THE ROLE OF NEUROSCIENCE AND NEUROTECHNOLOGY: DECISION MAKING IN CORPORATE ENVIRONMENTS

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The role of Neuroscience and Neurotechnology: Decision making in Corporate Environments.

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The Role of Neuroscience and Neurotechnology:

*Decision Making in Corporate Environments*

"Brain Science- From Bench to Boardroom: An Integrative Approach to the Use and Misuse- of Neuroscience and Technology for Decision Making in Corporate Environments".

Will include concepts of: Neuroeconomics, Neuromarketing, Neuroleadership, Neuroethics
1. **Abstract**

Decision making is a basic cognitive process and a critical skill set that can lead to a transformational change. This research is a study of the neurobiological basis of decision making, and how its results can be applied to the corporate world. Given the number of new discoveries in neuroscience due to technological advancements in neuroimaging, only partial knowledge about human brain have been utilized for business purposes. This research explores how this knowledge can be applied in business to improve decision making under uncertainty, and to find ways where business and science can be integrated and share best practices. It suggests to focus on cognition because its improvement is a key to high performance in business. Enhancement of cognition can be developed through training and practice of intelligence functions by creating virtual training environments that fully resemble real life, such as modelling and simulations.

This practical training could also measure cognitive abilities and identify weak spots in the decision-making process on individuals. The results could be especially valuable to decision makers in fast-paced operating environment, under stress and uncertainty, and could offer vital insights for policy makers and business leaders making decisions in management, ethics, and marketing.
2. Introduction

Most corporations do not provide the necessary tools for individuals to grow professionally, which results in poor performance, low productivity, and lack of motivation. There is a huge need for proactive initiatives from organizations to understand the employees’ needs, and then promptly respond to them. For example, one of the most significant needs is a strategy using progressive methodologies to identify these gaps by utilizing effective neurotechnological tools and behavioral science mechanisms that can address these issues. There should be a more structured way for critical thinking and rationality in-house directing to the right decisions.

Moreover, modern corporations where people’s satisfaction is the corner stone face many difficult decisions. In order to create successful organizations that invest in human capital and have high productivity along with high motivation, it is important to conduct a well-planned assessment of each individual’s behavior, along with their decision-making abilities facing constrained scenarios under uncertainty.

Making a good decision is a critical skill set that tests one’s intelligence and leadership ability. Sound decisions may lead to transformational change—either moving situations forward or holding them back. That is why making decisions can be also a very difficult task. Most times decisions have emotional connotation, and its results can have varied effects on the needs and desires of the individuals or organizations involved. The outcome of these emotions can cloud judgment, making reaching a decision a complicated and cumbersome process.

This research is a study of the neurobiological basis of decision making and how its results can be applied to the corporate world. There is a lot of new information on decision making process coming from latest technological discoveries in neuroimaging. Understanding the decision making process and the rationale that drives individuals to make decisions will help both the academic and business world find ways to improve the process, ensuring that people make better decisions for the benefit of both global society and corporations.

The subject of neuroscience is rather complex and the process of understanding how the brain works is still in its very early stages. Today new technologies allow the start an era of groundbreaking discoveries in the field and new components emerge in the process of neuroscience’s evolution.

The intention of this research paper is to help understand and build a bridge between neuroscience and the business environment by finding ways where both can be integrated, share best practices, which will lead to a better understanding of the brain and its potential in the near future.
We conducted this research to explore how recent discoveries in neuroscience with the help of technology can be applied to the business world to improve decision making under uncertainty. We believe that any type of an organization can benefit from this research by learning more about the brain and the ways to improve and increase efficiency and productivity. The research, however, is limited to available open-sources publicly, information, books, and articles, which allows to show only a part of application potential. To make this research complete, it would require a comparison of the efficiency and productivity before and after using new technologies for improvement of the decision-making process in a number of companies.

However, this is outside of the scope for this thesis, which intends to shed light on more ways than had previously been known on how neuroscience and business can cooperate, and new ways to address efficiency and productivity in the modern era. Given the number of studies that had been conducted in the past years, only partial knowledge about human brain have been utilized for business purposes. As neuroscience develops there would be a wider applicability.

Global economic changes, social risks and insecurity brought a lot of uncertainty, which emphasized the role of the leader; qualities and abilities of the leader became especially important. It led to the necessity developing the abilities of the brain that is capable of complex decision making because uncertainty prompts inability to make valid assumptions and determine the future. With a growing complexity of the globalized world, neurotechnology has taken on a new role in business. It is necessary to continue exploring the brain and its activities by using the latest technology because as studies show cognitive abilities can be improved by using digital intelligence.

Such an accomplishment related to the application of behavioral science practices, technology, and neuroscience in the business world will lead to new levels of efficiency and productivity that will reflect on overall business performance. It could also lead to better solutions and will guide corporations operate globally more effectively by tapping and quantifying the individual subconscious.
3. Methodology

The research was conducted by using theoretical methodology. To evaluate empirical studies, we conducted literature review of over 45 sources released and published within the last 40 years that included analyses of recent scholarly and scientific articles, transcripts from conferences in the field, TED talks, and etc. Considering a number of discoveries in technology and neuroscience that marked the last half a decade, the focus was primarily on studying current trends and closely following the developments in the field that triggered further evolution in many other neuro-disciplines, such as neuromanagement, neuromarketing, neuroeconomics, neuroleadership and neuroethics. Literature review has revealed that there is a strong connection between the brain and decision-making process, and with every technological improvement follows by new discoveries in neuroscience, which have potential to be applied to business world.

To gain in-depth understanding of current need for establishing substantial cooperation between business community and neuroscientists, we conducted survey research. The goal was to collect information and make assessment on the state of knowledge about the convergence between neuroscience and other industries among people in different fields and countries in order to see whether there is a need from their perspective to build stronger partnership between science and business.

Our hypothesis was that population places certain degree of importance on latest scientific discoveries, but typically neuroscientific knowledge is not explicitly incorporated in their framework of their workplace and people do not have much knowledge about a variety of neuro subjects. Additionally, we wanted to see if there is a correlation between education and knowledge about neuro subjects. Studying this data allowed us to get insights into respondents’ perspective and confirm our hypothesis. We sent a survey to a diverse group of people from a website www.neurodecisions.com that we created as a part of the work. Our criteria was to collect a diverse sample of noninstitutionalized population and be inclusive to a larger population.

The website neurodecisions.com serves as a platform, a global community of practice for business leaders, human resource practitioners, economists, neuroscientists and professionals from other fields interested in knowledge sharing and exploring the extent of the application of this knowledge across industries. We believe global community of practice will help global society to grow together.
4. Cognitive Neuroscience

In the last ten years, dedicated to neuroscience scientists put tremendous efforts in learning and discovering the brain. One of the uncovered potentials, was in learning how cognitive activities could possibly become a transformative power in the way the corporations were doing business, the functioning of the government, and in our interaction in life daily. The generated knowledge, tools and mechanisms, produced outstanding results by providing better understanding of processes that involve reasoning, emotions, and longer retention times (Giordano 2009). Thanks to technological advances in electronics and systemized computer systems, we have access to more knowledge and technology that gives us plenty of opportunities to accurately have access to brain scanning capabilities at a reduced cost to explore and participate in more complex experiments.

Dr. Javier DeFelipe in its publication related to the complexity of the brain, stated that “understanding the human brain is the ultimate goal but this is extremely challenging—not only because of its complexity and the technical difficulties involved, but also because ethical limitations do not allow all of the necessary datasets to be acquired directly from human brains. Consequently, most of our present knowledge of brain structure and behavior has been obtained from experimental animals”.

There is a myth that we only use between 10-25% of our brain, and that that the brain usually works at 20-35% of their potential under normal conditions. Dr. John Henely, a neurologist from the Mayo Clinic, suggested that most regions of the brain are always 100 percent active, and that the only difference is that at any moment the brain's regions do not fire. It is using the latest neuroimaging technology that research had confirmed the use of 100 % of the brain over a 24 hour-period. Dr. Henley also explains that “even during sleep, areas of the brain such as the frontal cortex, which controls things like higher level thinking and self-awareness, or the somatosensory areas, which help people sense their surroundings, are active”.

According to Robynne Boyd, the brain is divided into the right and the left hemispheres, and depending of our personal characteristics we tend to use only one hemisphere, which it is defined as the dominant hemisphere. The right side is the part of the brain responsible and credited with skills related to creativity, emotion, artistic expression, synthesis, memory skills. The left side is responsible for the dynamics of linear and sequential thinking, which allows us to recognize groups of words and letters, speech, writing, and mathematical logic.

1 Dr. Javier DeFelipe, extracted from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4542575/
2 Robynne Boyd, Scientific American, February 7, 2008
Research has shown that the “favorite” (dominant) side of the brain is accessed almost every time automatically, but this does not mean we cannot use 100% of its potential. To make our brains develop more, a series of continuous training, together with good health, would be needed to increase the capacity of reasoning, mental agility, and better concentration. This requires a great amount of patience, extreme flexibility, and its results will take time.

The decision making process involves several mechanisms, and the study of how these decisions are processed in the brain should provide sufficient evidence as to how to proceed. It is evident that the emotional state of an individual affects the outcome of a decision. As Dr. Daniel Saltzman\(^3\) stated, “we might fool ourselves into thinking, we’re perfectly rational beings, but of course that is far from the case. Clearly, emotional factors affect how we make decisions all the time”.

According to Dr. Saltzman, there are several questions and promising answers that researchers can and are able to address with precision in the near future. Some of these questions are:

- Coding: how neurons do the emotional weight of our experiences—do some neurons only become active in response to negative experiences while other neurons only fire when we experience something positive?
- How do neurons code the numerical value of various options—do more or different neurons fire for an option with bigger rewards than that for a lesser reward? How does the coding for rewards that you receive immediately differ from that of rewards that are delayed?
- How do the far-flung different parts of the brain that govern decision-making coordinate their activity when making a decision?
- What triggers a decision—is it the cumulative buildup of firing neurons that tip the balance to the final choice?

How do we alter our decision-making rules when we encounter new information that makes those rules obsolete?

Cognitive social learning theory can serve as a theoretical starting point for deriving hypotheses concerning the influence that social factors have on the development (and change) of FO and its impact on individual action\(^4\). Every time we learn about new things or acquire new information new neurons are generated in the hippocampus. As we know, this is the region of the brain associated with memory, emotions, and learning.

\(^3\) C. Daniel Salzman, MD, PhD., Department of Psychiatry and Neuroscience and Kavli Institute for Brain Science, Columbia University School of Medicine

\(^4\) Correlates and Conditions, Studies in Decision Making. P. 175
One of the worst enemies that can put neurons production to a halt is stress. Stress also affects the speed of connections between hippocampal cells. According to Dr. Bruce S. McEwen who published Brain on Stress\(^5\), stress is “a state of mind, involving both brain and body as well as their interactions; it differs among individuals and reflects not only major life events but also the conflicts and pressures of daily life that alter physiological systems to produce a chronic stress burden that, in turn, is a factor in the expression of disease”. The author illustrates how stress affects daily human behaviors and sleep and how the plasticity of the brain circuits can also affect the balance between anxiety, mood control, memory, and decision making. This has prompted to further develop research and studies on how the brain works under certain levels of stress and uncertainty.

5. **Theories**

Decision making is one of the basic cognitive processes of human behaviors that requires a cross-disciplinary approach. It connects neurobiology and cognitive science, where “cognitive models help to translate neuroscientific measurements into latent processes”. (Frank, 2015). Even though decision making study started getting traction only in the past 20 years, a number of behavioral decision theories related to managerial decision making have been developed throughout the years. For the purpose of this paper, we will focus only on the most prominent cognitive models and theories.

There are two categories of decision theories: the descriptive and normative theories. Descriptive theories are based on empirical observation and experimental studies of choice, while normative assumes a rational behavior with well-defined preferences.

An example of normative theory is the Bayesian decision theory that was developed by Thomas Bayes in mid-18 century. It is a statistical approach informed by Bayesian probability. To make a decision, a person needs to estimate the expected value of actions and expectations based on new information. It is a fundamental approach to the problem of pattern classification. The main difference of this theory from other approaches is that before the data is received, the decision-maker examines the degree of his confidence in the possible models and presents them in the form of probabilities. Relevant statistical data is usually absent during the process of decision making, this complicates the tasks of decision making that may question its conclusions and opinions. In situations like this, the application of the Bayesian approach is very effective.

\(^5\) Brain on stress: How the social environment gets under the skin
A much later developed rational decision making model, the Kepner-Tregoe model, developed by Charles Kepner and Benjamin Tregoe in the 1960s, is a structured methodology for gathering, prioritizing, and evaluating information in business environments. Its main purpose is to find the best possible way of dealing and prioritizing risks, based on achieving the outcome with minimal negative consequences in unbiased environments. The model is considering many possible factors that may be vital in making the decision.

The Vroom-Jago decision model helps to identify the best leadership style to adopt for each type of situation. It helps leaders to determine whether they should make a decision alone or involve a group, and to what extent the group should be involved. This method was first proposed by Vroom and Yetton in 1973 and later was modified by Vroom and Jago in 1988. A greater precision in situational assessment of the Vroom-Jago decision model allows to make better decisions effectively.

Cognitive theory stimulates new neuroscience investigations and provides a functional level of analysis that motivates a deeper investigation of the brain. Without cognitive theory, and its development, we would not know where to begin to include the use of formal and computational methods, and the functional significance of individual neuroscientific observations would not have been fully realized. Today, to further develop decision neuroscience, scientists need to identify and quantify all aspects of thinking in order to understand the physical basis of decision making. However, according to Kavli Foundation, researches are currently trying to answer:

- “How do neurons code the emotional weight of our experiences—do some neurons only become active in response to negative experiences while other neurons only fire when we experience something favorably?
- How do neurons code the numerical value of various options—do more or different neurons fire for an option with bigger rewards than that for a lesser reward? How does the coding for rewards that you receive immediately differ from that of rewards that are delayed?
- How do the far-flung different parts of the brain that govern decision-making coordinate their activity when making a decision?
- What triggers a decision—is it the cumulative buildup of firing neurons that tip the balance to the final choice?
- How do we alter our decision-making rules when we encounter new information that makes those rules obsolete?” (Kavlifoundation.org)
6. Neurotechnology

Technology often marks the speed and rhythm of development. In recent years, major advances in technology have allowed to enter and explore the marvelous world of the brain. Recent discoveries have uncovered a vast and still unknown areas that would help brain scientists explain most of the enigmas that still are unknown. These enigmas can affect all levels of society and will define the world of 2020\(^6\) with tools and methodologies able to be used for both social good and social ill (Canton 2012).

Neuroscience is taking a new approach into finding a new set of answers to the rather complexity of the brain. This approach is not new. Going back in history, neuroscientists have always looked into appropriate answers to the questions of how the brain responds and reacts under certain conditions or circumstances. To this day, only a percentage of the brain have been “discovered”, and a lot more of it will become known, especially on how it behaves when performing under uncertainty, stress, external conditions that affects individuals to tentatively make good decisions.

The neurocentric society of the future, according to Dr. Giordano\(^7\), will be very different where new technologies, will be able to decipher most of the remaining 70-75% of the brain, and we’ll be able perhaps to become better individuals overall. As Dr. Giordano stated, “will better brains make a better world”?

In the past, scientists have discovered and studied 83 regions of the brain, and have worked since then in establishing parameters accordingly. Now, latest technologies were able to unfold an additional 97 new regions. This new discovery\(^8\) on the outer shell of the brain, more than double, has opened a new horizon of opportunities to better understand the human brain. This is a very significant milestone since these regions are responsible for our mind’s higher functions, like consciousness, information processing, language, and problem solving (decision making).

Thinking positively, the discovery of these segments of the brain will be enough for us to make us smarter. Once having a better understanding how the brain works, we’d be able to further enhanced it and increase its performance, which translates in better productivity, and therefore make better choices and decisions.

Further, to anticipate where the development of neuroscience and neurotechnology leads us in the future we will review existing neurotechnologies in the detail. We already know that science

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\(^6\) Toward our Neurofuture: Challenges, Risks, and Opportunities (2012)
\(^7\) Giordano, J., Chief Scientist, Pellegrino Dept., Georgetown University
\(^8\) The National Institutes of Health’s Human Connectome Project
and technology have enormous impact and applications on every single aspect of our lives. The convergence of technologies in cloud, predictive analytics, internet of things, social, and mobile help businesses compete and disrupts the industries. However, recent ground-breaking findings in neuroscience, with the help of Neurotechnology, would allow to have a deeper understanding of the brain and its functions in the areas of memory, consciousness, awareness, attention, and biological basis of human behavior unraveled the potential that lead to a dramatic change. It may completely transform the way we used to interact with the world, which means almost everything we knew will be changing. Moreover, it will have an impact not only on how the humans used to do something, but considering the interconnected eco-system structure of today’s world, these innovations will also change us. And this is only the beginning of a new era. Neuroscience and neurotechnology are developing faster than any biotechnology, information technology, robotics or nanotechnology revolution.

Further development of neurotechnology will effect business, economics, defense, communication, entertainment, will have wide societal impacts, as well as will influence medicine, and health. It can improve quality of life, help improving neural capabilities that might lead to enhanced human intelligence and efficiency. Most importantly among all recent brain discoveries though that it may contain the key to human brain disorders. It is known that over 2 billion people today have mental health disorders that need to be addressed in a fundamental way.

There are four main sectors of neurotechnology:

- brain computer interface
- cognitive load technologies
- wearable technologies
- neuroimaging

**Brain computer interface (BCI)** – form of communication between a brain and an external device. This technology gives unimaginable before capabilities that allow to extend control over the surrounding environment beyond previously known physical abilities. In other words, even though it is still in the process of further research and testing, “a device, attached to the skull, is wired to several electrodes in the brain, and interprets and transmits data in the form of radio waves. These waves are transmitted to a receiver, where they become a signal to control an action. The data is transmitted faster than it has ever been before, but not up to par with the speed at which the human
brain process and transmits data (through neuronal signals)”9 (Neurotechnology Futures Study). It can tremendously help people with limited movement ability. In addition, researches from Duke University discovered that connecting several brains lead to collaboration that is characterized by improved abilities than a single brain. In addition to finding better ways of treating mentally ill people in the future, the technology holds large potential in treating people with severe injuries. The technology can also be used in other industries, for example in automobile industry for drivers, in airspace for astronauts, in aviation for pilots, etc. to have a hands-free device control. In will enhance the gaming industry as well by allowing to better recreate the reality. Marketing and ergonomics can employ BCI in monitoring reaction and evaluation. It will also certainly affect advertising. As a result, by 2020, according to the data from the Potomac Institute, the market for BCI is forecasted to expand to $1.46 billion dollars.

Cognitive load is the “demand placed on working memory as people perform various tasks technologies. New technologies help to improve brain processes when under extreme circumstances. We can experience high cognitive load when we need to perform simultaneous tasks, for example, answering an email and having a conversation at the same time. Both activities require effective communication and organizations started investing in technologies that would measure high cognitive load and identify high stress moments to optimize their call centers, for example, and make sure that they have the right number of employees in place. These technologies are beginning to be especially effectively employed in the automotive industry to identify the state of the driver and the degree of destruction by measuring the heart rate, electro dermal activity, electroencephalography (EEG) and to advance the design of physiological sensors in user interfaces.

A British company specializing in global information and measurement, Nielsen, a company that put the knowledge of what consumers watch and buy in the heart of their business, has patented a number of neurotechnologies to improve their marketing offerings to the automotive industry. By measuring brainwaves, the company can access the insights of consumer response to products, and better understand how customers can be best attracted to certain models10. IBM’s Watson Group found a use for this technology in travel industry. They use cognitive business operations to optimize and deliver behavioral patterns and identify the customer needs from bedding to bistros11. The same technology has found an application in defense industry. In order for a soldier to be able to detect threat despite fatigue, the DARPA Cognitive Technology Threat Warning Systems (CT2WS) that

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consist of three-part system of a high resolution and range video camera, cognitive visual processing
algorithms that run on laptops, and EEG that measures brainwaves, detect soldiers’ subconscious
detection of targets. This lead to the detection of 91% of threats.

**Artificial Intelligence (AI)** – is any type of technology that is capable of simulating human
brain abilities and is meant to reduce cognitive load. Robotics exactly fulfills this purpose and
increases efficiency in completing tasks. Enhanced user productivity “raise baseline intelligence
allowing performance to surpass current optimal levels.”\(^{12}\) (Neurotechnology Futures Study). In
fact, growing AI industry can boost growth in neurotechnology industry because both pursue
advancements in efficiency and productivity. There is a lot of interest from venture capitalists to
push development of artificial intelligence. IBM’s Watson Group today is the leader in artificial
intelligence technology applied to financial services and healthcare industries.

**Wearable technologies** have a sub-sector of wearable neurotechnologies where we will
focus here. It is a direction of wrist/head/hand-worn devices that measure and control nervous
system activity. At Arizona State University research was focused on creation of lifestyle wearable
device that would help balance different states of mind – energy, calm, and focus. Venture Capital
funding increasingly interested in these technologies and up to 2015 invested $450 million.

**Pain relief**, neuroscientists decided to seek for alternative way of alleviating the sensation
of pain. There is an active research and investigation looking into pain relief modalities that affect
nervous system directly. It might be potentially a breakthrough solution to the problem via direct
stimulation of key receptors. “Transcutaneous electrical nerve stimulation (TENS) is a non-
pharmacological and noninvasive treatment method for chronic pain. TENS-induced analgesia
occurs through effects on both the central and peripheral systems. Application of TENS to afflicted
areas activates opioid, serotonin, and muscarinic receptors in the spinal cord and brain-stem and
opioid receptors in the periphery.” These discoveries are being tested and will be applied to
development of stimulation technologies in the future. It can find an application in treatment of
chronic deceases as well as injuries.

In addition, these devices can not only monitor pain, but assess the level of sensation. The
advances in this technologies will also help to gather necessary data and help to detect early stages
of neuro system deceases.

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**Sleep and Stress**, due to increasing levels of stress we experience in our lives, it became necessary to develop technologies that help cope with stress. It is known that stress might lead to negative overall health effects and sleep problems that in its turn can increase risks of mental deceases. Recently, there is a boom in development of wearable devices that focus on stress and sleep problems. The goal is to help to maintain peak cognitive performance.

One of these devices is a sleep aid mask with which many people are already familiar. It measures biological signals such as EEG, EMG, pulse, eye movement, and body temperature, and wake the user at his or her lightest phase of sleep by creating simulating dawn lighting. Additionally, the scientists look at how lighting therapy can help normalizing sleep after traumatic brain injuries, reduce daytime sleepiness, and improve attention and concentration.

The other form of devices as headbands monitoring brain activities though seven sensors help reduce stress through meditation and focused activities. It transmits all the information to the application to track one’s own brain activity. While the application offers focus exercises, the headband measures brainwaves, heart rate and surrounding electromagnetic pollution to monitor stress level. It helps to understand which activities help reducing stress. The application for the technology is very wide, from treatment of mental disorders to HDHD.

There is also a new fascinating technology named Brain Wave Entertainment. It can synchronize brain frequencies and help to reach a desired state of activity or relaxation through light, sound, vibration, etc. Brain Wave Entrainment leads to an almost instantaneous change in brain frequency and state, justifying its use as sleep/stress/focus aiding consumer technology. Research of the Washington University of Medicine in St. Louis have discovered that when a brain is in Delta brain wave state, it stops production of “beta amyloid plaque, which is a major cause of Alzheimer’s decease (AD). This might be a possibility to treat AD decease and researches are currently working on that. There is not enough neuroscience research done studying this technology, but companies already started promoting the technology as improving attention.

**Neuroimaging** is a transformative technology in the industry that allowed us to see and read sophisticated human brain. Due to the developments of this technology neuroscientists were able to look at the structure and the function of the brain deeper. Currently, the researchers are working on advancing the technology making it portable and improving high image resolution. One of the recent discoveries on the market is a wearable device that uses the fNIRS (functional Near-Infrared Spectroscopy) imaging system and measures activity in the prefrontal cortex via changes in blood oxidation levels called cerebral hemodynamics. Using a mobile device users are able to monitor
which parts of the brain are activated. Current version of this technology is useful for field researches and as a ground for further advancements of portable imaging.

Researchers at UC Berkeley as well as some others study electronic signals of human brain reflected on a computer. It might be leading to a breakthrough in a justice system. Moreover, neuroimaging is a primary technology that helps constructing structural and functional maps of the brain. “At an MIT lab, material scientists have created neural probes that can transmit and collect electricity while carrying light and can also pump drugs. This is all done through ultrathin fibers that are implanted into the brain. Such probes can not only read electrical signals but also stimulate neurons to produce them”\(^13\) (Neurotechnology Futures Study). This has wide medical implications and could potentially revolutionize treatment.

Lastly, there is an emerging technology that injects implant devices that could help studying brain mapping. Studying electrical impulses of particular networks of neurons could improve understanding of underlying pathology of neurological disorders such as schizophrenia or Parkinson’s Disease.

This overview does not imply to list all possible emerging technologies, but only the main ones that are advanced enough to make a serious impact at this stage. However, the list should give a good overview of what is happening on the technological side and how it helps to move neuroscience further ahead. More importantly, it demonstrates its wide implications on the industries. For all these reasons, there is a lot of interest among investors in the development of new technologies and among governments, for example, mentioned in previous chapters BRAIN initiative of the U.S. government that calls for further innovation in neurotechnologies.

7. Neuromanagement

With the rise of recent neurotechnological discoveries that made a variety of neuroscientific tools available, practitioners and business leaders can make better decisions, improve productivity and achieve better results faster. In today’s world, the increasing complexity of global business environment and the necessity to act in the interests of multiple stakeholders puts even more pressure on effective decision-making. Therefore, business leaders have more responsibilities and accountabilities when making decisions.

Neuromanagement helps connecting cutting-edge discoveries from cognitive neuroscience and business. Its focus is on analyses of human brain and cognitive abilities when dealing with economic or management decisions. The goal of neuromanagement is to identify behavioral patterns when facing a problem, understand how to reveal full potential of human capital, how to create the atmosphere of trust and how to persuade effectively. In other words, understanding of how to create a high performance team is the cornerstone of the discipline. Technology and neuroscience help identifying the problem areas and point to solutions what areas need to be developed, how simulation games and special training could help in developing a specific skill. Neurotechnology can help by not only providing mapping, guidance and support to behavioral change for leaders and organizations, but making it a sustainable behavioral change.

One of the ways to excel is to find a productive way to connect with colleagues, clients and partners. Brain scanning technology is an example that adds a new dimension to management and hiring practices. It is important to develop high self-control in highly stressful situations. Multiple research has proven that bad mood can hinder a person’s decision making abilities, job performance and lead to poor decisions that affect the company. In contrast, a positive mood can enhance creativity and problem solving. However, positive moods can also create false optimism and negatively influence decision-making. In other words, the person’s state is important when solving problems. Lastly, it is also very important to embrace a leadership style that would highlight lead change.

Research, as one of the important facilitators of decision-making process, helps problem solving for decision makers and brings light to understanding of the decision-making processes. Recently, researches in psychology and neuroscience from Yale and NYU started studying choice behavior and its neural basis when people need to make decisions without knowledge of a possible

outcome, under condition of uncertainty. They compare neuroimages of animal and human brains making choices in the attempt to understand the process. They also test which computations are relevant and could be used in the development of abilities to make better decisions.

Outstanding HR Practices always look for a well-rounded approach to successfully implement capacity building programs for employees throughout an organization. Investing in training using simulation at all levels should be an important priority, and accessible to all levels of management. Good leaders have to ensure the investment in talent. As the good saying goes, train employees well enough that they are capable of leaving, but treat them well enough that they don’t want to leave.

There are several research methodologies that play significant role in understanding the process of making decisions. One of them is universe research methodology. This type of research can help neuroscience in the process of improving human intelligence and understanding the complexity of human brain, emotions, and perceptions and how it affects decision-making. In the case of neuroscience and decision-making, it encompasses emotions, perceptions, experience, education and stress.
8. Neuromarketing

To find a better way to approach and attract customers, there are new marketing models in place based on new technologies that can address the real needs of customers. Neuromarketing, a barely new concept, is the field that establishes the direct connection between marketing strategy and consumer behavior with neuroscience, and it is getting more credibility among marketing and advertising professionals.

Using latest technologies, this field can provide accurate data on consumer’s behaviors and preferences, by analyzing the brain images produced from an individual based on their emotions, and it also offers cutting-edge methods that could considerably improve the effectiveness of consumer behavior towards an improvement of buying power.

It is harder than ever to have a successful marketing program because a brand does not longer have control on its own. The audience today is now on the driver seat and under clear control of marketing and brand strategies\(^{(1)}\). To have a successful marketing strategy, a well-designed marketing plan is needed from the executive level, where most of the decisions are taken, and these should include a clear and defined tactical approach using latest neurotechnologies.

Marketing professionals these days are coming to a conclusion that data acquired from random surveys, focus groups, point of sale, or any other way of data collection cannot go far enough to conclude what are the real customers want, since most times consumers don’t always do what they say, and they don’t always behave predictably. The neuromarketing field offers state of the art methods for directly probing minds without the need of demanding and putting them through cumbersome processes, or conscious customer participation.

The field of neuromarketing has a potential to significantly improve the way of doing business effectively on both commercial and individual practices around the world. Companies including Coca Cola, Frito-Lay, Gillette, Google, P&G, Philips, and Hyundai, among others, are already utilizing latest neurotechnologies techniques to attract customers and test their products. Several techniques are available for this purpose, like imagery (fMRI), or functional magnetic resonance, (GSR) galvanic skin response, to include eye movement to measure people’s reaction to images, audio and other sensory activities.\(^{(2)}\)

\(^{(1)}\) Journal of Brand Management (2010)
\(^{(2)}\) Samuel Greengard, Smarten Up! Neuromarketing Is Getting More Intelligent
Are we approaching economic questions and decisions with the right angle? This question has always come up over the centuries, when economists tried to find answers to economic complexities based on human choice behavior. Theorists at the time, developed qualitative and quantitative methods that measured the tendency of rather complex decision-making processes. The rationale for this analysis is to explore how people make decisions that have economic consequences and its implications in today’s daily life.

The field of Neuroeconomics and its role is to make the connection between the brain and current economic studies in public and corporate environments, where relevant behavioral outputs can be applied based on good judgment. The name comes from the combination between behavioral and neural science with economics, a new research field relies on neurobiological data to have a clear view of a decision-making and economic behavior.

This new field of neuroeconomics, where its very main purpose is to make the bridge between cognitive sciences and economics, is challenging the traditional economics studies. Neuroeconomics has primarily challenged customary economics postulation that decision-making is a unitary process a simple matter of integrated and coherent utility maximization suggesting instead that it is driven by interaction between automatic and controlled processes (Satpathy, 2014). According to Satpathy, “Neuro-multiple-systems approach to decision-making can influence economics. The integration of these approaches and methodologies offers exciting potential for construction of near-accurate models of decision-making”.

This is an exciting time where researchers are beginning to understand what is going on in our brain. A time where technology can closely predict when and where better decisions can be made and the proper time to make this decision under some constrains and uncertainties.

According to Dr. Jyoti Satpathy, good and accurate decisions “should include all possible information, all of it accurate, and every possible alternative” (Satpathy, 2014). Our life is fulfilled with a series of decisions at all levels. Some do not require deep analyses and can be deliberately addressed, but others are very important. We as human beings are involved in making decisions throughout our life; these decisions can range from an individual, to an organizational level. We almost always want to make a good decision, and most times we rely on the available data we have at a given time, and

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17 Evan Wilhelms and Valerie Reyna, Neuroeconomics, Judgement, and Decision Making. 2015
18 Satpathy, Jyoti, Dynamics of Neuroeconomics Decision-Making
19 Dynamics of Neuroeconomics Decision-Making
the facts presented. This can be pretty much called the average and normal decision making process (ANDMP).

There are different approaches to analyze the decision making process. One of them from the theoretical standpoint is the basic principle of a decision analysis to break it up in several pieces, or decomposing it (Aschenbrenner, Mai, Ksienilk)\(^{20}\). Once decomposed, there are two mathematical models used to integrate them according to the need. (a) for value judgment, the multi-attribute utility theory (MAUT), and (b) for probability judgments, the help of probabilistic information processing systems (PIP) is used.

Going back to the theory of decision making, and to simply put things in context, there is just not enough of understanding so far of how the brain makes decisions if we do not explore the basics of how the brain works before and while making a decision. It is important to understand that better decisions almost always come from well-trained individuals, and that reliable answers from it addressed the many challenges we encountered daily. Corporations will be very much able to benefit from a comprehensive investment of resources and manpower, of “brain enhancement” discoveries, where individuals will be able to be in the driver’s seat and in the path for success.

The effects for having a better understanding of the brain are hugely extensive. Starting from how individuals perform within an organization that will directly affect the productivity as such, and going through the complexities of the organization itself where effective relationships between co-workers should be as important as performance.

In principle, neuroscientists have always worked with the idea to finding ways to properly assessed human behavior, but sometimes these assessments have not been very accurate. Data collected can be misinterpreted, and its results may lead to undesired outputs (Giordano 2012). Proper training can help to understand and better interpret the data outputs, how to use it, improve it, and not misuse it. In the decision making process, several aspects are taking into account. One of them is the ability of the individual to make a decision. People with a relatively unstructured Future Orientation (FO), are thought to make these decisions without measuring the consequences of their behavior, but rather acting impulsively requiring immediate rewards\(^{21}\).

Future orientation (FO) is an aspect of time perspective – according to Lewin (1948) – comprises plans, aspirations, expectations

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\(^{20}\) Utility and Decision Analysis, Studies in Decision Making. P.667

\(^{21}\) Conceptualization and Measurement, Studies in Decision Making. P.169
and fears concerning events and actions realistically possible in the near or distant future (Lewin, 1948).

On the other hand, good decisions do not necessarily come from high intelligent individuals, we don’t have to be rocket scientists to be a good decision maker, and intelligence does not have anything to do with making a good decision. Usually what happens is that very intelligent people tend to be more cognitively complex, and their tendency to take significantly longer time to make a decision since they have to absorb a large set of considerations before making it final decision, can be leading it to paralysis.

Decision-making is the ability that one can learn, and it does not depend on how smart we are. The decision making process is at the same time often highly polarized. The tendency to believe that women are more intuitively, emotionally inclined and less decisive while going through a decision process and that men are more cool-headedly is not quite accurate. People in general have different strengths and weaknesses, and decision-making process is not directly correlated with gender.

The decision making process in business presents several challenges and one of them is the decision maker’s behavioral state where it is as important as the results of the decision itself. Important economic decisions are most times done based on the emotional environment at a given time, and also made on forecasts or predictions that goes beyond any human comprehension. Recent studies have shown how emotions make a major difference in decision-making. The decision making process can be very complex in nature, and a lengthy process that involves external factors like collectable and available data about choice alternatives, and important factors such the level of maturation of the brain systems that deal with stress. Decision scientists were able to incorporate methods of behavioral science and the brain science to demonstrate that complementary roles of cognition affect the decision making process (Epstein et al., 1992). At the same time, recent research established the connection of people predictions and their emotions. Affective forecasting is predicting how an individual will feel in the future, this topic will become very often referred soon.

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22 David Welch, Decisions, Decisions, The Art of Effective Decision Making
23 Dan Goleman Ph.D, The Brain and Emotional Intelligence
24 Irwin Levin, Todd McElroy, Gary Haeth, William Hedcock, Natalie Denburg, and Daniel Tranel, Studying Processes Through Behavioral and Neurosciences Analysis of Framing Effects
10. Neuroleadership

Organizations are becoming more proactive and innovative in the process of improving the performance of their employees by implementing the findings of neuroscience studies of the brain, making them the scientific drivers and promoters of organizational change.

Neuroleadership, the new field that is building the bridge between neuroscience and leadership in organizations, is still in its very early stages. In general, brain studies are still being discovered, and techniques like fMRI and position tomography (PET) have uncovered connections in the brain that are advancing this field much further. Latest technology confirmed large number of connections between the brain and people’s behavior.

Human resources professionals are becoming more engaged by looking for better alternatives in organizations to improve people’s performance, promote creative thinking, structure better rewarding systems not just based on remuneration, and for ways to improve communications. The field of Neuroleadership is very tied to employment practices in finding the connection between the hard science and leadership, since neuroscience research studies suggest that positive relationships between managers and employees trigger an area in the brain that activates openness to new ideas and a more social orientation to others (Boyatzis, 2011). The field of neuroscience applied to leadership, will open windows of opportunities to further improve leadership behaviors.

Technology has also uncovered that gut feelings are real, and that can be helpful in leadership development. A gut feeling is a feeling that occurs without conscious thought, and leaders in the past have been taught to suppress their gut feelings and to rely more on making decisions based on logic and facts, but, as Waytz and Mason stated, there is a mounting neurological evidence that “emotional reactions like those should not be ignored”.” Gut feelings can certainly be fallible, but can be used to help bypass complex and time consuming analysis. In situations that involve risk, negative gut feelings can be used to stop leaders from overly optimistic decisions” (Waytz and Mason, 2013)²⁶.

11. Neuroethics

This field studies the implications of neuroscience to human self-understanding, ethics, and policy, and addressing the ethical, legal, and social issues arising in a neuroscientific research and its applications in the public domain (Giordano and Gordijn 2010; Roskies 2002).

Dr. Giordano and Dr. Benedikter27 already raised a question of what could happen if we are able to read someone’s mind? Or, if we could go back and forth in our thoughts, what we hear, think, and vice versa? How about the possibility to store our memories in a sort of chip, or implant?

What used to be science fiction, now the latest technologies can interconnect human brains and make them real. Let’s think for a minute of a possibility to establish an interchangeable method to switch back and forth a chip from person to person, and this data not only includes the historical aspect of our life, but also memories, thoughts, or experiences that do not fully represent ourselves, or belong to us.

The latest technologies in neuroscience, specifically in brain imaging techniques, can make possible to see how the brain functions. The Neuroethics field can make assumptions about someone lying, or how guilty or sane an individual is while reading these brain images. The question raised is how ethical these brain-imaging techniques are, and how reliable these images are in providing enough evidence about sanity or guilt on criminals with different brain characteristics. Ethical questions also rose about the use or misuse of brain imaging in the workplace to assess how employees performed under certain conditions, or how marketing experts are using neuroscience studies to influence the way we make decisions and purchases.

The evolving field of Neuroethics plays an important role of identifying the fine line between ethical and unethical practices, and the possibilities of use or misuse of this data that can undermine the way we interact with people around. Questions have risen as to how the field of Neuroethics can contribute significantly on issues related to the judicial system and be an effective and proactive partner in influencing politics, economics, and society (Giordano, 2012).

Just thinking about the possibility that modern technology can get data in and out of the human brain at any time is breathtaking. Also think that one day in the future we can manipulate intelligence and memory, and able to communicate thoughts from person to person, is even more incredible. Scientists are currently discussing the impact if two hippocampus chips are wired together. In another thought, the fact that we could communicate from one mind to another by

27 Dr. James Giordano, Chief Scientist Pellegrino Center, Georgetown University
transmitting data through our sensory motions, or to share what we see, imagine, think, feel to someone else, or perhaps that technology is so advance that can enhance our neurons by implanting a prosthesis, so our thinking, memory, attention, and decision making would be much better.

According to professor Ramez Naam28, “the ability to enhance and embrace the human could supercharge the process of innovation that today relies on the connections between minds. Just as the printing press, by improving the spread of ideas, helped bring on the Renaissance, mind to mind connections could herald a new era of progress”.

Professor Naam also highlighted the possibility of computer or electronic viruses, and malware that can potentially harm our brains if they are wired, or the possibility of a software crash alike that would make us behave out of control. All this may sound a bit out of context or reality, however, anything can happen in this high speed race into new neurotechnologies.

The study of the human brain is challenging, not only because of its complexity and technical difficulties, but also because of ethical limitations. “For obvious reasons, we are not always ethically allowed to collect all the necessary types of data directly from human brains.

28 Ramez Naam, adjunct faculty at Singularity University and fellow at the Institute for Ethics and Emerging Technologies
12. Neuroscience and strategic approach to decision-making in business

With a growing complexity of the globalized world and a digital economy, neuroscience has taken on a new role. A new field in this discipline is called decision neuroscience, and it attempts to uncover and describe the operation of the human thought process. It states that thoughts “are determined by the actions of specific neuronal circuits in our brains.” (“Kavli Foundation,” 2016). By studying the circuits with the help of neuroimaging, scientists are able to map thinking on a cellular level. Now they can see individual components within the thinking process and are decrypting how these components are integrated when the human brain is thinking. This knowledge will bring light to deeper understanding of the decision making process and its complexity, which is important in the success of modern business.

Today’s society has already adopted a brain-focused vision of the future, even though neurotechnology has been making sound discoveries for only the past two decades. New discoveries in this field prompt traditional business operations to take on a path of transformational change. Recent studies had demonstrated that there is a strong connection between the brain and decision-making process. That is why the core of such transformation is the human brain in itself and how individuals make decisions. It takes strong leadership to achieve exceptional results. That means that corporations have to focus on cognition and look for ways to improve it.

Cognition is a mental ability that is responsible for understanding and perception of the world and how a person acts in it. Enhancement of cognition can be developed through training and practice of intelligence functions. For example, advances in technology led to the development of many modelling and simulations of real-business problems and situations, creating virtual training environments that fully resemble real life. Recent research by Dr. Giordano, Neurotechnology in National Security and Defense, proposes to use these advancements in the training of intelligence personnel. He suggests to combine intensive instruction, simulation, and incorporation of the latest technologies (Giordano, 2015).

Applying similar practices in a corporate world could be one of the many ways to improve an organization’s performance. It would not only provide extensive training with practical exercises for human capital, but would also measure cognitive abilities and identify weak spots in the decision-making process of each individual. That would allow human resources to tailor job responsibilities and identify proper placement of the candidate. These types of activities will provide important information and data for comprehensive analysis: from assessment and diagnostics, to tracking the development of particular skills. Moreover, neurophysiological indicators can help
capture different states of the individual, such as confusion, confidence or interest. It is also
necessary conduct a well-planned assessment of each individual’s behavior and training, along with
their decision-making abilities facing constrained scenarios under uncertainty, because, as we
demonstrated before, decision-making process can be affected by the type and amount of
information individuals receive. These results can lead to the elimination of operational
inefficiencies and the identification of the right strategy to manage the business on a large scale.

IBM Watson recently published an article on their website, where they state:

One of the most impactful ways businesses can bring cognitive into their organizations is
through their operations. Operational weak spots represent a particularly heavy drain on
revenue and other resources, and are opportunities for applying the transformative potential
of the new cognitive era. (“IBM Watson,” 2016)

In other words, cognitive development will lead to new levels of efficiency and productivity
that will reflect on overall business performance.

Charles Duhigg, an American journalist and a non-fiction author adds another perspective
to decision-making and improved performance. In his recent book, he wrote that personal habits are
the basis of decision making. He illustrated how an individual can change the course of his or her
life by focusing on just one thing, which would result in a significant transformation. However, he
pointed out that “it’s not just individuals who are capable of such shifts. When companies focus on
changing habits, whole organizations can transform.” Mr. Duhigg gave a concrete example on how
companies like Procter & Gamble, Starbucks, Alcoa, and Target, transformed the way their
employees communicated with each other, resulting in better outcomes and increased performance.

There are also other authors, such as Jack Zenger and Joseph Folkman, who have several
studies related to decision making, where they prove how bad habits can lead to adverse decisions.
The following results were extracted from a recent Harvard Business Review29, in an effort to better
understand the roots of poor decision making. It compared the 360-degree feedback data from
50,000 leaders and 9 habits were found to be common: laziness, not anticipating unexpected events,
indecisiveness, remaining locked in the past, having no strategic alignment, over-dependence, lack
of technical depth, failure to communicate the what, where, when, and how associated with their
decisions, and isolation (See Appendix II).

There is another application of neurotechnologies to decision-making. For example, in any
client-oriented service industry, it is expected that a service provider is aware of customer needs and
is able to meet these needs efficiently. Incorporating the neurotechnologies in the process would

29 HBR, 9 Habits that Lead to Terrible Decisions, by Jack Zenger and Joseph Folkman
help service provider to make necessary decisions and choices faster and keep growing demand for customer service excellence on the level that modern customers need. Moreover, according to the report from McKinsey Global Institute, knowledge employees, such as data analysts, product developers, etc., spend about 75-80 percent of their time searching for the information to make a decision. Even though it is to absolute advantage of any business that information systems and telecommunication sectors have provided modern business leaders with substantial information on competition, market, labor, regulations, and taxes, it takes a lot of time to process all this information and make an informative decision. It can be very overwhelming. However, with a variety of technologies that are being perfected and adopted by the market, the decision-making process can be simplified in real time terms. An example of this is IBM Watson machine, a technology platform that uses a human language processing with a combination of large amounts of unstructured data. However, it requires skills to use this machine efficiently and know where to rely on it. If used effectively, the report says that 20 to 25 percent of knowledge worker time can be saved just by decision making synergy between a human and machine (“McKinsey”, 2012). Among other examples, Russian and U.S. scientists from Lobachevsky State University of Nizhni Novgorod and Duke University Medicine Center (USA) are closely working on developing a comprehensive brain-computer interface with electric brain stimulation and neurofeedback. It will help to produce the next-generation of brain-computer devices that can be used by groups or individuals and help in the decision-making process.

The intersection where neuroscience and the business environment collides needs to be closely studied by any forward looking business strategist. Just the couple of examples above demonstrate well that there is an urgent need for incorporation of decision management systems and technologies across all industries. As illustrated, these technologies can be used to increase human brain capabilities and train them and can supplement the decision making process. In other words, when neuroscientific discoveries are applied and integrated into business and they share best practices, we can unlock tremendous potential. This would lead to a real breakthrough and increase cognitive abilities of human brain that would help the world, the society and corporations make better decisions. Lastly, neurotechnology has the potential to enhance human abilities and “can provide objective measures of the highly subjective analytical process”, writes Dr. Giordano. It can also lead to a skill development training and assessment beyond current assessment capabilities. The results of such training and assessment will be especially valuable when decision makers are in a fast-paced operating environment working under stress and uncertainty, where they have to meet
“cognitive demands” imposed by this environment (Giordano, year!!!). Dr. Giordano\textsuperscript{30} also poses an important question whether technology could take us to a point beyond being a human, and that can affect the international balance of economic, social, and political power.\textsuperscript{31} Therefore, the development of neuroscience need to be closely followed not only by specialists on the field, but by a wider audience in order to be prepared for changes the science imposes on the society.

\textsuperscript{30} Dr. James Giordano, Chief Scientist, Pellegrino Dept., Georgetown University
\textsuperscript{31} Advances in Neurotechnology, ethical, legal, and social issues, Giordano, J
13. Conclusions

By building a bridge between neuroscience and the business environment and finding ways where both can be integrated, share best practices, and have a better understanding of the brain and its abilities, the research has the potential to contribute to society by improving and developing a better environment in organizations. A deeper understanding of the human brain may lead to uncovering new dimensions of human capacity to rationalize and optimize thoughts and decisions in the new century.

The intersection where neuroscience and the business environment collide needs to be closely studied by any forward looking business strategist. Just the couple of examples above demonstrate well that there is an urgent need for incorporation of decision management systems and technologies across all industries. As illustrated, these technologies can be used to increase human brain capabilities, train them and can supplement the decision making process. In other words, when neuroscientific discoveries are applied and integrated into business, we can unlock tremendous potential. This would lead to a real breakthrough and increased cognitive abilities of the human brain that would help the world, the society and corporations make better decisions. Lastly, neurotechnology has the potential to enhance human abilities and “can provide objective measures of the highly subjective analytical process”, writes Dr. Giordano. It can also lead to a skill development training and assessment beyond current measurement competences. The results of such training and assessment will be especially valuable when decision makers are in a fast-paced operating environment working under stress and uncertainty, where they have to meet “cognitive demands” imposed by this environment (Giordano, 2015).

The research showed that neurotechnologies are the basis for the development of a variety of disciplines that encompass neuromanagement, neuroeconomics, neuroleadership and neuroethics. Each of them capitalized on developing technology that allowed scientists to investigate the human brain directed at understanding how and why people make their decisions through studying neurobiological inquiries or biological causes of decision making. With the help of neurotechnology scientists today are able to observe which parts of the brain trigger the signals responsible for effective decision making.

By using neurobiological data neuroeconomics can help specialists in a wide variety of industries better understand economic behavior and decision making. The research of neuroeconomists validated economic models built on both game theory and other classical economic approaches, demonstrating that they serve as methods for linking human brain activity and behavior. Most importantly, the neuroeconomic approach may provide insights into the computations and
their organization, which underlie human behavior. Even though the neuroeconomic program is in its infancy, by using an economically based theory to describe behavior and physiological tools to search for neural models that underlie computations, scientists might be able to build a similar theory around neuroeconomics.

Behavioral economics, aside from pure economics, offers insights into the decision-making process that can contribute to policymakers’ awareness of the factors that may affect individuals’ behavior. Understanding the rationale that drives individuals to make decisions will help both the academic and business world find ways to improve the process, ensuring that people make better decisions for the benefit of both global society and corporations. In addition, insights into behavioral concepts can also help policymakers anticipate and plan for potential behavioral responses not accounted for in traditional economic models.

The application of behavioral science practices, technology, and neuroscience in the business world could lead to better solutions, as well as it will help corporations operate globally more effectively by tapping and quantifying the individual subconscious. Proper training could help leaders in the process of using appropriate procedures in the decision making process and avoid misusing neurotechnology in corporate environments.

In conclusion, decision making research in the field of neuroscience plays an increasingly important role in the modern society. It leads to developing a completely different approach in decision making from traditional business practices. This research offers vital insights for policy makers and business leaders making management, marketing, and moral decisions. It would also have an impact on risk mitigation by preparing decision makers to act in situations of uncertainty and stress. When global economic changes, social risks and insecurity brought a lot of uncertainty, it emphasized the role of the leader. The qualities and abilities of the leader became especially important, and that highlighted the urgent necessity for developing the human brain’s capabilities for complex decision making.

We hope, our recently created website would serve as a platform for knowledge sharing among neuroscientists, academia and corporate leaders, and it will help creating a global community of practice to help global society to grow together. By doing that, this research will continue to evolve and hopefully benefit to many people.

**Applicability**

Neuroscience demonstrated that there is a strong connection between the brain and decision-making process. That means that corporations have to focus on cognition and look for ways to improve it. The application of behavioral science practices, technology, and neuroscience
in the business world could lead to better solutions, as well as it will guide corporations operate globally more effectively by tapping and quantifying the individual subconscious.

Enhancement of cognition can be developed through training and practice of intelligence functions. For example, through modelling and simulations of real-business problems and situations, creating virtual training environments that fully resemble real life.

It is one of the effective ways to improve an organization’s performance. It would not only provide extensive training, but would also measure cognitive abilities and identify weak spots in the decision-making process of each individual. That would allow human resources to tailor job responsibilities and identify proper placement of the candidate. It can also lead to a skill development training and assessment beyond current assessment capabilities. The results of such training and assessment will be especially valuable when decision makers are in a fast-paced operating environment working under stress and uncertainty, where they have to meet “cognitive demands” imposed by this environment. These results can lead to the elimination of operational inefficiencies and the identification of the right strategy to manage the business on a large scale.

There is another application of neurotechnologies to decision-making. For example, in any client-oriented service industry, it is expected that a service provider is aware of customer needs and is able to meet these needs efficiently. Incorporating the neurotechnologies in the process would help service provider to make necessary decisions and choices faster and keep growing demand for customer service excellence on the level that modern customers need.

In conclusion, decision making research in the field of neuroscience plays an increasingly important the role in the modern society. It leads to developing a completely different approach in decision making from traditional business practices. This research offers vital insights for policy makers and business leaders making management, marketing, and moral decisions.
14. Fellowship, Survey, Website, Workshop, and Global Community of Practice

Fellowship (on-going)

The proposal for this thesis project was presented to the Center for Clinical Bioethics – Edmund D. Pellegrino\(^{32}\) at Georgetown University. Under the direction of Dr. James Giordano\(^{33}\), Chief Scientist, we are conducting a study on Neurotechnologies as a part of this research. The results of this fellowship will be published later.

Survey

Conducted survey aimed to understand whether there is a need to strengthen cooperation and knowledge sharing between business communities and neuroscience. It showed that individuals understood and welcomed cooperation, and there is a need to build stronger partnership between science and business.

We wanted to assess the degree of importance of latest scientific discoveries in neuroscience and the level of the individual’s knowledge about neuro subjects. Our hypothesis was while typically people do not have much knowledge about a variety of neuro subjects, they place high importance on scientific discoveries in neuroscience and agree that neuroscience plays an important role in business. We also wanted to see if there was a correlation between the education level and exposure to knowledge about neuro subjects.

The survey had 19 questions (total) that included 10 main questions and 9 supportive demographic questions to collect data on respondents. One of the most important answers distribution is listed below:

<table>
<thead>
<tr>
<th>Row Labels</th>
<th>Do you think brain science plays an important role in business?</th>
<th>If available, would you be interested in exercising your brain, and attending a BrainSpa?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Certified Professional</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>High School</td>
<td>7</td>
<td>7</td>
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<tr>
<td>Master</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Grand Total</td>
<td>31</td>
<td>28</td>
</tr>
</tbody>
</table>

\(^{32}\) https://clinicalbioethics.georgetown.edu/
\(^{33}\) http://explore.georgetown.edu/people/jg353/?PageTemplateID=360#_ga=1.88763931.1601749119.1472570196
We collected anonymous information from 31 respondents and were able to assess the state of knowledge among people in ten different fields from 3 continents about the awareness and importance of neuroscience in their workplace. Among 31 respondents all 31 were familiar with the neurotechnology term, and practically all respondents were willing to participate in the offered brain training. Most importantly, 31 respondents recognized the importance of the neuroscience’s role in business. The results showed that they welcomed the integration of science and business, and the benefit of it. Despite the fact that 16 respondents out of 31 had master degrees, we could see the same level of awareness among people with less education background.

Further, we looked how often respondents were familiar with several neuro terms such as: Neuroleadership, Neurotechnologies, Neuroeconomics, Neuroimaging, Neuroethics, and Neuromarketing.

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</tr>
</thead>
<tbody>
<tr>
<td>Neurotechnologies</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
</tbody>
</table>

The survey suggested that 100% of the respondents are familiar with neuro terms. Neurotechnology and Neuroeconomics are the most familiar terms, the remaining are primarily unknown. Below are the responses on how people described their level of knowledge about neuro subjects:

<table>
<thead>
<tr>
<th>Briefly explain what do you know about these subjects</th>
<th>I understand the use of fractional MRI scans to study learning disabilities, but not much else.</th>
<th>I wouldn't overstate the importance of brain science in business decision making. I think psychology and emotions matter more.</th>
<th>Imaging the neural network in the brain</th>
<th>I've heard some of these terms in context and was able to more or less understand what they mean.</th>
<th>Magazines and books</th>
<th>Muy poco</th>
<th>Neurofeedback, it's like a therapy by sensors on the scalp.</th>
<th>No comments</th>
<th>Not much since I'm unfamiliar with them.</th>
<th>Not too much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barely anything</td>
<td></td>
<td></td>
<td></td>
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<td>Brain stimulus activities that are used to increase ability in certain areas of expertise.</td>
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<td>For Professional motivation</td>
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<td>how to influence people through mind</td>
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<td>I do not know anything about any of these subjects</td>
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<td>I have never heard any of these words, but feel like I should look in to them.</td>
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<td>I have only heard about neuro-marketing as part of education, but none on the others.</td>
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<td>I know Neuromarketing is becoming more popular nowadays.</td>
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<td>I know very little, but enough to understand its importance</td>
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Most of the responses indicated that there was very little knowledge, and only some had few explanations. The survey proved our hypothesis. While typically people did not have much
knowledge about a variety of neuro subjects, they placed high importance of scientific discoveries in neuroscience and agreed that the neuroscience played an important role in business.

Even though this was a small sample to generalize results of a specific population, we can carefully assume that our conclusions would not be much different from a much larger population. To confirm, we would have to make an in-depth survey, which would be outside the scope of our work. These results demonstrated that while this was a sample of educated population of decision-makers in the workplace, the knowledge about neuro topics was not sufficient. The positive side was that the respondents admitted the importance the brain science played in business. Knowing the benefits of incorporation of new discoveries in cognitive neuroscience and its branches, it is necessary to build a solid bridge between neuroscience and business environment to improve decision-making, especially when changes in global political, economic, social risks and insecurity bring lots of uncertainty. The role of the leader is becoming even more important under these uncertain conditions. It would lead to the necessity of further developing the abilities of the brain, which is capable of larger and complex decision making. Training and assessment becomes especially valuable in these circumstances

Website (Live now)

A dedicated website is live now, and it will be an on-going project. The website with domain neurodecisions.com includes the topics covered in this research, a place to exercise the brain by interactive videogames, training available for capacity building of individuals and organizations, a blog for discussion for knowledge sharing, and links to the different social media networks (Facebook, Twitter, etc.).

Workshop (planning process)

A workshop on latest Neurotechnologies is in the planning stage to be hosted in Washington, DC, and will include international speakers from the organizations like The World Bank (WB), The World Health Organization (WHO), The Inter-American Development Bank (IDB), and Georgetown University (GU). The results of this high level meeting will be available on the website.

Global Community of Practice (on-going)

As part of this research, we made several contacts with people in the global community in different countries (see below). The rationale to include these organizations and individuals is to create a Global Community of Practice to engage the international community in these topics. This CoP will
eventually be sharing their knowledge and best practices of their expertise in Neurotechnologies, to include: Neuroeconomics, Neuroleadership, Neuromarketing, and Neuroethics
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### Appendix 1

#### Laziness

- "This showed up as a failure to check facts, to take the initiative, to confirm assumptions, or to gather additional input. Basically, such people were perceived to be sloppy in their work and unwilling to put themselves out. They relied on past experience and expected results simply to be an extrapolation of the past.

#### Not anticipating unexpected events

- It is discouraging to consistently consider the possibility of negative events in our lives, and so most people assume the worst will not happen. Unfortunately, bad things happen fairly often. People die, get divorced, and have accidents. Markets crash, house prices go down, and friends are unreliable. There is excellent research demonstrating that if people just take the time to consider what might go wrong, they are actually very good at anticipating problems. But many people just get so excited about a decision they are making that they never take the time to do that simple due-diligence.

#### Indecisiveness

- At the other end of the scale, when faced with a complex decision that will be based on constantly changing data, it’s easy to continue to study the data, ask for one more report, or perform yet one more analysis before a decision gets made. When the reports and the analysis take much longer than expected, poor decision makers delay, and the opportunity is missed. It takes courage to look at the data, consider the consequences responsibly, and then move forward. Oftentimes indecision is worse than making the wrong decision. Those most paralyzed by fear are the ones who believe that one mistake will ruin their careers and so avoid any risk at all.

#### Remaining locked in the past

- Some people make poor decisions because they’re using the same old data or processes they always have. Such people get used to approaches that worked in the past and tend not to look for approaches that will work better. Better the devil they know. But, too often, when a decision is destined to go wrong, it’s because the old process is based on assumptions that are no longer true. Poor decision makers fail to keep those base assumptions in mind when applying the tried and true.

#### Having no strategic alignment

- Bad decisions sometimes stem from a failure to connect the problem to the overall strategy. In the absence of a clear strategy that provides context, many solutions appear to make sense. When tightly linked to a clear strategy, the better solutions quickly begin to rise to the top."
### Over-dependence.

- "Some decisions are never made because one person is waiting for another, who in turn is waiting for someone else’s decision or input. Effective decision makers find a way to act independently when necessary"

### Lack of technical depth.

- Organizations today are very complex, and even the best leaders do not have enough technical depth to fully understand multifaceted issues. But when decision makers rely on others’ knowledge and expertise without any perspective of their own, they have a difficult time integrating that information to make effective decisions. And when they lack even basic knowledge and expertise, they have no way to tell if a decision is brilliant or terrible. We continue to find that the best executives have deep expertise. And when they still don’t have the technical depth to understand the implications of the decisions they face, they make it their business to find the talent they need to help them.

### Failure to communicate the what, where, when, and how associated with their decisions.

- Some good decisions become bad decisions because people don’t understand – or even know about — them. Communicating a decision, its rational and implications, is critical to the successful implementation of a decision.

### Isolation.

- Some of those leaders are waiting for input because they’ve not taken steps to get it in a timely manner or have not established the relationships that would enable them to draw on other people’s expertise when they need to. All our research (and many others’) on effective decision-making recognizes that involving others with the relevant knowledge, experience, and expertise improves the quality of the decision. This is not news. So the question is why. Sometimes people lack the necessary networking skills to access the right information. Other times, we’ve found, people do not involve others because they want the credit for a decision. Unfortunately they get to take the blame for the bad decisions, as well". 
Appendix 2

understanding how the different brain regions work in response to certain tasks, challenges, and under uncertainty

One hundred years ago, scientists were able to map 83 regions of the brain, and since then that was all we knew. Recently due to modern technology, scientists discovered nearly 100 regions more. It is not clear as to what extent scientists will be able to interpret these new findings, but this has been recorded as a major milestone for the future. A New Atlas of the Brain).

Researchers used a combination of three imaging techniques and a machine learning system to create this new map of the brain, which includes 180 distinct regions in each hemisphere of the cerebral cortex (the brain's outermost region).
The different colors relate to how connected an area is to a specific sensory input: Red is hearing, green is touch, and blue is vision. Mixed colors represent areas where two senses overlap.

The cerebral cortex of the brain is divided into two sections, left and right, and into several regions, where each is responsible for specific tasks as explained below:

- **Frontal Lobe**: Executive functions, thinking, planning, organizing, and planning solving, emotions and behavioral control, personality.

- **Parietal Lobe**: Perception, making sense of the world, arithmetic, spelling.

- **Occipital Lobe**: Vision.

- **Temporal Lobe**: Memory, understanding, language

- **Motor Cortex**: Movement

- **Sensory Cortex**: Sensations

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<thead>
<tr>
<th><strong>Left Brain</strong></th>
<th><strong>Right Brain</strong></th>
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<tr>
<td><strong>Logical</strong></td>
<td><strong>Random</strong></td>
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<tr>
<td><strong>Sequential</strong></td>
<td><strong>Intuitive</strong></td>
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<td><strong>Rational</strong></td>
<td><strong>Holistic</strong></td>
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<tr>
<td><strong>Analytical</strong></td>
<td><strong>Synthesizing</strong></td>
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<td><strong>Objective</strong></td>
<td><strong>Subjective</strong></td>
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<tr>
<td><strong>Looks at parts</strong></td>
<td><strong>Looks at wholes</strong></td>
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gaining insights how human behavior affects decisions - not stepping into organizational psychology

Emotions can short-circuit the brain to an extent of paralysis. Decisions can be difficult to make if certain level of stress are detected. Studies about stress demonstrated how contagious it is.

developing better communication strategies

It has been proven that individuals that understand the communication process will blossom into more effective communicators, and effective communicators have a greater opportunity for reaching success. Therefore, organizations must implement progressive policies that would benefit all in the long run.

learning how to incorporate the knowledge of the brain into the corporate environment

Several studies have addressed the issue of how to bring neuroscience into the business environment. Lately, corporations are actually hiring neuroscientists to help them to become more effective and rational in the use of common sense approaches.

Human resources practitioners should be in charge of promoting knowledge exchange within their organizations, capacity building, and extensive collaboration among their employees.
demonstrating how important and fundamental is the role of the brain in creating context for change

According to Stephen Covey in his book, “The Seven Habits of Highly Effective People”, he describes how the priority factor is important in creating the right context for change in organizations. There are always people taking sides, and supporting the right and the wrong way of doing things for change management.

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<tr>
<th>Creating an evidence based platform where leaders can utilize for better decision making</th>
<th>Mitigating and assessing risk at an earlier stage</th>
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<tr>
<td>Establishing a platform where common knowledge can be shared, so prompt decisions can be made.</td>
<td>Best practices make organizations perform better overall. Anticipating potential problems when caught at an earlier stage can avoid potential catastrophes. Every employee should be accountable for his or her outputs, Organizations should promote the foundation for their employees to collaborate with each other and share knowledge.</td>
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<th>Implementing policies in order to successfully stimulate leadership and innovation</th>
<th>Making smart business decisions and solutions</th>
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<tr>
<td>Implementing leadership and innovation should be the core of any organization if they want to keep the pace of globalized competitors. Being more participative and inclusive, by encouraging employees to collaborate and provide input by any means.</td>
<td>Making smart decisions depend on several factors: (a) what is motivating the need for a decision; (b) making decisions should be more inclusive to all levels of the organization; (c) do anticipated costs result in benefits? (d) good leaders always have a backup plan, or plan B.</td>
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developing a hot and cold reasoning strategy

This process relates to judgments to non-moral decisions. **Hot reasoning** is usually quick, implicit, and the reaction is automatic. “It functions from an associative-based network often relying on heuristics, and is involved in impression perception” (Kahneman & Tversky, 2003). **Cold reasoning** is an “intellectual and controlled process that requires explicit learning as well as conscious processing system and functions from a rule-based structure” (Posner & Snyder, 1975; Shiffin & Scheneider, 1977; Johnson-Laird, 1983; Evans, 1984, 1989; Pollock, 1991; Reber, 1993; Hammond, 1996; Sloman, 1996; Stanovich & West, 2000; Kahneman, 2003). Both systems have advantages and disadvantages.

improving decision-making that would impact the organization’s environment

Few steps would improve the way an organization make its decisions: starting by looking at the problem by using creative and critical elements, then; developing its goals by creating a game plan; seeking alternatives by anticipating or predicting next moves after starting; making the decision after reviewing all the facts on the available information; implement the decision by being accountable for it results; and, following up after its implementation to make sure it is working appropriately.

increasing leadership by the level of power and influence in difficult scenarios
developing the language of the brain science to better understand behaviors in decision making
<table>
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<th>Creating innovative pathways that demonstrates how the brain can rewire itself</th>
<th>Linking the brain science concepts relating to a specific problem with the specific solutions for better productivity in the business environment</th>
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<tr>
<td>Using the brain science to build constructive and prompt interventions</td>
<td>Identifying cognitive dissonance for better decisions</td>
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A similar sample, like the one shown, could be used to study the patterns of decision making. It is a fact that most individual’s behavior differs from what they actually believe.

**DECISION MAKING**

![Decision Making Diagram](image)
Creating a decision making model that could be utilized in most of business environments

Enforcing inclusiveness at a leadership/board level while making a decision

Most decisions are taken at a board or at a leadership level. Finding ways that individuals at all levels are included, so expected outcomes would be more comprehensive.

Implementing a training plan to exercise the brain

Implementing a community of practice for knowledge sharing
"Getting a better understanding of the neurobiological basis for those individual differences in decision making will have enormous implications. It can explain a lot of problems in our society, including differences in the tendency to develop psychiatric illnesses." — Daeyeol Lee


A new study from the Max Planck Institute for Cognitive and Brain Sciences and the Technische Universität Dresden finds that stress can be super contagious: not only can being around a stressed person physically stress you out, but so can watching certain videos.