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Neurofinance: the new world of finance based on human psychology and individual investment behavior

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***Abstract*---**Neurofinance is an emerging discipline in the area of behavioural finance. As the word neurofinance covers multi-disciplinary fields like neurology, psychology and finance it is a tool for understanding an individual's behaviour towards financial activity done through brain mapping. When it comes to financial or investment decisions made by an individual it is said to be cognitive as well as baised being executed by neural process. It becomes necessary to understand the psychological factors behind the origin of this biasness. The concept of neurofinance which has developed out of neuroeconomics has become the base for recent studies on behavioural finance that explains the relationship between financial behaviour and human brain activities. Thus, this paper constructs the concept of neurofinance as an emerging key by demonstrating available studies done by different researchers and authors. This study is largely based on secondary sources of data making it a research based on conceptual analysis. It is expected that this study will nurture the further empirical researches done for analyzing individual's investment behaviour and decision, with the concern of building and exploring Neurofinance as a foundation in the field of behavioural finance researches.

***Keywords*---**Neurofinance, Behavioural Finance, Investment Behaviour, Investment Decision

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Introduction

Neurofinance is a relatively young field of study that aims to better understand financial decision-making by merging psychological and neuroscience insights with financial theories. Neurofinance investigates how we evaluate information regarding financial possibilities that are ambiguous, time-constrained, risky, and strategic in character, as well as how emotions, psychological biases, stress, and individual differences influence financial decisions (such as gender, genes, neuroanatomy, and personality). It also investigates how the brain interprets financial data and how individual decisions are made within it. Finally, neurofinance tries to provide an alternate explanation for the apparent failure of standard finance theories by combining these trials with computer models. We look at how neurofinance is anchored in several sectors and provide an introduction to it.

Individuals' investment patterns have been discovered to be based on their reactions and perceptions. The study finds that formal processes and practises provide a strong substantiation of the brain activity connected with financial decision-making, demonstrating the value of Neurofinance as a tool for better economic decision-making via brain mapping techniques. The findings aid in determining risk choices and financial resources when investing. Neurofinance is an interdisciplinary field that aims to study human decision-making, the neurological activity that influences our understanding of the brain, and the ability to process multiple options available after taking a certain course of action. Market researchers have accumulated a lot of evidence on how individual speculators manage their monetary portfolios over time in recent years. Behavioral features influence investor decisions, and financial academics have been studying them for the past two decades. These findings have given rise to a self-governing branch of financial knowledge known as "behavioural finance." In the 1990s, scholastic journals, practitioner publications, finance magazines, and daily newspapers began to use the terms "behavioural finance" and "behavioural economics." Neurofinance combines behavioural finance, neuroscience, cognitive, and social psychology research approaches. Because people's brains and thinking are involved, econometric models with cognitive restrictions are unable to explain market behaviour. As a result, inside the rising discipline of Neurofinance, the delicate system that decides on certain decisions of folks in poignant, risk, awful, improbability, manipulating, and other circumstances is decoded and the ensuring outcomes are gained.

Neurofinance

Neurofinance Human and ecological scientists have been striving to understand how people make investment decisions for many years, using a variety of methodologies. Neurofinance as an interdisciplinary field has been attempting to clarify human decision-making, the ability to evaluate various possibilities, and to proceed with a course of action for the past two decades by combining these methodologies. It looks at how economic activity can influence our perspectives of the mind, as well as how cognitive neuroscience discoveries might constrain and direct economic models. Microeconomics, behavioural neuroeconomics, neurofinance, econophysics, and neuroendocrinology of decision-making have all

focused on decision-making under risk and uncertainty. Neurofinance is more concerned with the study of investor decision-making. Neurofinance brings together neuroscientific knowledge and technology to investigate how the brain makes financial decisions. In basic terms, Neurofinance presents all of the data on the brain that is available on the Internet in a usable format, including photographs, models of neuron behaviour, and maps of the genes that are "turned on" in various brain regions. This diagram depicts how the human brain thinks, Neurofinance aims to better understand financial decision-making by merging findings from domains like psychology and neuroscience with classic financial theories. It tries to explain how neurological and physiological signals link and give rise to individual differences in financial decision making, in addition to understanding individual and market behaviour as a function of traditional financial variables. Neurofinance incorporates noninvasive measures of brain and physiological activity to achieve this goal. Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are indirect indicators of local brain activity. Biosensors such as heart rate, skin conductance, eye movements, and hormones, as well as genetic analyses, are used to supplement these and, and solves issues. It's worth noting that all of these methods are correlational in nature, which means they can't usually be used to draw causal conclusions (Poldrack). Researchers control neurological and physiological signals by utilising direct transcranial magnetic stimulation (TMS), monitoring patients with brain injury, or delivering hormone- and neurotransmitter-manipulating medicines to demonstrate a causal relationship to observed behaviour.

Neurofinance encompasses behavioural finance to some extent, but adds two major goals: (a) elaborating the biological (neural and physiological) processes of financial market participants' behaviours (Tseng, 2006) and (b) providing a physiologically driven alternative theory for traditional finance theories' apparent failure. This paper presents an overview of neurofinance. We will focus on the key subjects and give a selection of sample findings because it is beyond the scope of this paper to describe every facet of neurofinance. The next step is to identify the most promising topics for future research that could lead to societal advantages and bridge the gap between neuroscience and business and everyday financial decision-making.

Traditional Finance, Behavioural Finance and Neurofinance: How are they different?

Table 1 Difference between Traditional, Behavioural and Neurofinance

Traditional Finance	*Behavioural Finance*	*Neurofinance*
Traditional Finance is a proponent of rational investors and markets.	According to behavioural finance, there are irrational markets and investors.	Neurofinance is the study of an individual who behaves or thinks emotionally not rationally.
It facilitates the creation of a logical portfolio.	Using behavioural finance, we can create the best possible portfolio.	It assists in framing an exceptional and exquisite portofolio.

The foundation of traditional financial models is an approximation of actual market realities.	In view of the actual issues related to human behavior, behavioural finance offers solutions.	It incorporates neurotechnology for evaluating the psychology of a financial market investors.
Traditional Finance outlines the proper conduct for investors.	The study of behavioural finance explains how investors "do" act.	It explains the reason and the processing of an individual's behaviour.
Traditional financial assertions assume optimal investment behavior.	The behavioural finance assumptions depend on financial behaviour of an investor.	Neurofinance is an in-depth study that aims to understand the external rationale of an investor.

Investment Decision Making:

Investors aspire to create sound decisions in order to boost earnings while reducing losses. Often these economic theory suggests that people make rational and logical decisions, that customers are conscious of their choices, and because they have spatial relationship, liberty, and stability. Thus behavioural finance indicates that customers' decisions are driven by cognitive factors. Besides, neurofinance - a fusion of psychology, neurology, and finance that seems to use two very different conceptual and practical tools to understand behaviour by examining the physiological functioning of the human brain once revealed to financial risks - objectives is to understand behaviour by examining the physiological functioning of the human central nervous system when subjected to financial risks.

A Biological Opinion

When conventional finances and economics relate to utility maximization and income, they are probably referring to value and income accumulated from commodities and currency. According to biology and psychology, optimizing utility is simply one dimension of pursuing a greater aim, namely, boosting individual biological wellness (survivability prospects) and overall health. As a result, it's possible that the recorded discrepancies from ideal investment decisions are biologically optimum. Individuals with intellectual impairments may be unable to increase their profits, forcing them to satisfice, or compromise for a satisfactory or "good enough" solution instead of the ideal one (Cohen & Simon, 2005, 1956)

Basic principles of nervous system anatomy

According to the quasi view, making decisions is a brain activity. Understanding the central nervous system's structure and functioning is essential for understanding the neurological basis of decision-making. The central nervous system and the peripheral nervous system are distinct body sections of the nervous system. The cranial nerves and spinal nerves make up the peripheral nervous system. The spinal cord, brainstem, diencephalon, and telencephalon make up the central nervous system. The medulla oblongata, the pons, and the midbrain make up the three parts of the brainstem (mesencephalon).

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Relationship between an individuals's personal investment preferences and their neurology

Relationship between a individuals's personal investment preferences and their neurology In anticipation of a potential reward, our brain responds. The conventional theory of finance doesn't really apply to humans because they are not regulated. A major aspect of decision-making is the capacity to understand and replicate the sensations and emotions of others in a public situation. This widget can indicate the intensification of a certain choice, among other preferences and utilities. Decision-making is such a natural part of the brain development that we frequently are ignorant of it until our choice leads in unpredictable outcomes.

The human brain can be divided into three primary categories, according to Neurofinance. The largest and most rational region of the brain, known as the cerebrum, contains the limbic system and cortex, which aid in making logical financial decisions.The mid-brain controls hearing, vision, and body movement, whereas the hind-brain/little brain controls essential bodily functions.
Neuroscience study and economic models are used in neurofinance to better understand how people make decisions about their financial well-being.

Brain Mapping Technologies

So why do researchers undertake the complex effort of brain mapping? For understanding our minds in detail is crucial because the majority of our understanding of the brain is predicated on a shallow perspective regarding what is genuinely inside. Academic data on the structure and operation of the brain use a range of techniques. Researchers can examine every single neural connections inside a healthy brain using the connectomics technology. Only animal studies are being conducted using Brainbow and the ATLUM (Automatic Tape-Collecting Lathe Ultramicrotome).

The following are some of the technologies used in brain mapping to record the participants' electrical impulses while participating in the investing process. The activity of your brain can trigger alterations in blood flow and oxygen levels, which fmri can identify. In order to assess and create images, it tries to manipulate the electromagnetic nuclei of water molecules using the device's magnetization.

i) FMRI

FMRI monitors metabolism while MRIs demonstrates anatomy and physiological structure. FMRIs can be employed for a variety of purposes, including:
a. evaluating mental activity
b. detecting a brain anomaly
c. making pre-operative brain mapping

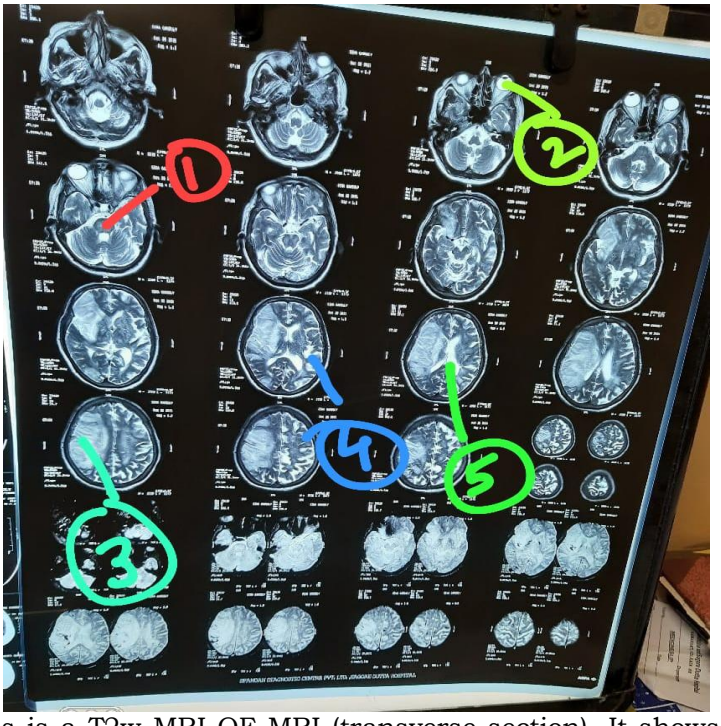

Figure 1 : This is a T2w MRI OF MRI (transverse section). It shows an Ischemic area in the right cerebral hemisphere (1. Midbrain, 2. Eyeball within orbit, 3.Ischemic Area, 4. Insular Cortex, 5. Lateral Ventricles) (Source: Real MRI images captured through mobile phones)

ii) CT SCAN

A succession of X-ray images are transformed into cross-sectional images of our brain during a computed tomography (CT) scan. Pairing such X-rays develops bridge segments or even a three-dimensional depiction of our brain. A CT scan's output potentially display additional data than a conventional X-ray.

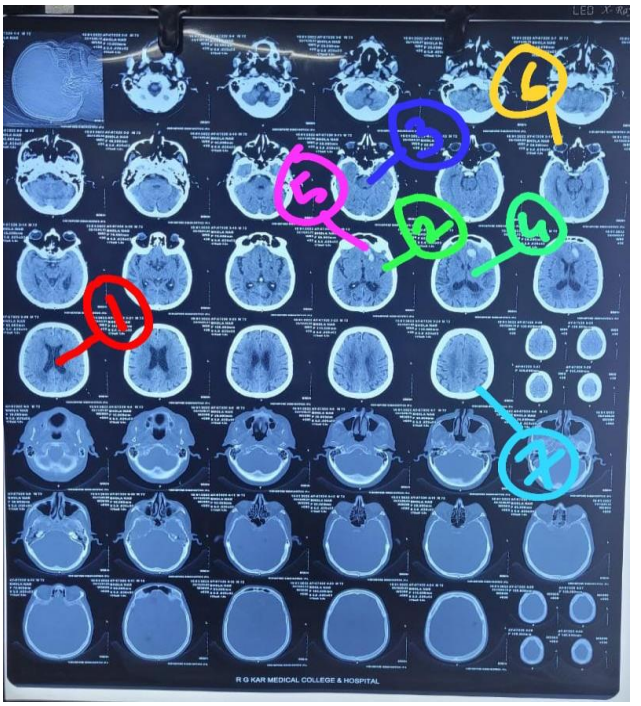

Figure 2: This is a NCCT Scan Brain showing an infarct in the anterior cerebral parenchyma (1. Lateral Ventricles, 2. Sylvian Fissures, 3. Midbrain, 4. Thalamus, 5. Infarction, 6. Eyeball within Orbit, 7. Skull Table) (Source: Real MRI images captured through mobile phones)

CT exams can:
a. detect specific sorts of neurological damage
b. determine cancerous cells
c. uncover any bleeding or inflammation in the brain
d. alzheimer's anatomical alterations in the brain

iii.) PET

During a positron emission tomography (PET) scan, a radioactive detector binds to the blood sugar. Since insulin serves as our brain's main fuel supply, the detector piles up in regions of our brain which are more active. These detector bullets can be seen by a PET scan, allowing us to track its movement and deposition within our brain. This assists medical professionals to detect problem areas where insulin isn't flowing properly.
PET exams can assess:
a. seizures, tremors, shocks, vertigo etc.
b. alzheimer’s, early onset dementia, diseases like parkinsons etc.
c. tumours, malignancy, cancers, neoplasms etc.

iv) EEG

During an electroencephalography (EEG) examination, individual's brain impulses are examined. Tiny sensors with electrical connections will be placed on our forehead prior to the test by medical professionals. These sensors track electromagnetic exercises in our brain and transmit that information to a computer, which generates a picture resembling a grid. A doctor can learn more about someone's brain activity function from each sort of vibrations that displays within its own track.
EEG can identify problems like:
a. anxiety, panic , fear etc.
b. head trauma
c. epilepsy
d. insomnia

v) MEG

The electric flux or magnetism is measured by magnetoencephalography (MEG) using the electrical impulses of nerves. Our brain's faulty neurons can be identified and diagnosed using this technique of imaging. MEG is a technology that doctors employ to detect both random and stimulus-induced brain responses.
Medical professionals can evaluate things like:
a.) seizures sources
b.) motor regions, muscular regions
c) sense organs
d) voice and sight

vi) NIRS

Our brain's respiration is monitored by NIRS. It employs infrared rays to identify the trends in our blood's haemoglobin oxygen concentration. Since our brain requires oxygen to operate normally, NIRS can help medical professionals in whatsoever practice situation in which brain oxygen concentration frequently vary.
NIRS is employed to track:
a) levels of cerebral oxygen during heart surgery
b) In a neonatal intensive care unit (NICU) setting, preterm newborns' brain activity and oxygenation levels are measured.

Decisions about Investments and Neurofinance

Typically, we observe that particular emotions have an impact on how an individual investor behaves. In contrast to negative emotions like anxiety, which have the opposite effects like over-curiousness, manipulation, etc., positive emotive moods like exuberance promote risk-taking actions and gullibility in one's ability to assess investing decisions. Opinions, values and beliefs are a crucial component of any judgement process. Beliefs are psychological phenomenon that compels people to maintain an upbeat, emotive demeanour by ignoring knowledge that conflicts with their earlier decisions. One social bias that arises from beliefs

and the distress experienced when those beliefs clash with the most recent knowledge is cognitive dissonance.
We will now talk about the neuroscience of the aforementioned emotions, including overconfidence, risk aversion, mental accounting, anxiety, etc., and how they affect investor behaviour.
The brain's architecture and secretions that influence investor behaviour are studied by neuroscientists.

Brain Hormones/Secretions that control Investor's Behaviour:

i) Dopamine's Function:

Dopamine is a neurotransmitter that the brain releases when we experience positive emotions. Dopamine is released in greater amounts when unanticipated gains are made quickly. Investors experience depression at the same moment as they suffer an unanticipated loss because dopamine secretion entirely stops at that point.
Advice on Investment Choices:
Dopamine affects the uncertain investment behaviour because it is liable for the emotions of satisfaction and despair. When an investor's projections result in wins, dopamine levels are higher; conversely, when expectations result in losses, dopamine levels are significantly lower. Dopamine is the chemical that causes fallacies in behaviour like group psychology, over-optimism etc.

ii) Serotonin's Function:

The gastrointestinal tract and the brain both contain the receptor serotonin. The hormone serotonin is in charge of stress, depression, and appetite.
Advice on Investment Choices:
Serotonin levels drop when expectations, such as capital losses, are not met. These circumstances cause the investor to feel unmotivated, worry, and hunger deprivation. Deeply anxious investors may act erratically to prevent risks and depression, yet doing so may result in increased losses and expensive purchases. Lower serotonin levels lead investors to prematurely exit profitable positions. Decrease in losses might be because of lower serotonin levels which eventually could be the cause of resistance.
The propensity to "take the cash and flee" was driven on by the decreased serotonin levels.

Brain regions in charge of Investor Behaviour:

iii) Amygdala's Function:

The almond-shaped body, which is located in the frontal middle part of the brain, is in charge of emotions including terror, happiness, the emergence of phobias, and chronic depression. Investor "fight or flight" reaction is controlled by the amygdala.
Advice on Investment Choices:
Investor selling tendency during bear markets is caused by how Amygdale works. Anxiety and fear makes investors want to flee from collapsing stocks, although in

reality, this is the moment to battle the bearish trend and put on certain technically successful equities at adjusted prices.

iv) Prefrontal cortex's Function :

The prefrontal cortex of the brain is in charge of making complicated cerebral decisions that affect interpersonal behaviour and personality of an individual. Memory, analysis, and forming inferences from various events are all functions of the prefrontal cortex.

Advice on Investment Choices:

Anytime an investor makes cognitive mistakes, it indicates that the prefrontal cortex lacks the information it needs to make decisions that are precise, suitable, and current. To give the prefrontal cortex the correct information and for it to make improved decisions, education is necessary. This education can take the shape of either intellect or expert adviser counsel.

v) Anterior Cingulate and Nucleus Accumbens :

A cluster of neurons called the nucleus accumbens is found in the human brain at the back of the ears. The growth of compulsive behavior is influenced by this cluster of neurons. The forward region of the cingulated cortex called the anterior cingulate has a critical role in judgement and benefit prediction.

The anterior cingulated and nucleus accumbens work together to aid with analytical thinking or pattern observation and decision - making process.

Advice on Investment Choices:

Patterns are produced by the nucleus accumbens and anterior cingulate, which lead investors to trust in patterns despite digging for in-depth justifications.

For instance, if a corporation reports per month that its profits projections have grown and the market reacts to this news by raising stock prices. Consequently, the above- mentioned areas of the brain would establish a rhythm whereby the stock price will increase after every month without conducting a thorough basic investigation of the company's shares.

Additionally, it has been noted that the majority of buyers make mistakes in detection and segmentation when making investments and are vulnerable to overlook business investment opportunities that have constant revenues.

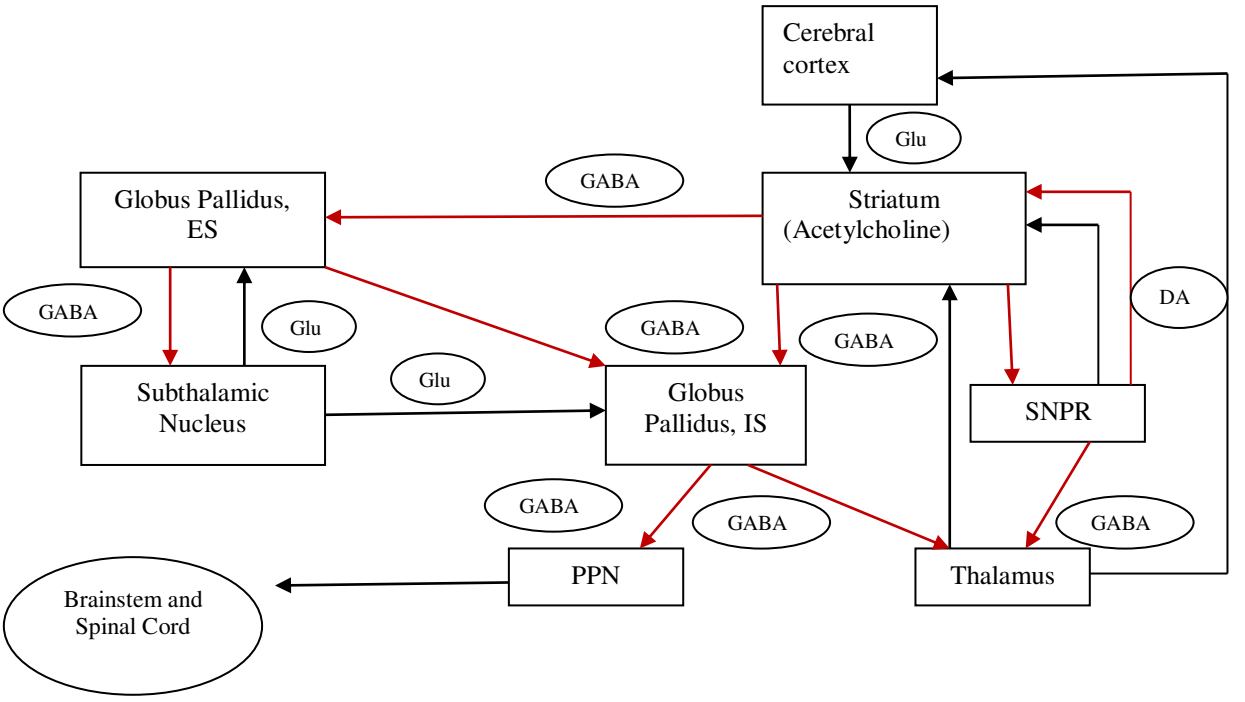

Figure 3: Diagrammatic Representation of the principal connections of the basal ganglia. The transmitters represented here as DA : Dopamine, Glutamate etc. Source: Ganong's Review of Medical Physiology, Kim E. Barrett, Scott Boitano, Susan M. Barman, Heddwen L. Brooks)

Men and Women think differently: Why?

There is a widespread myth that men deal with stress better than women because they don't lose their composure or go agitated. Whenever strain is underway and a crucial choice must be made, we are likely to turn to males rather than women if you hold either of these ideas.

According to neuroscientists, both of these widely held beliefs are false.
Men are more willing to accept risks when under stress, according to independent research. According to many researches when their pulse rate and insulin levels are higher, males get obsessively intent on benefits, even if those benefits have an extremely minimal possibility of coming true. Men take more and bigger risks than they normally does when pressure is applied and there is the possibility of a very lucrative result.

It is observed from researches that its somewhat different if we place women in an identical state of stress, boost their cortisol levels, then urge them to choose the same option. Their eyes would whirl to the dangers. Women spend longer considering the risks and are more intrigued in little benefits they could rely on when their hormones are experiencing an extreme stress wave. Women provide distinctive power to decision-making, not weakness. When in pressure, women frequently grow risk-averse and choose for the simpler, more certain gains.

Why is it so that it is said that women are more sensitive to society and social norms as compared to men. Is this social disparity justifiable? Many researches and studies have found that teams and groups within an organization having majority of women end up with the best decisions and develop the most desirable solutions too. When it comes to an individual woman, within a family or a society she is considered vulnerable and weak with tiny financial knowledge. But on the same side, since ages women have been seen to take better financial decisions than male member of the family. Even though a man is the bread earner of the family but the actual management of funds are done by the housewives. These modern days we find ample of professional women working, earning and are independent financially. They are aware with the financial terminologies and different investment avenues to select for investment. They do not seek advice from their husbands and manage their portfolios well. But if we want to make a smart investment decision we must really start listening and taking advice from women. Thus, Still, there are enormous proofs that when a woman takes the torch of leadership she handles situation better and eventually takes smarter and wise decisions.

Conclusion

We require improved fiscal enrichment of the human minds analyze financial decision-making in the quickly evolving corporate world of today. The area of behavioral and psychological economics, that seeks to connect the workings of the neuroscience to investment behavior, is developing and expanding. Courtesy to neurofinance, a burgeoning field of study. According to research, experimenters and investigators have begun evaluating the recently created investor psychological models. The neurological evidence provides consistent affirmations of comparative socioeconomic preference. Traditional economic concepts are consistently disproved by Neurofinance, which shows that investors use a variety of techniques rather than thinking through their choices carefully and relying on financial realities that vary from individual to inidvidual.

Humans have a complex, multilayered system that is influenced by a wide range of elements while making decisions. In the age of finance, neurofinance is a rather recent field. One of the key discoveries of the area relates to the crucial element of emotions in financial decision making. It strives to link mental abilities to investment behaviour. The examination of human behaviour and reactions can be pushed to the level of analysis of neurophysiology in the discipline of neuroeconomics, which is an active trend of modern finance where solutions to concerns regarding discrimination in investor behaviour are sought.

Individuals are required to be equipped to handle our economies' growing financial intricacy and complications. Technologies for imaging the mind are not just adopted by doctors to treat patients. In addition to identifying adult neurogenesis, researchers and academics can use it for analysis of both positive and undesirable expected and instant emotions while making decisions.

The foundation for judgement is the investor's independent and objective based perspective. These data ought to motivate all scholars and academicians to start using brain mapping technologies to study investor's financial choices. By

comprehending how their brains function, this aids in the individuals' optimistic and persistent progress in their investing patterns.

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