



## Brain-inspired Decision-making: A Reduction of the Stress and Anxiety Factor in Business Intelligence

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### Abstract

Decision-making is critical for every manager at all levels. Decision-making is necessary for managers to decide when to increase sales, improve customer service, develop new technologies, or conduct a project. However, decision-making can be subjected to many variables such as stress, emotions, morals, situations, etc. But brain-inspired decision-making (BIDM), using technologies such as artificial neural networks (ANNs) and artificial intelligence (AI), can eliminate indecision and stress, emotion, situations, etc., in the decision-making process. Stress has been discovered to be the most corrosive element in the decision-making process. Stress can cause managers to make the wrong decision in critical situations. Stress can affect decision-making by skewing critical decisions, causing emotional distress in individuals under stress, and leading to bad decision-making. On the other hand, using AI and ANNs to develop BIDM can lead to effective decision-making under the most corrosive stress. In this paper, we have proposed a method to test and evaluate BIDM using 25 engineering managers under stress. A literature review and history of BIDM is also given.

**Keywords:** Brain-inspired decision-making; Decision-making; Business Intelligence; Artificial Intelligence; Artificial Neural Networks; Cognitive Dynamic System

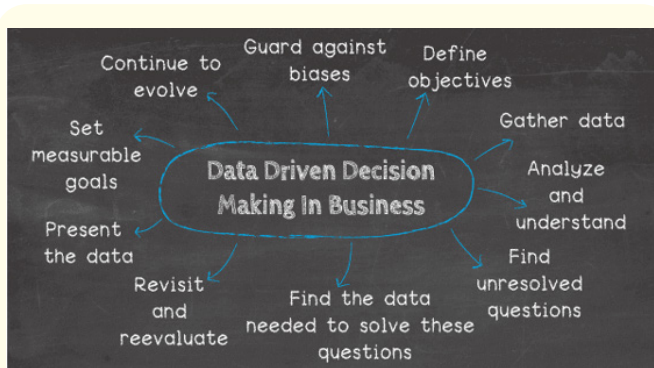
### Introduction

In every enterprise, the decision-making process is a critical task for employees and managers of all levels. Decision-making is required for project management, increasing sales, customer service improvement, upgrading technologies or developing new technologies, and hiring new employees. The leadership of an organization may use decision-making for most every situation and depending upon how autonomous the level of leadership, quite frequently [1]. However, decision-making can be affected by feelings, stress, anxiety, work relationships, or intuition which can ultimately lead to a bad decision, or one influenced by emotion or stress which again, can lead to an inconclusive or wrong decisions. Many times, this can be caused by frustration, depression, other

psychosocial factors, or simply a lack of data or connection between the data and the choices. In other words, multiple issues can affect human decision-making, including the lack of data or inconclusive findings, emotions, anxiety, work relationships, work environment, and numerous other factors [1,2].

Today's corporations use Business Intelligence (BI), a practice that organizations use to make decisions, evaluate the status of the organization, and safeguard the availability of quality information when making decisions. Numerous BI elements are used to make these critical decisions. One recently implemented practice used by leaders who understand BI is Big Data, which allows users access to multiple datasets used for decision-making

as the latest data is necessary for making decisions rather than not having facts [1]. Managers need information not only about the organization, but also about each division, and each activity. Figure 1 [3] demonstrates a brainstorming process whereby decision-making is data driven. Figure 1 shows how the manager processes information in a rational, non-biased way.



**Figure 1:** The data-driven decision-making process.

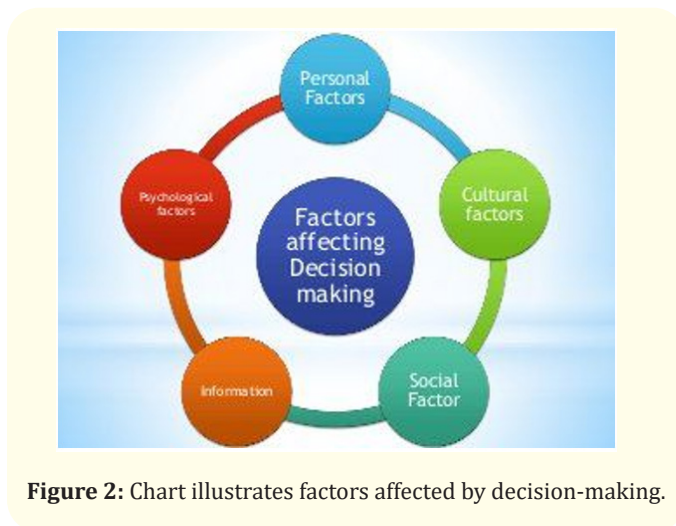
Because of recent developments in BI, which aims to provide easy access to data and analytical abilities capable of driving and accelerating information availability in every business line in the organization [2]. BI can provide a current overview of the enterprise's status, profit potential, product stock, sales targets, customer opinions, and overall assets. BI in companies can facilitate a better and more strategic decision-making processes and an ease of adaptation related to competitive strategies or changing company environments [1].

Brain-inspired decision-making (BIDM) uses Artificial Neural Networks (ANNs), a component of Artificial Intelligence (AI) which models the decision-making process like the human brain [1,2,4]. Unlike the human brain, ANNs can make decisions which are unaffected by stress, emotion, situational anxiety, the environment, anger, or relationships within the workplace. With brain-inspired decision-making, the psychosocial and psychological challenges for making decisions are eliminated by using a brain-like artificial intelligence neural network which reduces decision-making to a science and computational algorithm, and contributes to excellence for organizational leadership who use this method [2,5-7].

BI is used in monthly and weekly business reports, databases, status reports, billing overviews, etc. The objective of BI is to aid organizations in the process of achieving company goals and ensure the availability of quality information for basing deliberate decisions, which includes using big data and other methods of data intelligence to make calculated computational decisions for the company [5,6]. Using BI can unlock complexity, rapid competition, and environmental factors which drive the company and the decision-making process. BI factors drive organizational complexity, rapid competition, and modification, which increases organizational performance to meet challenges in an advanced manner over previous methods of decision-making [2]. Components of BI are used to analyze information, access data, and manipulate pertinent data. Furthermore, Big Data adds quality information and better accuracy for the use of BI [1].

Leaders of all levels actively practicing BI must also consider multiple contributing factors; the part information technology systems (IT) plays in BI and the function of other decision-making factors which can affect BI such as BIDM using AI [2]. Each enterprise, managers of all levels, employees, and stakeholders should pay more attention to improving the decision-making process, because decision-making is the fundamental essence of leadership at all levels and the responsibility of all organizations. Factual validity of this has been confirmed by expert opinions [8]. Working organizations should pay more attention to improving the BI process by identifying the outcomes, needs, etc. Structural factors, behavioral factors, environmental factors, outcomes, processes, output, consequences; these are factors that are considered when BI is used for decision-making [2]. Figure 2 illustrates the multiple factors that are affected by the decision-making process [9]. However, using BIDM, decision-makers can avoid being affected by the most important of these when making decisions.

With the advent of so many new technologies for decision-making in business, organizations should rely on tools that can impact these external factors the least, especially in this era of high-tech decision-making tools and competitive technology. Today, maintaining competitiveness and innovation without damaging the factors associated with decision-making is essential to the continued existence of the organization [10]. BI is one of those technologies



**Figure 2:** Chart illustrates factors affected by decision-making.

which add a layer of innovation to the organization's decision-making methods however, strategic and tactical decision-making can be difficult and is affected by stress, emotion, situations, relationship status in the workplace, workplace environment, etc. [8].

Fortunately, there are artificial methods to avoid involving the emotion that is so detrimental to the human decision-making process [11]. Managers at all levels need to consider several factors affecting BI and decision-making. These factors can work both directions, and are typically recognized as: a) structural factors such as leadership hierarchy, technology, and innovation in the workplace; b) behavioral factors such as stress, anxiety, workplace relationships, and emotion; c) environmental factors including office spaces, workplace culture, etc. [12]. Some tools and techniques of BI are a) interactive graphical data analysis; b) data mining; and c) predictive analysis [2]. There is an intrinsic value of BI as a useful influence in the popular implementation of insights for managers, employees, and stakeholders making decisions, that will benefit from successful implementation of BI in corporate areas. Of course, BI has the greatest effect when it is successful. But some scholars want to study a more cost-effective and efficient decision-making process. This is known as BIDM using AI and ANNs [4,13,14].

### The problem statement

The question at hand is whether scholars can build a cognitive architecture which functions like the human brain. The corticotha-

lamic pathway, ascending arousal systems, and vision are the result of many years of development. Yet a distant dream for inventors of AI and ANNs are deemed attainable as researchers get closer to the use of artificially constructed brain pathways [15]. Decision-making is a vital part of leadership, and a cognitive function which is essential to all intelligent beings. However, decision-making has many limitations such as emotional affect, stress, psychosocial distress, work relationships, and structural and environmental factors [16,17]. Stress is one of the most toxic subjects for executives that can affect decision-making. Stress is a state of mind, involving both the brain and the body; it is different among individuals and affects people in various ways and at a variety of levels, reflecting not only daily life but, the personal life with feelings about everything that is going on around the individual. Stress differs in that it may be temporary, a result of a situation or relationship at work, home, or other; stress is conflict that may become chronic, may affect sleep, thought processes, etc., and cause an untold and wide path of destruction in thought and action as cortisol, the primary stress hormone is released when the body is under severe stress [7,18]. Decisions that may be easy to make without hurtful feelings may be turned into desperate clutches at a conclusion or end to chronic stress. However, with a lack of real choices, decisions that are dependent upon a leader's judgment may be ineffective, cause more stress, or be just plain wrong [8,19-21,23-26]; therefore, the purpose of this proposal is to suggest that brain-inspired decision-making (BIDM) can eliminate the stress associated with decision-making for management professionals and provide a clear platform for management professionals to make good decisions, unaffected by emotion or stress.

### The goal

Many models and methods construct BIDM. Since beginning a search for an artificial brain architecture, AI has been the most widely accepted method for developing a superior working BIDM model. Scholars have developed one AI model using smart systems, which function like brain neurons, the Cognitive Dynamic System (CDS). The CDS is based on a human brain-inspired decision-making neuroscience model built upon the principles of a cognition-based Perception-Action Cycle (PAC). Smart systems are created starting with the human brain model, and using cognition, memory,

attention, intelligence, and language, craft a cyber processing layer, the CDS; the CDS has been determined to be the best solution for improved decision-making in non-Gaussian and nonlinear environments (NGNLE). Typical algorithms are also inapplicable in NGNLE [5,6]. The importance of NGNLE is that the environment outputs are not linearly dependent upon the environment inputs. Understanding the NGNLE decision-making process suggests deciding between specific recognizable situations in NGNLE to understanding the existing state condition. Figure 3 [5,6] will detail a slightly complex decision-making model using the CDS, what components are important to the environment, etc., which makes it appropriate for real-time situations, a vital fact for those organizations depending upon real-time data for survival.

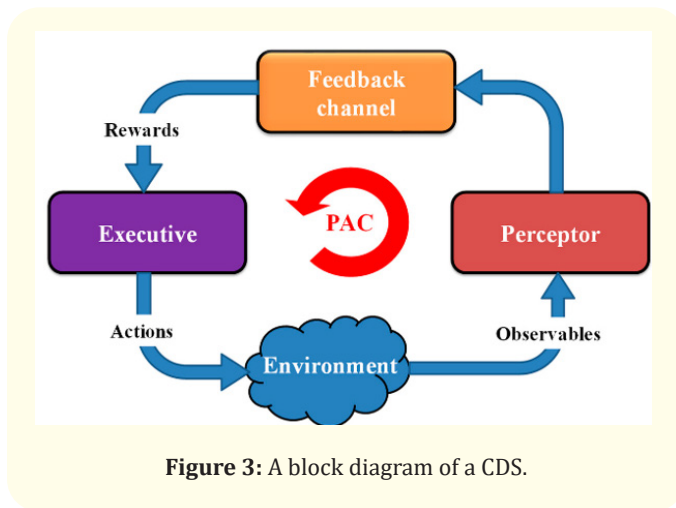


Figure 3: A block diagram of a CDS.

The most important fact to note about these NGNLE is that most AI applications are NGNLE [4-6]. There are three central subsystems of CDS shown in Figure 2, all key to making excellent real-time decisions: a) a preceptor for perceiving the environment; b) a feedback channel for sending internal rewards; and c) an executive for acting on the environment. The CDS is enhanced AI. The distinction between AI and the CDS is that the CDS establishes internal rewards and uses them to take a few or some actions while AI is reward-based action [4-6].

The goal of this proposal is important to the field of engineering management as managers at all levels are responsible for decision-

making. However, BI is human decision-making essentially assisted by technology. But BI and human decision-making is vulnerable to human emotion, stress, and human events; BIDM however, is not susceptible to human emotion, stress, or human events. The goal of this proposal is to explore BIDM as a viable option for a new BI platform designed for engineering managers of all levels as an alternative to human decision-making, whether assisted by technology or not.

To determine whether 20 engineering managers of all levels benefitted from using a CDS-based BIDM process while under stress, a combined interview approach of five qualitative questions evaluated using grounded theory and five questions using a 5-point Likert scale which will be analyzed using the correlation coefficient  $r$  will be the methods for analysis. To gather the data for this proposal, two complex situations will be presented to the 20 managers via computer simulation. The situations they will confront should include elements of stress found in human business situations, such as deadlines, time constraints, financial strain, etc. In one situation, managers will decide using BI and Big Data analytics under one aspect of emotional stress as described. In the second situation, managers will apply CDS-based BIDM to the same situation with the same aspect of emotional stress. After each simulation is completed, the questionnaire will be completed which details each situational process and result. A grounded theory analysis of the five open-ended questions and a correlation of the five Likert scale questions will be completed. The goal is to determine if the situational decision-making process results in similar decisions or if the CDS-based BIDM helps the managers make a less emotional, better decision.

### Relevance and significance

AI can be narrow, which is like the AI found in cell phone assistants, or AI can be more specific, such as ANNs. The ANN functions like a human brain; the model for ANNs is the human brain neuron and many artificial neurons can be found in an ANN. Once the topic is decided, an ANN forms a neural model of the information, like a human brain cell. ANNs are a form of machine learning and deep learning. If a computer program, or a model, is based on static rules, it will not continue to evolve. However, ANNs are not

static, as they are like brain neurons and continue to advance with each new problem. Artificial neurons are used to form the basics of the computational algorithms that can solve BIDM [25,26]. This proposal suggests these artificial neuron-based computational algorithms can foster better decision-making than the BI use of Big Data analytics. By harnessing the power of AI and ANNs, engineering managers can make better, more informed decisions which will lead to commercial growth, evolution, and fiscal prosperity. By employing the technique of BIDM, engineering managers can accurately measure data, rise above human emotion and its affect on decision-making, and drive the organization forward [14,27].

As data becomes more and more complex as it is in today's business climate, conventional methods of decision-making can become strained and affected by many human factors including the personality of the managers or employees, the work group environment, etc. [15]. The problem of stress in decision-making can affect more than the bottom line. Work relationships, productivity, customer relationships, and environment are some of the areas that can be influenced by stressful decision-making [28,29]. Difficult decision-making and stress can also affect the manager, corporate culture, and personal and home relationships. As managers, especially at a time when there is truly a complex mounting pile of data to decipher, even with technology such as Big Data analytics, BIDM can be a process that not only affects the organization positively, but also enriches the manager and the eases the stress of having to analyze multiple data points [11].

A single improved decision, one made without prejudice or emotion, can affect not only the entire organization, and improve it wholly, but it can effect change in customer relationships and improve organizational standing among its peers [9,19,23]. This proposal addresses the challenge of improving decision-making when the decision-maker is under stress, a potentially difficult situation. There are three types of decisions made by individuals within an organization: a) unstructured—typically made by senior managers; b) semi-structured—made by a middle manager; and c) structured—operational managers or individual employees and teams. Unstructured decisions are typically made by senior managers who make non-routine decisions about strategic issues which may have long-term effects. The BI process for decision-making includes intelligence, design, choice, and implementation [30]. On the other hand, BIDM uses AI to develop ANNs which through deep learning and functioning like the human brain, make a decision based

on facts, computational algorithms, and absent of any emotion or stress [16,17]. Figure 4 demonstrates the processes involved in BIDM [25,26]. The function of deep learning is a process of ANNs.

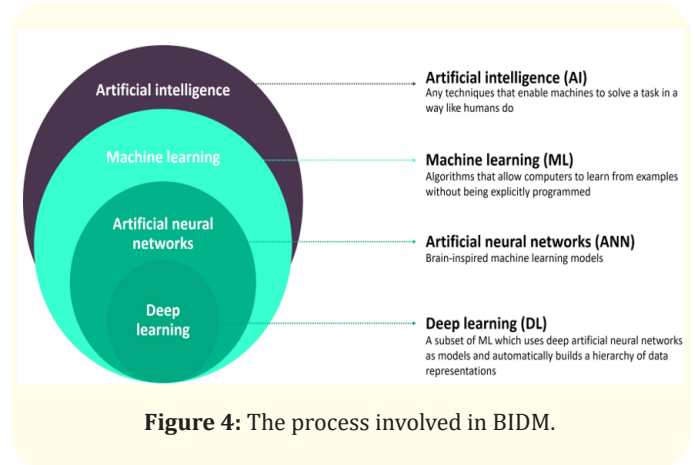


Figure 4: The process involved in BIDM.

By surveying and analyzing the results of the engineering managers, this proposal will provide beneficial results potentially proving that BIDM is a working alternative for BI. Rather than human brain decision-making using Big Data analytics or other technologies, BIDM can achieve neutrality, stress-free, and human-brain-like decision-making for any situation that engineering managers may encounter. Future research should be focused on using BIDM in various situations and under varied circumstances to determine the extent of its effectiveness. The next section is a review of published peer-reviewed literature on stressful decision-making which affirms this proposal's hypothesis that BIDM would be a better choice as a technology for decision-making.

## Literature Review

Stress is a major factor in management's decision-making process. Studies have shown that personality traits and stress are critical underminers of organizational managers' good decisions [19,23,24]; Personality traits have a strong affinity for how a person makes decisions. The more extroverted a person is, unfortunately the riskier and lower the rational decision-making style, while managers with a higher degree of agreeableness were more likely to make better and more rational decisions. The more intuitive and open a manager was increased the likelihood that their decisions would be more conscientious and rational. However, this study showed that the higher the degree of conscientiousness and

agreeableness unfortunately made for more dependent decision-making, while more openness to experience was associated with a more independent level of decision-making. Emotional intelligence (EI), a term that has been loosely defined by the study's author as ability to recognize one's feelings, the feelings of others, for motivating oneself and others, and for managing the emotional nature of both self and other relationships [23]. EI seemed to mediate the role between conscientiousness and agreeableness to the point that managers were able to make better decisions. This study showed that personality influences decision-making practices and EI has a significant effect on intuition and decision-making and a negative effect on avoidant and other dependent decision-making styles. Therefore, it is essential to reduce or eliminate stress and dependence from managerial decision-making at all levels [23,24].

Reward-seeking behaviors are part of any decision-making process. Stress is well-known to increase reward-seeking behaviors and risky decision-making steps. When faced with uncertain outcomes and a stressful situation, optimal decision-making may be difficult. Therefore, most people look back on prior experiences and compare outcomes of previous experiences with the present situation. Choices that seem more rewarding at the present time may seem more appealing however, after some time, the long-term rewards of deciding becomes more evident [19]. Effectively making decisions regarding costs and benefits is an essential function of upper-level managers. 'Rational' decision-making is the target of all senior-level managers and all employees working under them. Unfortunately, neuropsychiatric orders such as bipolar, depression, anxiety, etc., can interfere with rational decision-making and cause stress levels to rise in managers who may function at near normal or normal levels. Cortisol levels rise causing stressful conditions for the manager and this could interfere with the manager's ability to make rational decisions about company issues. Prolonged stress can also induce aberrant decision-making or irrational decisions. The ability to make decisions that reflect the core values of the organization and are both rational and considerate of the fiscal and competitiveness of the organization [24].

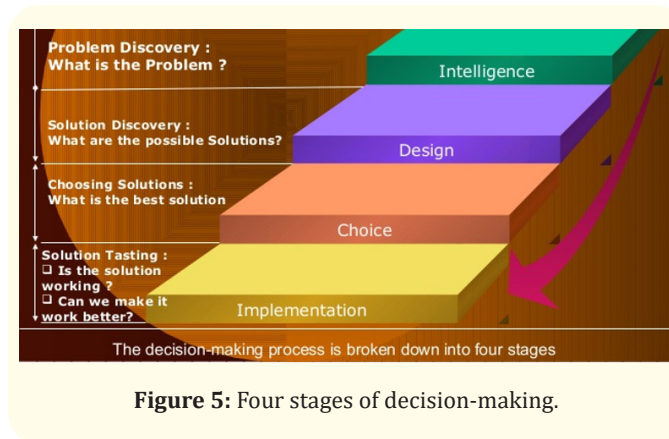
Decisions are made every day ranging from critical to nonessential. The physiology of the human brain makes decision-making a process that can be vulnerable to a host of human factors such as

neuropsychological status, stress, illness, relationships, etc. In high threat environments, which includes most engineering firms, the expertise of the manager can affect the decision-making process and stress can mitigate the experience factor and cause undo chaos in the decision-making process. When the body is under stress, the brain may compensate, or it may not. Vital decisions regarding a business's critical functioning such as customer relations, fiscal priorities, competitiveness, etc., should not be left to a system influenced by hormones, even if it is the human brain [5-7]. The next generation of AI which includes ANNs can mitigate the damage that stressful conditions can do to management decisions. An AI platform capable of functioning like the human brain and making decisions which are rational, stress free, and good for the organization will help advance engineering to new heights [31]. The use of ANNs can help map cognitive functions such as decisions with a computational accuracy. Neurobiological experiments are the basis for this technology. BIDM uses the best of ANNs and AI to help managers of all levels make decisions that are both rational and without prejudice [32].

### Approach

There will be a group of 20 engineering managers who will be exposed to a stressful situation then make two decisions, one using a CDS-based BIDM and the other using their own human brain and Big Data analytics using a computer simulation program. AI is meant to interact socially with individuals to form neural networks which function similarly to human brain neurons [31]. There are some key schematics that should be implemented as critical building blocks for ANNs. Plans and commitments, emotions, moral and ethical values, and psychosomatic comfort are essential for decision-making ANNs. There have been studies by some scholars who have found that time of day also affects decision-making, with the afternoon being the riskiest time of day for management decision-making. Scholars found that the riskiest decision-making occurs in the afternoon as the inhibitory controls of the human brain relax and individuals have a decreased sensitivity to loss as negative feedback, etc. Active human-like learning is the cornerstone of AI and can be vital for engineering managers who want to make good decisions while under the weight of stress or other emotions [33].

While decision-making is often a complex task and coupling the physiological states and neural networks are the underlying mechanisms regulating behavior but is hard to decipher. Figure 5 is a detailed progression of the decision-making process [34]. The stressful influence can interrupt possible intelligence, design, or choice [34].



**Figure 5:** Four stages of decision-making.

To gain more insight into the neural computations required for decision-making using ANNs, the CDS process can be used to examine binary decision-making tasks and nonlinear feedback [10]. One effective method in achieving intelligence and decision-making is simulating various intelligent processes found in the human brain. While BIDM uses a mathematical computing program, the BIDM algorithm is very different from most mathematical processes [20]. There is significant links to research [9,20]; Abderahmane, Lemaire and Miramond, 2020 [19,22,29] that indicates reinforcement learning plays an important role in neuroscientific decision-making and significant neural substrates play a critical role in linking ANNs to a similar pathway as human brain neurons for decision-making. Training is key to finding correct ANNs for a CDS-based decision-making model [20,29].

Decision-making, as a crucial function of engineering management and other sectors, is also a fundamentally critical ability for intelligent animals. A spiking neural network is used to model human brain behavior [16,17]. By interacting with the environment, managers can improve decision-making skills and many state-of-

the-art models improve by interacting with the environment. This contributes to better autonomous decision-making by the manager. The human brain continually stores a working memory in the basal ganglia and pre-frontal cortex. This has a top-down effect of reducing bias in reinforcement learning [16,17]. Decisions can range from the mundane about what to eat to the critical decision about customer relations, profit earnings, or something even more important to the organization. The context by which decisions are made is critical and an individual's physiology can determine the adaptive response to the environment. Stress is a particularly individual response and depends on a key number of factors including neuropsychological data, relationships, personal coping skills, and how the individual responds to the environment. The ability of the manager to decide under stress can also be influenced by how well the individual makes decisions while in a high-threat environment. Physiological profiles and adaptive response are the primary factors that determine whether a stressful decision will be successful or not [5-7].

In a stressful situation, decisions are often made with limited information. Reducing stress and cognitive aids are sometimes used to assist managers who are under a tremendous amount of stress to help with difficult decisions [25]. In BIDM, an ANN algorithm affects individuals differently, is a state of mind, and differs among individuals in how they handle it. Sometimes a stressful situation can turn in to a chronic stress situation, where the pressures of daily life alter the physiological state of the body and mind [26]. Therefore, when conducting the proposed study of 20 engineering managers, it is critical that measures of stress be conducted. Heart rate, cortisol levels, oxygen saturation levels, blood pressure, and respiratory rate are just a few measures of stress. There are also two neurobiological mechanisms in the human body responsible for stress induction; the sympathetic nervous system which quickly increases the heart rate and blood pressure and occurs right after exposure to the stressor. In contrast, the hypothalamus-pituitary-adrenal (HPA) axis slowly releases the hormone cortisol from the adrenal cortex, a glucocorticoid, in response to the stressor. Cortisol then binds to receptors in the prefrontal cortex (PFC), hippocampus, and amygdala which are responsible for decision-making. Cortisol can influence decision-making by altering how

the PFC, hippocampus, and amygdala process decisions [19]. In the proposal, before the stressor is presented to the subject, a random baseline cortisol level will be drawn via venipuncture to determine a baseline stress level. Heart rate, respiratory rate, oxygen level, and respiratory rate will also be measured and recorded prior to stress. Cortisol levels can be measured using urine ELISHA tests [12] or blood serum levels [19]. However, the plasticity of the brain circuits can re-wire to handle stressful decision-making and the capacity of the brain's ability to re-wire itself is only now being explored to an extreme [26].

Spiking neural networks (SNNs), can be used as a predictive method for determining how a person might decide between two cognitive tasks. SNNs are a form of ANNs and are used when specificity and learning are necessary to lean one way or the other [16,17]. Modeling, visualizing, and comparing complex brain data are capabilities of SNNs and SNNs can be applied during the decision-making process, making them especially useful for this proposal. These are interactive models that serve to mimic the brain's complex neuronal units [35,36].

## Conclusion

While Business Intelligence is important to engineering managers and others, it is not a perfect solution for decision-making, even when using technologies like Big Data analytics. However, Brain-Inspired Decision-Making can substitute for other technologies and foster better decision-making through ANNs and SNNs which will act like human brain neurons, omitting the stress, morality, emotion, fear, etc. from the decision. BIDM will replace other technologies in decision-making so that engineering managers of all levels can make decisions free of polarizing emotion and stress. Stress has been shown to diminish the ability of human decision-making in a number of roles, increase the amount of risk-taking among managers at all levels, and can cause permanent financial harm to the organization if poor decisions are made due to stress. With a small sample size of 20 engineering managers, the use of Grounded Theory qualitative interview techniques and correlation coefficient  $r$  for the Likert scale questions, the two simulated decisions will demonstrate the gulf between making a decision using BIDM and BI using Big Data. Also, examining other factors such as cortisol lev-

els, vital signs, and indicative signs of stress prior to making the specific decision on the simulator will help validate the results as in other studies. Studies on BIDM could increase in sample size, use unique techniques to evaluate the effect of stress on decision-making, and compare the results to using other technologies in the future. The primary challenge to this proposal is that not every person responds to stressful situations in a similar manner. However, the wide array of variables to measure for assuring the subjects are under stress will ensure validity.

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