

## **Neuroentrepreneurship: What Can Entrepreneurship Learn from Neuroscience?**

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*“Experience is not what happens to you, experience is what you do with what happens to you.”*

--Epictetus

### **Abstract**

Like strategy, entrepreneurship has begun to wrestle with the psychological microfoundations of its key phenomena. One term that has come increasingly in vogue is the “entrepreneurial mindset”. On one hand, this is a healthy recognition that there are clearly cognitive and emotional underpinnings for entrepreneurial action and that those underpinnings lay deeper than we may realize. On the other hand, the term is rarely defined and almost never defined in satisfying ways that allow us to test rigorously, for example, critical antecedents of entrepreneurial behavior. We argue here that the cognitive microfoundations are crucial to understanding entrepreneurial thinking, feeling and action.

We offer an overview of neuroentrepreneurship's potential to provide psychological mechanisms for advancing entrepreneurship research and practice. More important, a recurring theme will be that neuroscience offers us a powerful alternate research sensibility that gives us some new key assumptions about the genesis of entrepreneurial decision making. We use some well-chronicled shortcomings and challenges in existing entrepreneurship research to discuss profitably how the application of neuroscience theory and methodology can address these limitations and help extend entrepreneurship theory. We provide practical suggestions of a best practice application of neuroscience in entrepreneurship and identify research questions especially well suited for this methodology.

Entrepreneurship scholars have long nibbled around the edges of cognitive science, in large part because to skillfully use its theoretical concepts and empirical tools is challenging. However, we will argue here that the investment will yield exceptional returns (Krueger 2004; Krueger & Day 2010) as long as we stay true to the course and be both rigorous and imaginative in our studies.

The great quote from the Stoic philosopher Epictetus is a reminder that we take away lessons from our life's experiences but it is not the experiences that matter. What matters are the lessons that we take away. However, those lessons are often learned – and shaped – at levels which

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<sup>1</sup> This chapter draws on extensive past work by the first author as well as work with the second author and with Mellani Day [Krueger & Day 2010]. We would be remiss not to give great thanks to other colleagues such as Angela Stanton, Rob Wuebker, Gabi Kaffka, Silvia Fernandez Costa, Alan Carsrud, Malin Brannback, Steve Gedeon and the many attendees of presentations and workshops on neuroentrepreneurship. We further cherish the pioneering work by Ron Mitchell who started us on the right path and Robert Baron who helped keep us on it. We also want to thank Zoltan Acs, Holger Patzelt and David Audretsch (and the Max Planck Institute for Economics) for their enthusiastic encouragement early on. N.B. Any errors should be attributed to the first author. ☺

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lie far deeper than we may suspect. Understanding that will pay huge dividends in our understanding of entrepreneurial thinking and... action.

**The entrepreneurial mindset is decidedly not a set of facts to be learned or even a set of skills to be taught, it is a way of thinking and feeling.** If we are to truly understand the entrepreneurial mindset, we need to look deeper. It will not be easy; the theories and methods are challenging. But it will be worth it. And if we want to better understand how to change the mindset and assess our scholarly and practical impact, it is more than worth it, it is imperative. We invite you on the adventure!

## Introduction

A recent study at Cambridge (Lawrence et al. 2008) compared serial entrepreneurs to top managers and found that successful entrepreneurs and managers shared great ability at rational analysis ("cold" cognition). However, entrepreneurs demonstrated a significant edge in analyses that engaged both rational and emotional thinking ("hot" cognition). Perhaps unsurprisingly, 'hot' and 'cold' cognition tend to occur in different areas of the brain's front lobes.

This is but one striking study suggesting a fruitful research agenda for applying theory and methods from neuroscience to a deeper, richer understanding of entrepreneurs and the processes that lie beneath entrepreneurial cognition and emotion. We propose here to present **(a)** a concise overview of the key issues where neuroscience can play a useful role and **(b)** present experimental evidence that examines interesting differences between economic entrepreneurs and social entrepreneurs. Note carefully that *emotions matter*; it is no surprise that the Cambridge study found that 'hot' cognition was critical.

Zald and his colleagues (2009) claimed that entrepreneurs differed from the general population in the numbers and density of dopamine receptors in their cerebral cortex. His claim centered on multiple experiments that demonstrated subjects who consistently took more risk also had significantly higher numbers of dopamine receptors. (Dopamine is a hormone released as essentially a reward, in this case for successfully accepting risk.) However, this research has not compared entrepreneurs to non-entrepreneurs, nor to social entrepreneurs nor have we looked at temporal changes: Does being an entrepreneur change one's dopamine receptors or are entrepreneurs simply born with different brain characteristics? We now know to ask such questions...and we have the tools to answer them.

We know that entrepreneurs engage in considerable (and complex) cognitive appraisal of opportunities (Welpé and various colleagues) but recent experimental data (Krueger, Grichnik & Welpé 2009) suggests that when nascent entrepreneurs appraise separately the economic and social dimensions of their proposed venture, only appraisal of the social dimension engaged the subjects' 'hot' cognition. This suggests that social entrepreneurs, stereotyped as unusually passionate even for entrepreneurs, should be a fruitful vehicle for extending studies such as those described. For example, Baierl, Grichnik, Spörrle, & Welpé (2014) look at antecedents of the intentions of social entrepreneurs and study the role of general social appraisal on social entrepreneurial intentions.

However, few explicit distinctions between entrepreneurs and non-entrepreneurs have been made in empirical studies although Shane (2003) argues that entrepreneurs use a qualitatively different decision-making process than others. Yet, this theoretical explanation remains untested and thus unsupported by empirical investigation (Krueger & Day, 2010). Moreover, it appears very likely that neuroscientific methods are the only way to efficiently and effectively address claims such as Shane's. Thus, this essay aims to look at evidence as to whether seeking differences in actual behavior and neural activities between entrepreneurs and non-entrepreneurs would be productive.

Risk taking behavior seems an ideal starting point for neuroscientific analysis of entrepreneurs (Stanton & Welppe, 2010). There is growing consensus in the literature that the central nervous system reacts differentially to risk. Functional magnetic resonance imaging (fMRI) studies reveal neural correlates of risky stimuli or decisions in various brain regions including the striatum, insula, inferior frontal gyrus, lateral orbitofrontal cortex, and anterior cingulate cortex (Paulus, Rogalsky, Simmons, Feinstein & Stein, 2003). Decision making under ambiguity and under uncertainty is correlated to activities in the amygdala, orbitofrontal cortex, inferior frontal gyrus, and insula (Huettel, Stowe, Gordon, Warner & Platt, 2006).

Moreover, the literature suggests that risk-taking propensity need not generalize. Thus, we aim to clarify if social & economic entrepreneurs tend to be more willing to take risk in general and/or only in business related situations, e.g., can an “opportunity” be triggered into something actionable and which factors are inhibitors or promoters. Finally, a key conundrum in social entrepreneurship research circles is whether social entrepreneurs differ significantly from economic entrepreneurs in how they perceive and appraise opportunities. Recall that the Krueger et al 2009 study above found cognitive appraisal differed between the economic dimension and social dimension. When subjects were induced to think like a social entrepreneur, we saw more 'hot' cognition. This suggests the value of testing social entrepreneurs and economic entrepreneurs, rather than just entrepreneurs and managers.

Other recent<sup>2</sup> studies from neuroscience suggest immediate possibilities for replication looking at entrepreneurs. Consider the recent work by Sheeran, et al. (2014) that changing risk appraisals affects intentions and behaviors. This is a topic that has long been intriguing to entrepreneurship scholars and practitioners alike. Simply replicating this work in entrepreneurial contexts should be intriguing and relatively straightforward. In a similar vein, Rogers, et al. (1998) looked at difference in brain activity when deciding between a smaller, likelier reward and larger, riskier rewards. Another replicable study was done by Owens, et al. (2012) that looked at the interplay of genetic markers and childhood experiences on later cognitive processing.

However, one study that perhaps offers the most value, theoretically and practically, is the work on the “Aha!” moment: what happens in the brain at the key moment of insight? (Bowden & Jung-Beeman 2003). How can we best replicate with entrepreneurs?

Neuroscience offers us a different way of thinking about our research and the research

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<sup>2</sup> Wherever possible, the most recent work in neuroscience is cited (but isn't it interesting how so much fits... entrepreneurship?)

questions that we ask. Simply by recognizing there are deeper levels than behaviors and attitudes, we open the door to a greater understanding of what makes entrepreneurs act. We already know that there is very much that “lies beneath” our usual data on entrepreneurs and entrepreneurship (e.g. Krueger 2007) but even a cursory review of neuroscience suggests that there is far more than we realize – and perhaps we can realize. That is, neuroeconomics and other neuroscience domains also show us that much more of our behavior is driven by physiological/neurological factors than we really might want to believe. *Homo oeconomicus* might have been already dead but neuroscience may have added the proverbial stake in the heart.

Understanding entrepreneurial behaviors requires understanding entrepreneurial thinking and feeling at a deeper level (e.g., Krueger 2007). But if we need that deeper understanding then we need deeper theory and methods to match. Entrepreneurship studies still have to struggle for legitimacy (Shane 2003) as an independent field of research while scholars also struggle to understand the distinctive contribution of the field of entrepreneurship. Where does studying entrepreneurship inform other domains?

### **Neuro... hype?**

We have all been deluged by items about neuroscience – neuromarketing, neuroeconomics and so forth (even neuroethics). Much of that is hype – but much of it is even more valuable than it seems. The field of entrepreneurship has evolved from looking at just “words and deeds” (Herb Simon's 'semantic' level) to attitudes and beliefs ('symbolic' level), but deeper still there is the 'neurological' level where we look as directly as we can at neural processes and activities. If we are to look at the neurological level of human decision making, then it seems likely that this will be very useful for a better understanding of entrepreneurs and entrepreneurship.

- \* It is an opportunity to ask questions that we could not answer before**
- \* It is an opportunity to test questions that we couldn't even think to ask before**
- \* To ask and test questions in a better way and to get better answers**

The latter point is a good place to start. Results and progress in entrepreneurship have sometimes been limited (if not potentially distorted) for methodological reasons. Leading voices such as Shane (2000) and Venkataraman (e.g. 1997) have noted that we have not properly and rigorously specified the dependent and independent variables, let alone account for the common variance between them.

Consider the perhaps focal phenomenon in entrepreneurship, *opportunity*. Rigorous measurement of, for example, the value and the qualities of entrepreneurial opportunities (e.g. Markman & Baron 2003; Sarason, Dean, & Dillard 2006) has been too often lacking. Neither have we controlled for obvious confounds such as the opportunity costs and the outside options of potential entrepreneurs (Shane & Venkataraman 2000) nor controlled carefully for context effects such as the effect of growth motivation (Shane 2003). For methodological reasons, we too often take a static instead of a dynamic perspective by simultaneously analyzing the antecedents of perception, evaluation and exploitation, which seems especially advisable given that many selection steps are involved until the decision for or against entrepreneurship is reached (Shane 2000).

All this means that previous research to date has yet to truly answer the question, ‘who perceives, evaluates and exploits entrepreneurial opportunities’ (Shane 2003). Simultaneously, it brings into serious question the methodological rigor of entrepreneurship as a field of research, but even where substantively rigorous, we have made insufficient use of the entire scope of available empirical methods, in particular, we have grossly neglected the use of experiments (Schade 2005).

If the field has underachieved in studying one of its central constructs then it would seem reasonable to seek different, more suitable methodologies. Consider again Herb Simon's classic distinction depicted below in Figure 1. Entrepreneurship research spent its formative years focusing quite understandably on the surface or “semantic” level: What people say and do. More recently, the rising use of social psychology, behavioral economics, evolutionary sociology, and cognitive and even developmental psychology has enabled the field to explore at deeper levels such as Simon's “symbolic” level: What people feel and believe.

**Insert Figure 1 about here**

For example, consider research into entrepreneurial intentions. Using proven models such as the Theory of Planned Behavior has been highly productive and yielded deeper (and more useful) insights than merely observing words and behavior. However, it has recently become clear that entrepreneurial intentions themselves rest upon deeper phenomena such as deep anchoring beliefs (Krueger 2007; Brannback, et al. 2007, Neergaard & Krueger 2012). If deep beliefs are critical, then we need to find methods that permit us to delve more deeply. But if we delve more deeply, we must do so with great rigor. Fortunately, recent intriguing work provides clever ways to identify how deep beliefs can be surfaced from surface decisions (e.g., Raudies, et al. 2014). Even more important, we now have the theory and methods to assess how education/training interventions influence deep beliefs: What activities yield what experiences that mold deep beliefs?

Simon's third and deepest level was dubbed “neurological” and argues that there is a substrate that is biological in nature, that our physiology comes into play in ways that cannot be understand without direct examination. The rising tide of neuroscience appears to offer both conceptual insights and empirical research tools that will help.

Consider again entrepreneurial intentions, then consider the classic work of Benjamin Libet who demonstrated the provocative finding that the experimenter can often detect human intent in advance, suggesting a neurological antecedent to intent and behavior. In turn, that opens the door for us to ask some new questions as well as shedding light on some older ones (such as the antecedents of entrepreneurial intent.) Let us next turn to a brief, simplified overview of neuroscience and its potential to advance entrepreneurship research.

**Neuroscience: What Entrepreneurship Scholars Should Notice**

Recently neuroscience has become popular in research applications on social science and behaviors. Neuroscience focuses on the “ultimate black box” – the brain - and infers information from images of brain activity and similar techniques (Camerer, et al. 2005) Entrepreneurship

increasingly takes advantage of rigorous experimental methodologies to better understand deeper structures of entrepreneurial cognition. Neuroscience, in particular, gives us new ways to conceptualize and measure important facets of entrepreneurial decision making.

**How can neuroscience best inform entrepreneurship?**

- (1) By answering questions that have thus far resisted analysis of causal relationships.
- (2) By enabling us to ask new questions we could not even ask before, For example, we can begin to identify the actual drivers of opportunity perception, but we can also map its pre-decisional dynamics. Just as neuromarketing and neuroeconomics have already yielded important new insights, why not **neuroentrepreneurship**?

Neuroscience is a general term referring to a wide range of techniques in which neuroscience methodologies allow for the investigation of ‘theories in use’ rather than ‘espoused theories of action’ (Shepherd & Zacharakis 1999), overcoming retrospective bias, and enable the collection of contingent respondent data as well as the study of interactions among independent variables and the neurological correlates of entrepreneurial decisions and behavior.

Note in particular that the popular view of neuroscience as being all about use of PET scans and functional MRI and other mechanisms, the key import of using neuroscience is directing our attention for the first time to the **biological** dimension, the physiological and neurological substrate that drives our behavior far more than we realize – or can realize.

Note also that the growing interest in neuroscience appears to be driving increased interest in and utilization of rigorous, controlled experiments. Experimental methods have been rarely used in entrepreneurship research, often on the grounds that one cannot explore “real world” behavior in a lab setting. Neuroscience, particularly neuroeconomics, has clearly shown the power of using experiments. If neuroentrepreneurship’s only contribution is to provoke rigorous experimental studies on entrepreneurship-related topics, it will be worth it.

**Insert Figure 2 here**

Neuroscientific methodologies have been successfully applied in many domains: Witness neuromarketing, neuroaccounting, neuroethics and especially neuroeconomics. Neuroeconomics research argues we must explicitly consider much deeper cognitive phenomena, even physiological, if we are to understand important human decision processes (Andreassen 2006; Camerer, 2006). For one very important example, this requires explicit consideration of entrepreneurial emotions, not just rational cognitions, something too rarely considered in entrepreneurship research (Spoerrle & Welpe 2006; Mitchell et al. 2007; Stanton, et al. 2008, Michl, et al. 2009).

Neuroscientific methodology is a potential means to overcome previous limitations in entrepreneurship theory and methodology because it offers a number of possibilities to address some of the methodological shortcomings, especially as a well-suited methodology to investigate pre-entrepreneurial decision processes and the cognitive and emotional processes underlying them, which have recently risen on the entrepreneurship research agenda (Baron 2006). Consider for example the neuroscientific evidence that rational and emotional cognitions take place in different

parts of the brain. We have long studied differences between “hot” and “cold” cognitions but this evidence places that work on much stronger foundations.

For another important example, while we understand that perceptions of opportunity are the heart of entrepreneurial thinking, we have only a superficial understanding of “opportunity” as a construct and how to measure it (Baron 2006). Neuroscience argues that if perception of an opportunity is a phenomenon of profound importance, then we should rigorously identify salient neurological markers of opportunity perception in real time and of their antecedents (Cacioppo & Petty 1985; Camerer 2006).

To the lay observer (and the entrepreneurs themselves) it appears that entrepreneurs perceive different things and assemble those environmental cues/signals differently. Doesn't that make entrepreneurs an interesting topic for neuroscientists? How do we [entrepreneur] pick out targets [opportunities] in complex, messy environments (Peelen & Kastner 2014)?

More important: Do we know what actually triggers entrepreneurial action? An important extension of this is the extent to which “automatic processes” are part of the entrepreneurship process. Automatic processes exert minute or no conscious effort on part of the individual (Camerer et al. 2005). Neuroscience offers the potential to understand the operations and effects of such processes: “Because people have little or no introspective access to these processes, or volitional control over them, and these processes were evolved to solve problems of evolutionary importance rather than respect logical dicta, the behavior these processes generate need not follow normative axioms of interference and choice (Camerer et al, 2005: 11).

### **Limitations of Neuroscience**

Neuroscience is far from a panacea. It and offers its own weaknesses and limitations for entrepreneurship research. We are particularly interested in finding those limits. For example: Entrepreneurial action is not necessarily an action of an individual, but can also be an action of a group of people. How well are neuroscientific methodologies suited to explain group decision processes?

### **The most serious caveat (Science is *hard*)**

The exciting promise of neuroscience has a cautionary side. We are now dealing with powerful theories and models that are far beyond what most entrepreneurship researchers are remotely familiar with. The methods are equally challenging: Consider that rigorous experimentation itself is not easy. All of this has implications for research design and statistical analysis that require a quantum jump in methodological and conceptual precision. Moreover, the philosophical underpinnings are often poorly developed. Our understanding is shifting as we recognize the limits of our more dominant theory of the mind (e.g., the computational model is increasingly difficult to justify; the brain is far more than an organic computer).<sup>3</sup>

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<sup>3</sup> I am deeply indebted to Russ McBride and Rob Wuebker for their vigorous nudging on this point (e.g., McBride, et al. 2013). Far too much of entrepreneurship research itself is built on theoretical “sand” (and underpowered/unreplicable empirical work) but even neuroscience can share those issues.

Even neuroscience is plagued with methodological issues, for example, Bennett, et al.'s 2009 neuroimaging experiment that found consistent significant response to stimuli from an interesting “subject”<sup>44</sup>. It is daunting to know that top neuroscientists and their journals produce and publish studies that are, bluntly, flawed. Beyond issues with Type I errors, much of the phenomena in neuroscience research are idiographic not nomothetic. Some of the very best work (e.g., Lawrence et al 2008) offer elegant, deceptively simple research designs, whose elegance derives from researchers who bring a deep understanding of the theory and of the empirical tools plus the experience to recognize the need for patience required by experimental work.

How many of those studying entrepreneurship-related phenomena have training and experience in, say, cognitive developmental and developmental psychology? In physiological psychology? This is changing; it needs to change more. A recent structured literature review on the impact of entrepreneurship education found a stunning lack of references to educational theory; it was as though few of the authors were even aware of terms like “constructivism” or “situated learning” (Nabi et al., 2014).

There is also the “shiny pebble” issue. Hardly a week goes by without some neuroscience study being published that cries out “Hey... that could be relevant for entrepreneurship!” For example, research is booming on the limits and delimits of the priming effect. It is easy to realize the profound implications for opportunity identification and its practical applications to entrepreneurial learning but also easy to gloss over the profound theoretical and methodological issues underlying even seemingly simple experiments.

However, on the other hand, we cannot deny the potential for using these tools to get at entrepreneurial phenomena at a level we might otherwise never get to, at least not rigorously. We will go into more depth into some of these issues but first let us look at some of the more popularized findings from neuroscience applications that also have implications for entrepreneurship and entrepreneurs.

*Automatic vs. Intentional Processing:* We have already addressed the issue of deep beliefs. Where that has surfaced is in research that looks at our colorfully-titled “inner zombie”, decision processes that we are not mindful of. While we may often exhibit intentional, planned behavior, much of our decision making is automatic processing, driven by deep assumptions that we are likely unaware of. This is highly adaptive in that we cannot consciously process every single decision we face. This is often described as “system 1” and “system 2” processing; in entrepreneurship we have long focused on the intentional system and not enough on the automatic.

*Mental Prototypes:* However, since we operate under significant bounded rationality, there are many gaps that our minds readily fill – often based on those deep assumptions. If we have automaticized how to drive out of a skid on an icy road, that is good. If our deep assumption is an ugly racial prejudice, that is very bad. We all have mental prototypes (not just stereotypes *per se*) of “opportunity” and of “entrepreneur.” If someone's mental prototype of “entrepreneur” does not include them, it will be much harder for them to become (let alone succeed at) entrepreneurial

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<sup>44</sup> A rather deceased Atlantic salmon. No word if they got different results from Pacific salmon.



(Baron 2006; Krueger 2007, Costa, et al. 2013).

*Fluid Intelligence:* Very recent work by Jaeggi and her colleagues (2008) showed that fluid intelligence [ability to solve new problems] need not be fixed, but can be increased by compelling subjects to solve important, complex new problems, Entrepreneurs are a population that almost by definition face a steady stream of important, complex new problems. Entrepreneurs could make ideal research subjects; Jaeggi et al looked at activity in working memory as a key leverage point in this process, suggesting that this might be fruitfully explored neuroscientifically.

*Change Blindness:* One of the most famous experiments asks viewers of a video to count how many times people pass a ball. In the middle of the video, a person in a gorilla suit walks through quite visibly, yet the experimental subjects tend to not see the gorilla at all. Later work by Triesch and colleagues argues that we focus our attention in ways that preclude noticing other things. Rather the physical appearance of a gorilla or Triesch's colored blocks, entrepreneurs may focus in ways that preclude them seeing obvious opportunities (or, worse, visible threats.) These attentional limits are grounded in neurological realities that we now have the tools to explore.

### **Opportunities from weaknesses in existing entrepreneurship research**

The next section reviews some methodological challenges and shortcomings of entrepreneurship research that particularly illustrate the potential contributions of neuroscience for the study of, for example, entrepreneurial opportunities.

**Pre-entrepreneurial processes: Affective & cognitive reasoning.** Perception and positive evaluation of entrepreneurial opportunities are preconditions for any entrepreneurial activity it is surprising that most entrepreneurship research to date has started *after* the decision to exploit an entrepreneurial opportunity has been taken (Shane 2000). As a consequence, we know only little about the pre-exploitation decision processes of potential entrepreneurs. Thus, the majority of studies have not looked at the antecedents of the actual decision to act entrepreneurially but have focused on researching individuals who have already decided to become entrepreneurs. As a consequence we know only very little about the **pre-entrepreneurial** decision processes. However, the increasing interest in the concept of opportunity has been accompanied with an increased interest in the earliest phases of the entrepreneurial process and researchers such as Shane (2003) have argued for the study of decision processes leading up to the decision to become an entrepreneur. Research studying the actual decision to exploit entrepreneurial opportunities would greatly enhance current understanding of entrepreneurship.

Studying pre-decisional processes lends itself well to experimental methods, however, the foregoing suggests that it is imperative to dig more deeply than surface phenomena and even beyond Simon's symbolic level and understand the physiological underpinnings.

A better understanding of the pre-entrepreneurial decision processes would also help us to better refute or confirm conceptual theories that have been put forward by scholars. For example, Shane (2003) argues that entrepreneurship uses a qualitatively *different* decision-making process than the one used by the participants to buy and sell standard resources in the market place. This theoretical explanation remains yet untested and thus unsupported and by empirical investigation.

Currently, entrepreneurship scholars offer only theoretical descriptions of the judgmental decision-making processes that entrepreneurs use (Sarasvathy et al 1998). Ardichvili, Cardozo and Ray (2003) note that a number of conceptual models on the pre-entrepreneurial process have been proposed in recent years based on conflicting assumptions borrowed from a range of disciplines, ranging from cognitive psychology to Austrian economics.

Research on entrepreneurial cognition has increased during the last years (e.g. Tumasjan, Welpe, & Spörrle, 2012). Ron Mitchell, the pioneer of studying deep cognitive processes in entrepreneurs (Mitchell & Chesteen 1995, Mitchell et al. 2007) defines entrepreneurial cognition as the knowledge structures that people use to make assessments, judgments and decisions involving opportunity evaluation and venture creation and growth. The Austrian perspective would argue that it is mainly differences in information that determines whether opportunities are discovered and exploited. Mitchell et al. (2007) already predicted upcoming opportunities for entrepreneurial cognition research: Besides emotions and affect they refer to entrepreneurial action as important route for further analysis. An important question in entrepreneurial cognition research is how entrepreneurs deal with information. Given the importance of explaining opportunity discovery to our understanding of the entrepreneurship process, empirical evidence that supports or refutes the Austrian perspective of the discovery process is important (Shane 2000).

**Common variance bias.** Empirically, we tend to assume the attributes of people who discover opportunities are uncorrelated with the attributes of the opportunities that they discover. Researchers making this assumption have studied how individual differences affect the way people exploit opportunities while ignoring attributes of the opportunities themselves. However, if human attributes are correlated with the opportunities that people discover, then these researchers have confounded attributes of entrepreneurs and opportunities in empirical tests of who is an entrepreneur (e.g., Venkatraman 1997).

Entrepreneurship research needs to deploy rigorous experiments to the interaction of opportunities and individuals and find ways to measure both in fair comparisons. The joint investigation of both factors is critical to the investigation of the individual-opportunity nexus advocated by Shane (2000, 2001, 2003) and other scholars. Entrepreneurship cannot be only a fixed attribute of certain people, but must involve their reaction to the existence of opportunities (Shane 2003). However, to date, very little research has incorporated both parts of the puzzle in a fair way.

**Dynamism of entrepreneurship processes.** Shane argues that entrepreneurship is a process with tremendous selection at each step and the field needs to use research methods that are appropriate to the study of the phenomenon. As entrepreneurship is a dynamic process it demands investigative techniques that take this dynamism into consideration. However, most research about entrepreneurship – whether it is psychological – or economic in nature – tends to be static, seeking to explain outcomes as if they are found in equilibrium or are in some sort of permanent state. Static research designs in entrepreneurship, however, are problematic, as they assume that a given independent variable influences all steps in the entrepreneurial process equally, and that the effects of a given independent variable do not select out some people at earlier stages in the process.

Shane, Locke & Collins (2003) emphasize that entrepreneurship is a process that occurs over

time and criticized that previous research has not looked at the effects of independent variables on specific steps in the entrepreneurial process. The discovery of opportunities does not automatically result in exploitation, but that opportunities are exploited only when an entrepreneur decides to exploit an opportunity she perceives (Shane & Venkataraman 2000; Kirzner 1973). Failure to treat entrepreneurship as a dynamic process obscures the fact that most entrepreneurial activity is episodic, staged and short-lived and involves much selection (Shane 2003).

Simultaneously analyzing the antecedents of opportunity perception, evaluation and exploitation, seems especially advisable given that many selection steps are involved until the decision for or against entrepreneurship is reached (Shane 2000). As a result of the aforementioned limitations, previous research to date has insufficiently answered the question, '*who perceives, evaluates and exploits entrepreneurial opportunities*' (Shane 2003), has led to inconsistent results with regard to the influence of individual characteristics on entrepreneurial behavior (e.g. Foo, et al. 2009) and has questioned the methodological rigor of entrepreneurship as a field of research. Shane & Venkataraman (2000) also point out that to date we do not know why some people and not others exploit opportunities that they discover.

We need more research that examines the actual decision to exploit opportunities rather than the static nature of being an entrepreneur. Research on the actual decision to exploit opportunities among people at risk of such exploitation would overcome many of the limitations inherent in much of our existing research on this topic as well as provide more precise explanations for how individual differences influence the entrepreneurial process (Shane 2003). By using a dynamic approach to investigation researchers could capture these essential features.

For example, certain independent variables that are physiological in nature might have different effects on opportunity discovery, evaluation and exploitation. For example, how does the role of trust affect the process - and vice-versa? Over a very short time horizon, one could argue that entrepreneurial decision making was classically rational; however, over the entire process it makes plausible sense to delve into the deeper level.

Consider also the role of triggers (e.g. Shapero's precipitating event [Krueger et al 2000]) that link intent to action. If triggering events do occur, entrepreneurship scholars need methods that permit identifying these phase changes in entrepreneurial thinking. Neuroscience research is beginning to understand the "aha!" moment, for example, when subjects considering future circumstances identify a positive future state, we see increased activity in the amygdala.<sup>5</sup>

Failure to consider the dynamic nature of the entrepreneurship process has led the field to develop an ignorance about these differences, which hinders the development of a true understanding of entrepreneurship. But to fully consider the dynamics, we need the insights and the research sensibilities we find in neuroscience.

**Conflicting effects of independent variables.** Not analyzing potentially conflicting effects of independent variables on entrepreneurial processes has been a consistent *bête noire* for entrepreneurship scholars. For example, people who are high in independence may be more likely

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5 Again, please note that we are simplifying, often significantly, to illustrate points.

than those low in independence to exploit entrepreneurial opportunities, but they may not be better at formulating strategies that capture the returns of the entrepreneurial activity. It is likely that the factors that explain one part of the entrepreneurial process (e.g. opportunity evaluation) do not necessarily explain other parts (e.g. opportunity exploitation). Researchers interested in explaining the effects of independent variables on the exploitation of opportunities should also consider the potentially conflicting effects of specific individual variables on different aspects of the entrepreneurial process, and on performance at entrepreneurial activity (Shane 2003). This often requires experimental methods to counteract this and, again, the critical independent variables may well prove to be physiological.

**Perceived value of opportunities.** While it is apt to say “opportunity is in the eye of the beholder” we have often failed to use that in our research. A major criticism of prior research in entrepreneurship is that we simply use the construct “opportunity” and the size, quality, attributes and opportunity costs of entrepreneurial opportunities have not been controlled in a dynamic research design (Shane, Locke & Collins, 2003). Opportunities can differ on multiple dimensions. In order to accurately measure the effect of independent variables on entrepreneurial decisions, it is necessary to control the qualities and effects of opportunities (Shane, 2000). Venkataraman (1997) argues that opportunities are valuable for individuals if they exceed the entrepreneur’s opportunity costs and offer a premium for the illiquidity of money, time, and effort expended and a premium for bearing uncertainty and risk. Because opportunities will differ in these aforementioned qualities, the nature of opportunities will influence the entrepreneurial decisions (Shane, Locke & Collins 2003). Unless researchers know the effect exerted by the opportunities themselves, they cannot accurately assess the effect of the independent variables on entrepreneurial decisions. Without such controls, researchers cannot know whether the observed effects represent the effects of the independent variables or the effects of the unobserved relationship between the opportunities and the independent variables, such as motivation to exploit opportunities (Shane 2000). Shane, Locke & Collins (2003) note that previous research has generally failed to control the effects of opportunities by modeling the value of the different opportunities pursued.

Future entrepreneurship research should thus study identical opportunities in designs which allow respondents to make a series of entrepreneurial decisions in a controlled simulation, limiting sources of variance outside of the independent variables.

Note that all the foregoing suggests the growing realization that experimental methods are needed to address common method variance as well as to simultaneously assess rational and emotional cognitions. The field needs great experimental work.

### **Neuroscientific designs as possible solutions?**

Entrepreneurship as a field of research is in need of experimental methodologies fully study key phenomena (again, e.g., Shane 2003). First and foremost, researchers need to develop hypotheses and test explanations rather than just assemble facts. This, however, poses a not so trivial challenge for entrepreneurship researchers. In real life situations, (potential) entrepreneurs need not be controllable nor can all situations be manipulated and randomly assigned to (potential)

entrepreneurs (we are making progress though). Neuroscientific studies would seem a promising possibility.

Here we propose neuroscience as a source of research design (not just methodology) which allows for the current analysis of entrepreneurial decision processes while at the same time controlling for the situational specifics of entrepreneurial opportunities. By proposing experimental neuroscience we heed the call for research on methodologies that enable entrepreneurship researchers to simultaneously control for the influence of opportunity and individual characteristics on entrepreneurial decision-making (Shane et al. 2003). It also corresponds to Gatewood, Shaver, and Gartner (1995) who advocate the use of experimental designs in entrepreneurship research in order to randomize the allocation of respondents to research conditions.

### Types of neuroscientific experiments

	Natural experiments in the field	Economic experiments in the lab	Hypothetical questionnaire experiments			Quasi-experiments
			Between-subject design	Within-subject design	Conjoint experiments	
<b>Predominant subject pool</b>	Non-students Non-students in a mobile lab	Students	Students and non-students			Students and non-students
<b>Environment</b>	Natural	Artificial but context can be manipulated				
<b>Stakes</b>	High	Usually low but high stake decision can be implemented via ex-post random draw (Schade et al. 2002)				
<b>Incentives</b>	High	High	None (though flat payment for participation but incentives are not coupled to decisions)			
<b>Manipulation</b>	Not possible	Conditio sine qua non				

Table 1: A possible classification of experiments

Schade & Burmeister (2008) offer the above Table 1.

### Advantages of (different types of) neuroscientific experiments

One key advantage of using neuroscience experiments in entrepreneurship is their ability to focus closely on individual decisions (Schade, 2005). In addition, an experiment enables the plausible establishment of causality and, if properly designed, can exclude alternative interpretations by direct and indirect control. Experiments thus address the internal validity problem of empirical research in entrepreneurship. In entrepreneurship, many objects and relationships are dynamic or embedded in a dynamic environment and these dynamics threaten the reliability of identified relationships in field studies. Only with experimental control can we effectively discriminate the factors of interest from other factors, which are often rapidly changing. Schade (2005) concisely explains the advantages and necessities of using experimental methods in entrepreneurship. More recently, Burmeister & Schade (2008) offer this ever-growing list of neuroscientific experiments (defined broadly).

	Quasi-experiments	Within-subjects experiments	Between-subjects experiments
Decision experiments (including judgment of economic alternatives)	<ul style="list-style-type: none"> <li>Burmeister and Schade (2007)</li> <li>Bouckaert and Dhaene (2004): strategic</li> <li>Busenitz and Barney's (1997) study on the representativeness bias</li> <li>Palich and Bagby (1995)</li> </ul>	<ul style="list-style-type: none"> <li>Burmeister and Schade (2007)</li> <li>Lévesque and Schade (2005)</li> <li>Mullins and Forlani (2005)</li> <li>Forlani and Mullins (2000)</li> </ul> <p><i>Conjoint experiments:</i></p> <ul style="list-style-type: none"> <li>Moore and Cain (2007): strategic DM</li> <li>Franke et al. (2006)</li> <li>Muzyka et al. (1996)</li> <li>Riquelme and Rickards (1992)</li> </ul>	<ul style="list-style-type: none"> <li>Burmeister and Schade (2007)</li> <li>Elston et al. (2006): strategic</li> <li>Lévesque and Schade (2005)</li> <li>Mullins and Forlani (2005)</li> <li>Gatewood et al. (2002): Judgment</li> <li>Camerer and Lovallo (1999): strategic</li> <li>Krueger and Dickson (1993)</li> </ul>
Non-decision experiments but rather experiments on the measurement of knowledge, (distortions of) perceptions and beliefs, general evaluations etc.	<ul style="list-style-type: none"> <li>Fiet and Patel (in press)</li> <li>Brundin et al. (2008)</li> <li>Souitaris et al. (2007)</li> <li>Baron et al. (2006)</li> <li>Baron and Ensley (2006)</li> <li>Maurer and Schade (2006)</li> <li>Forbes (2005)</li> <li>Baron and Markman (2003)</li> <li>Peterman and Kennedy (2003)</li> <li>Mitchell et al. (2002)</li> <li>Baron et al. (2001)</li> <li>Amit et al. (2000)</li> <li>Mitchell et al. (2000)</li> <li>Baron (1999)</li> <li>Busenitz and Barney's (1997) study on overconfidence</li> <li>Kaish and Gilad (1991)</li> <li>Cooper, Woo, Dunkelberg (1988)</li> <li>Begley and Boyd (1987)</li> </ul>		

Table 2: Experimental studies in entrepreneurship: discriminating between studies within and outside the EDM perspective

**Table 2.**

It certainly appears that the ground has been tilled and appears fertile; it awaits only the next step, which is more explicit testing of physiological variables.

**What research questions appear particularly suited for neuroscience methodology?**

**What issues of practice appear particularly well suited?**

Obviously, there are many questions relevant to entrepreneurial decision making and action. Given the extent of research in neuromarketing and especially neuroeconomics, we already see the breadth and depth of potential topics where we need to consider Simon's neurological level (Figure 1 above). We already discussed how some existing research challenges can be addressed. But what else seems fruitful? Table 2 above suggests there are many interesting questions. Moreover, there is a wide array of models and hypotheses from behavioral decision theory that neuroeconomics has already begun to explore experimentally (e.g. Camerer et al 2005, Camerer 2006).

### **Case in point: How Does the Entrepreneurial Mindset Evolve?**

Studies on the “entrepreneurial mindset” are growing but are painfully atheoretic (and often fail to even define the term) despite this being an arena that has been explored in much more depth in cognitive developmental psychology (e.g., the well-established domain of child development) and, more lately in the newer domain of social neuroscience. We will return to some useful insights from cognitive developmental psychology, but social neuroscience offers newer insights that justify all the attention being paid to entrepreneurial cognition: *It focuses our attention on the deep beliefs and anchoring assumptions that ‘lie beneath’ how an expert entrepreneur thinks and feels.*

Social neuroscience is known for its focus on the neurological underpinnings of human cognitions. (This might conjure up an image of putting subjects through a PET scan (positron emission tomography) and seeing what parts of the brain light up when they see an opportunity.) However, the real lesson from social neuroscience for entrepreneurship scholars is that deep cognitive structures –and the deep beliefs they entail – are real and they lie at the heart of all human activity, whether stimulus-response or intentional. But we need to be precise in our methods and clear in our theoretical frameworks (e.g., Cacioppo et al. 2003, Bennett, et al. 2009).

To social neuroscientists, beliefs are the key building blocks of the symbolic level, yet at the same time we find that cognitive processing at the symbolic level also influences the development of beliefs reciprocally. While they often focus heavily on the neurological origins of human beliefs and belief structures, social neuroscientists argue that understanding deep beliefs are the key leverage point in understanding human cognition and thus human action. If true, it makes it even more important for entrepreneurship scholars to learn more about those deep beliefs that drive entrepreneurial thinking – and from whence they derive. From there, we can now assess entrepreneurial learning in ways that move far beyond learning facts – from learning **about** entrepreneurship to learning to **be** entrepreneurial.

**Neuroplasticity:** Many of us grew up believing that we never grew more neurons and that is simply not true. Neuroplasticity is real. And if experiential learning is indeed transformative at a deep cognitive level, neuroplasticity is likely to be involved (and something we can test. Think back to the Zald et al. study (2009) referenced early on.) If we want to go really deep cognitively, there are clever tests for the size of our working memory – do entrepreneurs have more? Do they grow more? Note that most of what we have discussed thus far need not require fMRI, CAT or PET scans, however, neuroimaging will eventually come into play. This is one area.

Consider the study of London cabbies who cannot use maps or GPS; was it surprising that after 10-20 years the parts of their brain dealing with spatial reasoning were more developed? Like exercising a muscle... **so what cognitive ‘muscles’ are entrepreneurs growing?**

Neuroplasticity opens the door to rigorously mapping interventions and cognitive outcomes. If we want to get a finer-grained understanding of what specific experiences/lessons induce what specific cognitive changes, neuroscience offers good places to start.

### **Practical Value of Neuroentrepreneurship?: Assess Experiential Entrepreneurial Learning**

One area that seems especially intriguing for entrepreneurship scholars deals with deeper

cognitive structures and how we can investigate them. For example, Mitchell (2000) notes that while we cannot detect the script directly, we *can* identify cues for an entrepreneurial script. We may now have the tools to identify exactly when such a script is switched on or off. We had already mentioned the utility of identifying the triggers from intent to action. For example:

\* When does this “good idea” coalesce into a genuine “opportunity”?

\* When does this “opportunity” be triggered into something actionable?

We already see hints of both these tipping points as entrepreneurial intentions evolve (Brannback, et al 2007). This research could vividly demonstrate them.

Neuroscientists have begun to call to “build bridges” between neuroscience and human learning in the assessment of educational activities (Sigman, et al., 2014). Why if we started explicitly linking learning activities to change in mental prototypes of “entrepreneur” and “opportunity”, etc.? (Costa, et al. 2013). If we look at the basic tenets of constructivistic learning it is clear that human learning is ultimately about changing deep beliefs, i.e., that elusive entrepreneurial mindset (not learning ‘stuff’ or even skills, it’s deep beliefs.) And to study mindset change requires theories and tools from neuroscience. It also tells us that it will be crucial for us to accept the challenge of assessing the impact of what we do.

### **From Novice to Expert**

We know that in human learning, it is far more than merely acquiring items of knowledge content, true learning entails changes in how we structure that knowledge. Neuroscience methods may help us to see some hint of those differences. In particular, knowledge structures often change discontinuously in the wake of critical developmental experiences as shown in Figure 3. (Think of it as another variant of the “aha!” moment.)

**insert figure 3 here**

### **From Novice to Expert**

Research into what differentiates experts from novices and the mechanisms associated with that trajectory increasingly draw from cognitive science. What happens to us in the alleged ‘10,000 hours of deliberate practice’ that has become a meme? One thing that confirms observations from educational researchers suggest that no amount of learning knowledge content can guarantee reaching the mindset of an expert. What differentiates experts is not how much they know but rather how they structure their knowledge. And how they see their world depends primarily on deep cognitive structures (scripts, maps, etc.) that are in turn influenced by changes in deep beliefs and assumptions that anchor those structures (again, Figure 3).

The implications for learning should not be surprising even if politically challenging to implement. In the entrepreneurial setting, however, it affords us multiple opportunities to assess whether teaching and training interventions change deep beliefs in ways that **a)** change knowledge structures, **b)** in positive directions. Neuroscience tools allow us to see how specific interventions [a/k/a critical developmental experiences] affect specific deep beliefs (Krueger 2007, 2009a, 2009b; Krueger & Day 2010).



The constructivistic model that entrepreneurship's best learning tools tend to follow argues that what we observe in the novice-expert trajectory is largely true of any human learning: The real growth, the only route to transformative learning is not from acquiring knowledge content but from changing how we structure that knowledge (Löbler 2006, Krueger 2007, 2009b, Goleman 2014).

Constructivism also suggests that we might fruitfully explore markers of those deep beliefs. What makes an expert entrepreneur... *expert*? How would we know? We know to look for markers of those deep beliefs, even if proxies like measures of ambiguity tolerance, action orientation, learned optimism, grit, or market orientation.

### **Implications for educators: What influences deep belief change?**

The evidence is quite strong for the best entrepreneurial learning activities (in fact, the best learning activities period) are constructivistic. If there is one single takeaway for educators it is:

*First*, help people learn to be and think like entrepreneurs and quit teaching about entrepreneurship. Think about the reputed 10,000 hours to become an expert – that actually is not true. Without deep cognitive change, you will not get there no matter how many hours. With deep cognitive change you can (Dweck 2010, Goleman 2014, Krueger 2009, Neergaard et al. 2012). We need those key components of transformative learning that might be the single best contribution that neuroentrepreneurship can offer to entrepreneurship.

*Second* is the role of emotion. We need to learn to get much better at 'hot' cognition. Consider how memory (and thus decision making) are irretrievably connected with emotions. Think about "flashbulb" memories – most of memories are coded imperfectly via short-term memory but a few are all but seared into long-term memory because of the emotional intensity.

*Third*, memories and learning are highly dependent on the surrounding context (which itself is perceptually filtered) including and especially the "who". This is why cooperative learning usually trumps individual learning. This is why peer engagement is critical to constructivistic learning.

*Fourth* is back to Epictetus: How do we ensure that we take away the right lessons from our experiences? We learn from credible others such as expert mentors but they need to be experts. (It also means that entrepreneurship educators need to be brilliant at managing these processes and that might be the hardest hurdle of all.)<sup>6</sup>

*Fifth* is that the mindset can be changed and that the belief it can change are critical. As educators, it is imperative to help learners to see how mindsets change – whether from experts, peers or themselves (Dweck 2010).

*Sixth*, assess impact but at the deep cognitive level. Are we **really** changing the mindset? (Note that we may not want to see the results.)<sup>7</sup>

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<sup>6</sup> Elephant in the room: How many entrepreneurship educators are fully trained in... education? Maybe 1 in 100 have even had any training or exposure to educational theory. Constructivistic education is **not** for amateurs.

<sup>7</sup> Current projects that are rigorously studying this include Gabi Kaffka and Aard Groen (Twente), Karen Williams and Martin Lackeus (Chalmers School of Entrepreneurship), Kare Moberg (Danish Foundation for Entrepreneurship), Heidi Bertels and Peter Koen (Stevens Tech) and the European Institutes of Technology (Pasi Malinen and first author).

## Implications for Researchers

For example, we can test the impact of entrepreneurial learning activities against the key principles of constructivism. What is the impact of deep immersion as in a Startup Weekend? Impact of peer support? (Of an emotionally ‘safe’/encouraging environment?) Of expert mentoring? Of deep personal reflection (Kaffka & Krueger 2012)? How well does reflection get managed? Does it matter whether the pedagogy relies on the principles of social learning, situated learning, existential learning, etc.? (Neergaard, et al. 2013). Ultimately, though, how can we identify deep belief change to advance our craft as educators?

The very best entrepreneurial learning programs available to us like Startup Weekends, Lean Startup Machine and the Kauffman-backed Ice House and the best accelerator programs like TechStars, 500 Startups and Y-Combinator<sup>8</sup> explicitly deploy all three of these (immersion, peer support, expert mentors, plus expert management of the process) to great effect. Shouldn’t we study these programs? But this will require the theoretical and methodological tool kit that neuroscience gives us.

Again, while neuroimaging could easily be game-changing in entrepreneurship (and management studies in general) we need to begin with precisely-crafted and meticulously-executed field and lab experiments.

But to do this, we may need the help of great neuroscientists. But they should be interested. If there is growing research on how human identify targets in complex, real world environments (e.g., Peelen & Kastner 2014) why wouldn’t they enjoy looking at how entrepreneurs identify the optimal cues that align with their interests? (Or how do they do *not* see “the gorilla”?)<sup>9</sup> McGuire & Kahle (2014) show how very simple cuing can affect economic judgments<sup>10</sup>. Shyti (2014) recently showed how manipulating entrepreneurial over-confidence affects choice under ambiguity

In short, looking at the microfoundations of entrepreneurial cognition (and action) through the lenses offered by neuroscience is **a)** already giving us new insights to what exactly the murkily-defined “entrepreneurial mindset” actually comprises, **b)** helping understand how it changes and **c)** how we might rigorously measure it. It also will make us much better educators.

## Conclusion and Recommendations for Future Research

We argue that neuroscientific methodologies studies are suitable for, at minimum, a subset of research questions in entrepreneurship. Neuroscientific methodologies studies are especially useful for controlling the value and opportunity costs of entrepreneurial opportunities, for analyzing the cognitive and affective processes in the pre-entrepreneurial decision processes (pre-stage)

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<sup>8</sup> [www.Startupweekend.com](http://www.Startupweekend.com) , [www.WhoOwnsTheIceHouse.com](http://www.WhoOwnsTheIceHouse.com) , [www.leanstartupmachine.com](http://www.leanstartupmachine.com) , [www.TechStars.org](http://www.TechStars.org) , [www.ycombinator.com](http://www.ycombinator.com) , [www.500.co](http://www.500.co) [see also J Richman, 2012]

<sup>9</sup> The famous gorilla experiment by Simons & Chabris (1999) where subjects typically failed to notice a gorilla (!) walking through the scene. Inattentive blindness affects entrepreneurs too. And what we teach them matters.

<sup>10</sup> Not to mention Kahneman and Tversky!

(including cognition and effective influences) and for studying decision-processes in a dynamic perspective. We strongly believe that this tool kit is imperative if we are to understand entrepreneurial learning, e.g., what is really happening in deep experiential learning (and, less cheerfully, what is not happening in many classrooms).

However, it is important to note that neuroscience methods offer us powerful new ways of thinking about our research and the research questions that we ask. Simply by recognizing there are deeper levels than the semantic and symbolic, we open the door to greater understanding. Very much lies beneath our usual data on entrepreneurs and entrepreneurship. But it will not be easy.

Moreover, there is considerable evidence from neuroeconomics and elsewhere that much more of our behavior is driven by physiological/neurological factors than we really might want to believe. But we must if we are to extend our understanding of entrepreneurs.

We intended here to provide a simple overview that examines the application of neuroscientific methodologies to existing research questions in entrepreneurship (and a few new opportunities). At bottom, our intent was to make some small contribution to the discussion of how to test and develop entrepreneurship theory and to have added to the spectrum of entrepreneurship research methods, overcoming some of the challenges faced by alternative methodologies.

To conclude, we have all been deluged by items about neuroscience – neuromarketing, neuroeconomics, even neuroethics and so forth. Again, some of that is hype (dead salmon? really?) but some of it is even more valuable than it seems.

If we are to look at the neurological level of human decision making, then it seems likely that this will be very useful for a better understanding of entrepreneurs and entrepreneurship. What should be growing now is the realization is that neuroscience offers us a chance to learn things from entrepreneurs that we can apply even more broadly.

We may not like the answers we find – what if entrepreneurs really are born, not made? Or, more likely, driven by deep beliefs learned in early childhood? **That entrepreneurial decision making is hostage to our neurochemistry?**

Again, we welcome you to the adventure!

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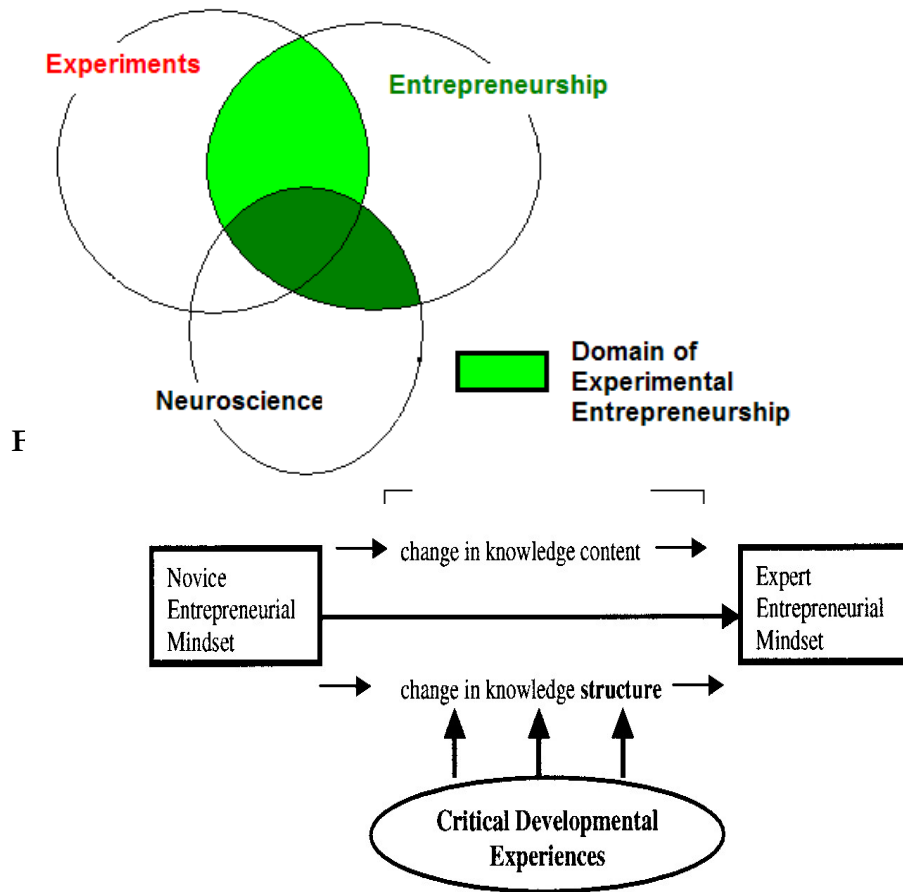


Figure 1. Simon's Levels





Figure 2. The domains of neuroentrepreneurship and experimental entrepreneurship



### Appendix 1. Additional fertile ground for neuroentrepreneurship

The variety of potential topics is quite broad; the following is just a sampling of entrepreneurship-relevant topics:

#### Behavioral Decision Theory

Framing Effects & Paradoxes - Consider the extensive experimental evidence that has elucidated our understanding of things like Kahneman & Tversky's classic gain-loss framing effects (prospect theory) including work assessing the role of affect in decision making. What we are seeking to explain are the various consistent deviations from rationality that we observe, typically in pencil-and-paper exercises.

A very early experiment (Krueger & Dickson 1994) with an entrepreneurship theme showed

how perceived self-efficacy would override the Ellsberg Paradox which reflects aversion to high uncertainty [as opposed to Kahneman & Tversky looking at risk aversion.]

*Research Opportunities:* We can manipulate perceived uncertainty and observe decisional outcomes such as choice of script. Also, other paradoxes (e.g. Allais paradox) that reflect seeming violations of rationality have not been well-tested in the lab, let alone in the entrepreneurial context.

Preferences - Preference judgments can now be observed through neuroimaging. Thus, entrepreneurial preferences with regard to resource mobilization, resource commitments, and decisions on how to exploit a perceived opportunity could be studied.

*Research Opportunities:* Human decisions are inherently multi-criteria; multi-attribute utility theory (MAUT) can be explored more directly with tight experimental controls. We have recently observed lexicographic preferences in entrepreneurial intentions (Douglas & Shepherd, 1999; Krueger, et al 2009).

Utilities - Activity in the rewarding behavior is likely to influence entrepreneurial decisions, e.g. how much to invest, general disposition to sell winning investments too early. Investing money and gaining is shown to correlate with activation in the rewarding system.

*Research Opportunities:* Neuroimaging technique allows us to measure the utility derived from a good objectively. There is also a difference between the expected and the experiences utility. Release of dopamine might lead to acceptance of risk more easily. Previous research shows that dysfunction on the OFC-amygdala-Nac reward circuit explains extreme risk-seeking behavior. All of these aspects could be studied experimentally.

## **Game Theory**

A specific area of human decision making that lends itself to experimental study has been the use of games whose rules have been cleverly specified so as to elicit interesting phenomena. Much of neuroscience's best-known work has been focused on games.

*Research Opportunity:* The classic Prisoners Dilemma and the recently popular Ultimatum Game have rarely, if ever, been used in entrepreneurial settings. For example, could we reverse the Prisoners Dilemma with VC replacing “prisoners” unable to communicate about investing?

## **Perceptions**

A core topic in any book on cognition is perception; it is also a core topic in any book on experimental psychology. Most of the key phenomena in entrepreneurship research are perceptions-based. What is “opportunity recognition” without opportunity perception? In the lab, we can manipulate perceptions quite readily.

*Research Opportunities:* Kirzner (1973) argued that entrepreneurs need a significant degree of alertness to opportunities. Alertness is likely situational (Shapero’s analogy was to ask in what directions is an entrepreneur’s antenna tuned?). Controlled experiments could map that “tuning.”

In general, we have devoted considerable effort to research into how we recognize, discover, identify or enact opportunities and threats. However, very little of that research has explored, for example, the psychophysics of perception.

Finally, entrepreneurs are renowned for their above-average abilities to “connect the dots” in enacting opportunities. Whether the experiments focus on "dot connecting" or on broader issues of pattern recognition, we can draw upon a long tradition of research into pattern recognition, its antecedents and consequences.

### **Emotions & Affect**

Affect - . Neuroeconomics suggests that that decision-making as hypothesized in economic theory depends on prior emotional processes. To date only very few studies and economists have studied the role of emotions in entrepreneurial decision-making (e.g. Spoerrle & Welppe 2006; Michl et al. 2009, ).

*Research Opportunities:* We could look at the role of emotion in uncertain conditions. The influence of emotions on entrepreneurial decisions should be greater in situation is supposed to be even greater than in certain ones. Thus, entrepreneurship with all its uncertainty and risk makes a prime context for studying the impact of emotions on decisions. We could use cognitive appraisal theory (i.e., primary appraisal, rationality, irrationality, and coping potential) in entrepreneurial situations in order to examine the impact of cognitive and emotional processes on the evaluation and exploitation of entrepreneurial opportunities.

Passion & Fear – We can look specifically at passion and fear, two popular themes relating to entrepreneurial decision-making. Long ago, Keynes argued that initiative-taking was not a function of rational calculation but the presence/absence of a more emotional factor he called “animal spirits”.

*Research Opportunity:* As such, this would seem particularly amenable to study using neuroscience techniques; is entrepreneurial passion merely the arousal of the amygdala? And is passion... contagious? (Cardon, et al., 2009).

Trust - Cooperating, trusting others, etc are important aspects in the creation of a venture. We could design imagines or real scenarios in which we manipulate the social and the entrepreneurial aspect and see what influences evaluation and exploitation of these entrepreneurial opportunities. Social neuroscience provides insights into the neural mechanisms underlying our capacity to represent others intentions and feelings, referred to as “empathy” (Singer & Fehr, 2006).

*Research Opportunities:* What if trust is merely the consequence of a hormonal change (e.g. oxytocin)?