes possible the gathering of prospective data at a brain level. Such a step forward is to positively impact and heighten the efficiency of extant policies and measures to boost entrepreneurial development, entrepreneurship education and even entrepreneurial enhancement. Put simply, this kind of research can advance the establishment of the most effective means of support (Naudé, 2010).

It helps that presently there is an enormous demand amongst policy makers for new insights from neuroscience matched by an increasing willingness on behalf of behavioral scientists to translate the policy implications of their work (Seymour & Vlaev). Concepts and findings ‘translated’ from neuroscientific research are already finding their way into health and social policy discourse (Broer &

³ Output indicators conceive entrepreneurship as the creation of a new business or an entry into self-employment (Ács, Autio, & Szerb, 2014)

⁴ Attitude indicators track opinions, values and attitudes that are relevant for entrepreneurship (Ács et al., 2014).

⁵ Framework parameters distinguish between framework conditions, entrepreneurship performance and economic impact (Ahmad & Hoffmann, 2008).

Pickersgill, 2015), but due to the complexity of this issue, it will take more time to gain momentum within the confines of entrepreneurship promotion.

The insights of neuroscience should be taken with caution when it comes to translating its findings into public policy (Seymour & Vlaev), but as the gap between findings in neuroscience and its usefulness for education are bridged (Beauchamp & Beauchamp, 2012); as the issues of misapplication⁶, multiple disciplines⁷, language⁸ and knowledge development⁹ are handled (Beauchamp & Beauchamp, 2012); as neuroscience technologies and their methods keep improving; and as its findings get polished, it is only a matter of time for this wind to permeate the field.

To name one of many examples, educational neuroscience studies using neuroimaging have not only revealed for the first time the brain basis of neurodevelopmental differences that have profound influences on educational outcomes, but have also identified individual brain differences that predict which students learn more or learn less from various curricula (Gabrieli, 2016). Think of the policy implications that could arise from this finding; think of the potential of these findings to scientifically measure the impact of the myriad of methods and pedagogies to teach and promote entrepreneurship. I foresee that this wind of disruption together with the theme of entrepreneurial enhancement is to be the most impactful in the years to come. Yet as stipulated earlier, it still requires time to blossom.

4 WAYS TO EXPAND NEUROSCIENCE INPUT ONTO ENTREPRENEURSHIP RESEARCH

Despite its advantages the present added value of neuroscience into entrepreneurship research is minuscule and much constrained to a very limited view of the issue of decision making (Pérez, 2017a). The contribution of neuroscience needs to be speeded up, deepened and progressively fine-tuned. Such an aim could be greatly facilitated in four ways: importing concepts, tools and methods from other branches of neuroscience; considering other levels of analysis of the entrepreneurial phenomena; encompassing the analysis of the various stages of the entrepreneurial process; and proving new neuroscientific mechanisms to nurture and enhance entrepreneurial skills and performance (Pérez, 2017a).

⁶ Inappropriate interpretation and use of neuroscientific findings (Beauchamp & Beauchamp, 2012)

⁷ Problem associated with many disciplines each with their own fundamental theories, epistemologies, origins and methods (Beauchamp & Beauchamp, 2012)

⁸ The fact that education and neuroscience have their own language and that researchers within these disciplines may struggle to communicate (Beauchamp & Beauchamp, 2012)

⁹ Problem associated with gaps in knowledge among individuals attempting to breach the divide between the two disciplines (Beauchamp & Beauchamp, 2012)

Importing theories from other fields is a paramount first step towards developing unique theories of one's own (Zahra, 2007). Simultaneous to the adoption of cognitive neuroscience frameworks, forthcoming investigations could benefit from inputs from other branches of neuroscience such as affective, behavioral, cultural, computational, social, neuroinformatics and systems neuroscience, as these sub-fields could unveil out-of-the box levels of scrutiny on the entrepreneurial phenomena. Low and MacMillan (1988) suggest that entrepreneurship studies could and should be carried out at multiple levels of analysis: individual, team, firm, industry/population, regional and national levels (Davidsson & Wiklund, 2001). A second way to expand the contribution of neuroscience into entrepreneurship should involve other levels of analysis in the inquiry of the entrepreneurial phenomenon, especially farther studies that use neuroscience to investigate an entrepreneurship topic at a team level are highly encouraged. Next to the need for more studies at the individual level, new studies are incited at a team level. For instance, how the interaction (Breugst, Patzelt, & Rathgeber, 2015) and composition of a team influence the team's and the venture's development (Knockaert, Ucbasaran, Wright, & Clarysse, 2011) are two key research areas of entrepreneurial teams that can be approached at a brain-level with the aid of neuroscience.

Existing entrepreneurship studies executed at a brain-level (Laureiro-Martínez et al., 2014; Ortiz-Terán et al., 2013) do not explicitly focus on the stage of entrepreneurial process. A third way to escalate the analytical power of neuroscience includes its use across the three stages of the entrepreneurial journey: the idea or conception of the business, the event that triggers the operations and implementation and growth (Bygrave, 2009). This issue is germane as every stage of the entrepreneurial journey entails differing knowledge structures, skills, expertise and mindsets.

The fourth way is the most relevant as it points to the biggest input that neuroscience could provide to the development of entrepreneurship research, education and practice in the future: the use of neuroscience to create and enhance entrepreneurial outcome. The discovery of neuroscience-based therapies have scientifically cultivated and empowered entrepreneurial performance. Due to the impact it may provoke in every structure of the field, it remains a luscious challenge to be conquered in the future.

5 THE FUTURE GOES TO ENTREPRENEURIAL ENHANCEMENT

The potential of neuroscience in entrepreneurship research (Krueger & Welpel, 2014; Nicolaou & Shane, 2014; Pérez, 2017a) should neither be limited to the topics of behavioral decision theory, game theory, perceptions, emotions and affect (Krueger & Welpel, 2014), nor the exploration of brain processes and brain activations.

Although this static perspective adds value to the scholarship of entrepreneurship, it needs to be revitalized. I hold the vision that the inputs of neuroscience into entrepreneurship research lie in a more dynamic view motivated by a higher challenge: to aim for ‘entrepreneurial enhancement’. Seeing that this term lacks definition, I conceptualize it as ‘the individual or combined use of neuroscience technologies, methods and therapies to scientifically stimulate, create and improve new mechanisms to enhance entrepreneurial behavior, learning and performance, ergo lifting the development of entrepreneurial skills, competencies, expertise, mindsets and other brain-originated features that may arise in the future’.

If entrepreneurship scholarship has the potential to deal with issues that are central to developments in the world (Wiklund et al., 2011), if entrepreneurial learning and performance could be scientifically enhanced, I believe the help of neuroscience should be accepted.

At a macro level four major lines of action have been suggested to enlarge and speed up the synergies between the fields of neuroscience and entrepreneurship: further research based on experimental designs, increase the individual and combined use of brain-assessment technologies, upgrade researchers’ skills in the use of neuroscience methods and tools; and build up interfaculty and interdisciplinary collaborative research (Pérez, 2017a).

At a micro level, I envisage that neuroscience tools and methods are to be notably instrumental because they could revamp the core of entrepreneurial cognition’s research focus: ‘the knowledge structures’ in the words of McMullen et al. (2014) or ‘information processes’ in Forbes (2014) terms. Likewise, I anticipate that the capabilities of neuroscience on influencing Kyrö, Seikkula-Leino, and Mylläri (2008) affective and conative aspects of ‘entrepreneuring’ (Steyaert, 2007) plainly because of these three aspects: cognitive, affective and conative, which originate in the brain of those in the process of ‘becoming’ entrepreneurs (Johannisson, 2016).

In doing so, neuroscience could influence people’s assessments, decisions and capacities involving opportunity identification, business creation and growth. Put briefly, neuroscience will play a key role in the dynamic discovery and improvement of new mechanisms to nourish and heighten ‘entrepreneurial enhancement’ principally, but not only in terms of learning, skills, competencies, expertise, mindset and performance.

Hence, the four major cognitive issues, heuristic-basic logic, perceptual processes, entrepreneurial expertise and effectuation (Mitchell et al., 2007), can be furthered within the umbrella of ‘entrepreneurial enhancement’. In the following section I introduce the three dynamic tools relevant for aiming towards ‘entrepreneurial enhancement’: neurofeedback, braining training and brain-stimulation.

5.1 Neurofeedback

Neurofeedback experimentation is one of the tools suited to conquering ‘entrepreneurial enhancement’; its application may change the game of entrepreneurship research and cognition. Consider the idea of unconsciously deleting your fear memories. Is this brain-wizardry? No, it’s naked, forthcoming reality.

Recent neurofeedback research has led to advances in knowledge of neural function by using brain activity as the independent variable and behavior and thought as dependent variables (Sitaram et al., 2016). In other words, neurofeedback consists of monitoring one’s own brain activity with a view to influencing it (Howard-Jones, 2014a).

The promise of neurofeedback as a scientific tool is beginning to be realized (Perez, 2017; Sitaram et al., 2016), and its use is becoming cheaper (Howard-Jones, 2014a).

For instance, electrophysiological tools to detect neurofeedback activity include electro-encephalography¹⁰ (EEG), magneto-encephalography¹¹ (MEG) and functional magnetic resonance imaging¹² (fMRI) (Perez, 2017).

Late studies tell that neurofeedback is capable of extinguishing fear memories, changing facial preferences and more at a subconscious level (Koizumi et al., 2016). Studies with undergraduates and children point to its effectiveness in improving performance (Howard-Jones, 2014a). Similar to how the horse could not stop the invention of the engine, neurofeedback keeps gaining applicability despite the natural improvement of existing conventional research methods within the field.

The application of this method in entrepreneurship research unfurls possibilities that could lead to specific behavioral changes (Sitaram et al., 2016) and influence a variety of cognition-like themes, such as the reduction and—why not?—elimination of fear of failure (Cacciotti & Hayton, 2015).

After all, fear is a form of memory (Izquierdo, Furini, & Myskiw, 2016), which is a schema (script) (Ghosh & Gilboa, 2014) and deep inside is a ‘knowledge structure’ (Hughes, 2008), and neurofeedback *métier* squarely focuses on altering ‘knowledge structures’ like those of fear memories. Neurofeedback is also beneficial in the enhancement of entrepreneurial skills because learning brain control with neurofeedback is similar to skill acquisition (Sitaram et al., 2016), and entrepreneurial action as memory accounts for much cognitive control of action (Logan, 2008).

¹⁰ EEG is a non-invasive technique that measures the gross electrical activity of the surface of the brain (Carter & Shieh, 2015).

¹¹ MEG records the magnetic potentials produced by brain activity (Banich & Compton, 2011)

¹² fMRI is a tool to study the neural basis of cognition (Aldrich & Carter, 2004).

Furthermore, neurofeedback has proved to improve creative performance (Howard-Jones, 2014a), creative improvisation and measures of attention (Gruzelier, Foks, Steffert, Chen, & Ros, 2014) and cognitive skills learning (Yin et al., 2009), all relevant features to the practice of entrepreneurship and entrepreneurship education.

A recent neurofeedback study conducted among entrepreneurship students, Rahmati, Rostami, Zali, Nowicki, and Zarei (2014), concludes that it helps to increase focus, reduce stress, improve emotional control, increase workload tolerance, increase failure tolerance, self-efficacy, creativity and the internal locus of control.

Another cardinal issue within entrepreneurial cognition is that of opportunity beliefs, which could also be addressed from the perspective of neurofeedback because it oversteps the level of brain activations and brain-mapping suggested by McMullen et al. (2014).

The former can impact the plasticity of complex knowledge structures because the constructs that participate in the formation of states like beliefs, cognition and emotion (Spezio & Adolphs, 2010), can be molded by neurofeedback. The above are a few examples of the applications of neurofeedback to entrepreneurship research, expressly when it comes to the possibility of inducing or changing existing knowledge structures. Entrepreneurial enhancement is attainable, and neurofeedback can help to accomplish it.

5.2 Brain training

A late study undertook by 250 successful entrepreneurs to investigate the primary cognitive and emotional capacities that support their entrepreneurial success reveals that they showed significant elevation in motor processing, cognitive flexibility, recall memory, perceived resilience and positivity bias (Hanna & Gordon, 2016). These sorts of cognitive skills can be augmented with brain training.

Brain training is the second tool that assists entrepreneurial enhancement. It is broadly defined as the engagement in a specific program or activity that aims to enhance a cognitive skill or general cognitive ability as a result of repetition over a circumscribed time frame (Rabipour & Raz, 2012). It is sustained that brain training, especially computer-based, helps to enhance executive functions such as reasoning skills, working memory and inhibition control (Howard-Jones, 2014b). For example, ‘Cogmed¹³’ computerized training studies have shown the transfer of improved working memory to untrained tasks (Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009). A

¹³ Cogmed is a working memory and attention training program developed by Torkel Klingberg, neuroscientist from the Karolinska Institute of Stockholm Brain Institute.

commercial game called Dr. Kawashima brain training game has been reported as improving executive functions, working memory and processing speed in young adults (Nouchi et al., 2013).

Impressively, the ultimate outcomes of entrepreneurship are determined by a wide range of cognitive tasks: attention (staying focused), memory (retrieving and using information obtained in the past), solving problems, making decisions and many other activities having to do with acquisition, processing and use of information (R. A. Baron, 2007). These cognitive skills are also relevant for entrepreneurs because they are associated with higher earnings (Jones, 2011), a key indicator of entrepreneurial performance.

For instance, together with existing cognitive errors and biases, memory is posited to be one of the two highly relevant topics for entrepreneurial excellence (Ariely, 2008) due to its role in prioritizing and processing information, ignoring what is irrelevant and focusing on what is important (Alloway & Alloway, 2014), a fundamental task for entrepreneurial success (A. R. Baron, 2013).

Brain training could help to advance the above tasks and, by doing so, enhance entrepreneurial learning, behavior, skills, expertise, competencies and eventually the entrepreneurial mindset. Other processes that rest on important cognitive foundations such as creativity, alertness, opportunity and pattern recognition (A. R. Baron, 2013) can also be strengthened with brain training.

The role of imagery and visual processing on performance (Cumming & Williams, 2012; Katwala, 2016) are less obvious yet are of parallel pertinence for entrepreneurial excellence; both can be served by brain training. Imagery or simple visualization work because they recruit the same neural circuits that the brain uses for action (Katwala, 2016). Apropos visual processing suggests that 80 per cent of the information we use to make a decision for an action comes from vision and the average person uses their eyes only at 50 per cent of their full potential (Katwala, 2016).

This data is weighty because entrepreneurs are wild creatures driven by consistent action and decision making. In the field of sports it has been proved that brain training on visual training enhances peripheral vision, visual processing, attention and memory (Katwala, 2016). In the domain of entrepreneurship, peripheral vision is argued to augment entrepreneurial learning (Chia, 2008). These are a few of many prospects of brain training that benefit entrepreneurship.

But brain training is not the magic bullet; there is conflicting evidence for the effects of brain training on executive function (Howard-Jones, 2014b), and there is a lack of convincing evidence for anything other than short term effects (Melby-Lervåg & Hulme, 2013). Nonetheless, it is a tool that is improving in efficiency as part of the accelerated development currently being experienced in the sphere of neuroscience.

5.3 Brain Stimulation

The third tool to chase entrepreneurial enhancement is brain stimulation, singularly non-invasive brain stimulation. Since it bypasses the correlative approaches of other imaging techniques, it makes possible the establishment of a causal relationship between cognitive processes and the functioning of specific brain areas (Miniussi, Harris, & Ruzzoli, 2013).

The two most frequently used techniques for noninvasive brain stimulation, transcranial magnetic stimulation (TMS¹⁴) and transcranial direct current stimulation (tDCS (Dettmers et al., 2011)¹⁵), take advantage of different electromagnetic principles to noninvasively influence neural activity (Wagner, Valero-Cabre, & Pascual-Leone, 2007).

Both types of brain stimulation modulate brain activity and in turn modulate cognitive behavior (Veniero, Strüber, Thut, & Herrmann, 2016), hence having therapeutic applications in cognitive neuroscience, neurophysiology, psychiatry, neurology (Wagner et al., 2007) and entrepreneurship. For instance, repetitive TMS and tDCS increases dorsolateral prefrontal cortex (DLPFC) activity and, consequently, working memory performance (Brunoni & Vanderhasselt, 2014), which is an imperative feature for entrepreneurial excellence (A. R. Baron, 2013).

The fact that working memory is a system not only involved in ‘cold’ cognitive processing, but also in ‘hot’ affective processing (Hofmann, Schmeichel, & Baddeley, 2012) suggests that these apparatuses could be used to elucidate new mechanisms to stimulate enjoyment, hope and pride, so-called achievement emotions (Pekrun, 2006; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011), herein tackling the exigent need to cognitively approach the interplay of emotions and entrepreneurship (Cacciotti & Hayton, 2015; Delgado García, De Quevedo Puente, & Blanco Mazagatos, 2015). But memory and emotions are not the only constructs that could be stimulated with these apparatuses to the service of entrepreneurial enhancement; there are more.

Transcranial electrical stimulation (TES) (electrode-based), a variation of TMS (coil-based), is claimed to raise learning processes (Howard-Jones, 2014a). In a study of the military potential of TES using a virtual reality training game, adults who received 2 milliamps to the scalp showed twice as much improvement in learning and performance as those receiving one-twentieth the amount of current (Clark et al., 2012). TMS has also been used to study attention, episodic memory, language, memory, mental imagery, short-term memory, task switching, visual perception, visual processing and working memory (Rossi, Hallett, Rossini, Pascual-Leone, & Group, 2009).

¹⁴ TMS electrically stimulates brain tissue via localised magnetic field pulses (Heinrichs, 2012)

¹⁵ Technique that reliably induces and modulates neuroplasticity in the human cerebral cortex (Nitsche, Kuo, Paulus, & Antal, 2015)

At the same time, tDCS studies comprise inter alia, attention, visual target detection, visual memory recall, affect and mood, risk behavior, word recognition memory (Heinrichs, 2012), decision making and so on. (Ouellet et al., 2015). What is on the side of tDCS is the fact that scientists have begun identifying the size, type and location of a current that is optimal for demonstrating different effects (Howard-Jones, 2014a).

Against the contribution of these tools for entrepreneurial enhancement, the specific underlying mechanisms of stimulation-induced behavioral and physiological effects remain unknown (Dayan, Censor, Buch, Sandrini, & Cohen, 2013). Alike, the ethical implications (Heinrichs, 2012) must be taken into account. Still and all, the opportunity and capability of these tools to advance the edges of entrepreneurship exist.

6 NOT FINAL, ROSY REMARKS

How could I settle something that is so lustily arising on the horizon? I initiated this position paper hinting the rise of a new era within the field which I name ‘brain-driven entrepreneurship research’, or simply ‘brain-age’, generated because of current and swift advances in the frontiers of neuroscience, growing methodological constraints and theory-building needs faced in entrepreneurship research and cognition.

I have postulated that the main paladin of this brain-era is neuroscience and asserted that even though its tools and methods are not flawless, they are outfitted to help us win some battles in our intellectual crusade to advance our understanding on how entrepreneurs think.

But across this work I have furthered my futuristic assessment to argue that the real mission of neuroscience in our field is to concentrate on and achieve what I call ‘entrepreneurial enhancement’.

This aim goes beyond static yet necessary analysis of the kind of brain mapping, networks, activations, reaction time studies and the like; it goes towards a more dynamic view of the entrepreneurial phenomena capable of bettering the affective, cognitive and conative facets of entrepreneuring.

Cognitive tasks such as attention, memory, problem-solving, decision making (R. A. Baron, 2007), cognitive errors and biases (Ariely, 2008), creativity, alertness, opportunity and pattern recognition (A. R. Baron, 2013) and many other activities related to acquisition, processing and use of information (R. A. Baron, 2007) such as imagery, visual processing, emotions and beliefs are pressing for entrepreneurship development. As these tasks are at bottom ‘knowledge structures’, and ‘knowledge structures’ are the area of strength in neuroscience, we are facing an ideal match that unfolds the possibility for inducing entrepreneurial learning, skills, expertise, mindset and ultimately performance.

To provide some ideas on how to start, I introduced three neuroscience tools that will be instrumental in aiming for ‘entrepreneurial enhancement’: neurofeedback, brain training and brain stimulation.

By now I should highlight Robert Heinlein’s phrase: ‘there aren’t no such thing as a free lunch’. The synergies between neuroscience and entrepreneurship, the brain-driven entrepreneurship research era and the seeking of ‘entrepreneurial enhancement’ are to unchain changes in any of the building platforms of the field: philosophy (ethics), research (naturalistic), education (pedagogies), practice (performance), and policy making (prospective). For some these winds of change will represent a source of sudden inspiration, to others it may look like a ‘forced marriage’. The common point is that wedding preparations have already begun. I am ecstatic; let’s wear our best clothes and join the feat!

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