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Insights from Neuroscience towards Investment Decision Making

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Abstract
As the advancement in the field of finance continues, the human brain plays a vital role in understanding the investment behavior. Over the passage of time, it emerges as a challenge for traditional views to make decisions by the investors. This research highlights the impact of neurotransmitters on investment options and their relationship with information sources. Moreover, this study focuses on the following aspects: (i) Role of Emotional Intelligence (EI), (ii) Revealing the cognitive biases which influences investment decisions. Data collection is done through a close-ended questionnaire from 719 retail and institutional investors in the financial and stock market of Pakistan (PSX). Data is then analyzed with the help of Partial Least Squares Structural Equation Modeling (PLS-SEM). The study reveals a substantial relationship between neurotransmitters, information sources, and investment decisions. It is quite notable that EI was found to have no significant regulating effect on the relationship between neurotransmitters and investment decisions. This research study corroborates the critical influence of neurotransmitters on investment decision making, highlighting the cognitive biases that direct the investment behaviors. The contribution of the research expands to a deeper comprehension of cognitive mechanisms in the age of neuroscientific financial exploration and giving the novel outlooks within the field.

Keywords: Information Source, Neurofinance, Investment Decisions, Emotional Intelligence, Neurotransmitters

JEL classification: G4, G41, G11

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1. Introduction

Decision-making is a multifaceted process influenced by various parameters, including the number of available choices, the time allocated for the decision, perceptual uncertainties, personal experiences, and the subjective valuation of probable outcomes. Moreover, it's significantly affected by the internal subjective neural encoding assigned to different choices based on individual preferences (Toma, 2023). The limitations of traditional economic models in explaining human behavior within financial contexts have led to the emergence of the interdisciplinary field of neuroeconomics. Neuroeconomics combines economics, psychology, genetics, and neurobiology to provide a comprehensive understanding of investment decision-making (Nixon, 2023a). Notably, Nixon (2023b) delves into the practical application of neuroeconomics principles in addressing the challenges faced by clients and financial advisors. This convergence of economics, psychology, and neurology has enriched the realm of behavioral finance by establishing connections between brain activities and prevalent behavioral biases that affect investment decisions.

Intriguingly, neurofinance, as an extension of behavioral finance, provides a unique lens for exploring the neurobiological underpinnings of financial choices. This area of study is further underscored by Miendlarzewska et al. (2019), who employed neuroscience principles to investigate how investors perceive volatility. Their research revealed that prolonged exposure to high volatility can lead to the underestimation of risk due to neurobiological-grounded perceptual bias. Similarly, Toma (2023) harnessed neural data to construct a neural-based classifier for investment decision-making within a volatile market, aligning with the principles of the Efficient Market Hypothesis (EMH). However, despite the growing interest, there are significant research gaps that need to be addressed for a more comprehensive understanding of how the human brain functions during financial decision-making. Developing sophisticated real-time decision-making models that take into account the role of emotions in investment decisions is crucial. Addressing these gaps is essential to advance the field and gain a thorough understanding of the interconnected dynamics involving neurotransmitters, emotions, and investment choices (Srivastava et al., 2020).

This study extends the groundwork established by previous scholars who have contributed to the development of neurotransmitter scales in the field of management sciences. It also highlights significant research gaps, such as the need to understand the functioning of neurotransmitters during investment decisions, which have yet to be explored comprehensively (Bihari et al., 2022; Khan and Mubarik, 2020; Singh et al., 2022; Srivastava et al., 2020). In building upon the foundations laid by these prior scholars, this research seeks to delve even deeper into the intricate involvement of neurotransmitters in the decision-making behavior of financial and stock market investors in Pakistan. Furthermore, this study is conducted in Pakistan, which is a developing country with a distinct financial landscape. The research conducted in Pakistan is significant for various reasons. Firstly, it can contribute to the global understanding of neurofinance by exploring how neurobiological factors influence financial decision-making in a diverse economic context. Secondly, it can address the need for context-specific research, as existing neurofinance studies predominantly focus on developed economies. Thirdly, Pakistan's financial market has unique dynamics such as diverse investor profiles, economic challenges, and market uncertainties, offering a rich ground for investigating the interplay between neurobiological factors and financial decisions in a developing country context. The application of neuroeconomic principles in Pakistan provides an opportunity to uncover novel insights into investor behavior, decision biases, and emotional responses within an evolving economic landscape. By extending neurofinance research to this developing country, the study aims to enhance the external validity of existing neuroeconomic theories and contribute precious knowledge for both the local and global financial professionals.

Furthermore, as mentioned by Bihari et al. (2022), Singh et al. (2022) and Yaghoubian (2024) highlights the dire need to explore decision making behaviors of investors and their emotional biases under unpredictable market conditions, specifically in the financial market. The socio-economic condition in Pakistan provides an exceptional environment for intriguing that how investors steer and respond to uncertainties, accumulating a critical dimension to the global discourse on neurofinance. This research study targets to bridge the gap between cognitive biases, neuroscience and investment decision making processes. Through investigation on the role of neurotransmitters in investment decision making, this study provides valuable aspects which can enhances the assistance to the individuals as well as institutions in executing more informed investment decisions and navigate the intricate terrain of financial markets while keeping in view the cognitive biases that underlie these choices.

2. Literature review

2.1. Theoretical exposition

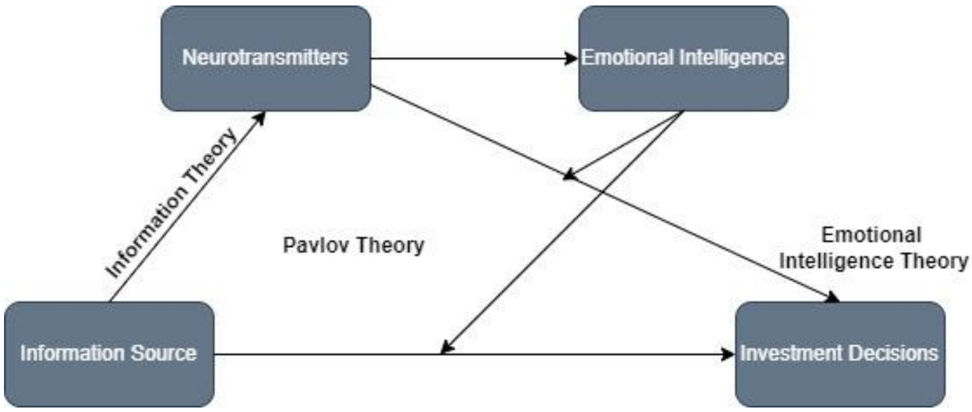
The study engages an amalgamation of three established theories to elaborate the mediating model that connects the neurotransmitters with investment decisions.

- Palov Theory of Classical Conditioning (Pavlov, 2010),
- Information Theory (Shannon, 1948),
- Emotional Intelligence Theory (Goleman,1995).

In Pavlov theory, the concept of stimulus like the ringing of a bell reminding a conditioned response (such as a dog's salivation) discovers an interesting parallel in behavior of investors. Individuals may follow the action of others rather than rely on their own rational understanding (Kahneman and Tversky, 1973; 1979). Information theory plays a pivotal role in explaining how stimuli, like fluctuations in securities prices, are processed and transmitted by the brain (acting as a processor) to ultimately produce an investment decision (the output). Additionally, the theory of emotional intelligence underscores the significance of comprehending and managing one's emotions in the decision-making process. Notably, studies have shown that losses tend to evoke stronger emotional responses than equivalent gains (Lerner et al., 2015). Consequently, some investors may prematurely sell their winning investments while retaining their losing one's (Barber and Odean, 1999; Shefrin and Statman, 1985). Nevertheless, investors possessing a high degree of Emotional Intelligence (EI) exhibit the ability to regulate their emotions, resulting in sound investment choices, even amidst market volatility.

In this context, heightened emotional intelligence empowers investors to resist the herd mentality and remain impervious to the emotional impact of market stimuli (Kahneman and Tversky, 1973; 1979). Notably, this heightened emotional intelligence is often more pronounced among institutional investors compared to retail investors. Institutional investors tend to exhibit greater resistance to market fluctuations and emotional influences on their investment choices, distinguishing them from their retail counterparts. Thus, it is evident that the interplay of classical conditioning, information processing, and emotional intelligence introduces a complex set of dynamics in financial investment decision-making. These theories collectively offer insights into the mechanisms by which investors arrive at their choices, shedding light on the intricate neural and psychological processes governing investment decisions. Furthermore, the prevalence of cognitive biases and their potential impact on these processes is a theme that runs through this theoretical foundation. Thus, this study is built on these theories to uncover how neurotransmitters interface with these mechanisms and influence investment decisions, with a particular focus on mitigating the cognitive biases that can influence choices in the financial domain. (See Figure 1)

Figure 1 - Theoretical Framework



2.2. Empirical literature

2.2.1. Areas of brain involved in investment decision-making

The decision-making process in finance is significantly shaped by the evaluation of benefits, risks, and losses associated with various options (Pirtošek et al., 2009). This evaluation process is crucial for making informed choices, and it involves assessing risks, rewards, uncertainties, and the neural underpinnings of such evaluations. Central to this process is the role of dopamine, a neurotransmitter that plays a key role in motivating and assessing cognitive processes (Pirtošek et al., 2009). The limbic system, situated in the limbic and subcortical frontal lobes, serves as the primary reward mechanism, providing critical information about potential rewards or penalties to the corresponding cognitive regions. This, in turn, enables individuals to make decisions that are more aligned with their goals and preferences, particularly in financial contexts.

The hierarchical structure of decision-making in the financial domain initiates from lower brain regions such as the limbic system and ventral striatum, extending to the orbital and medial segments of the prefrontal lobe (Assadi et al., 2009; Sahi, 2012; Takahashi, 2012; Dewitt, 2014; Gowdy, 2008; Markett and Reuter, 2014; Rangel et al., 2008). Moreover, from an interdisciplinary standpoint, Srivastava et al. (2019) offer insights into the relationship between specific brain areas and investment decision-making, particularly in the context of competitiveness. Meanwhile, Zhang et al. (2019) explore the neurological and psychological foundations of the herding behavior of top executives when establishing enterprises in industrial zones. Thus, these studies emphasize the significance of neural processes in investment decision-making. Furthermore, Neurotransmitters play a pivotal role in various cognitive functions, serving as the primary biological messengers responsible for transmitting information from different senses (Srivastava et al., 2020). This literature focuses on the central role in mediating cognitive processes. Hence, the following hypotheses are derived in the light of contemporary review of the literature:

Hypothesis 1: Neurotransmitters significantly transmit the simulated information.

Hypothesis 2: Neurotransmitters have a significant relationship with the investment decision.

Hypothesis 3: Neurotransmitters positively or negatively mediate the relationship between information sources and investment decisions.

2.2.2. Emotional intelligence and investment decision

Emotional Intelligence (EI) is defined as the ability of an individual to perceive, comprehend and regulate their own emotions and the emotions of others as well as the effects of these sentiments. It also involves using this emotional understanding to advise and influence behavior within a specific context (Kunnanatt, 2014). People with high level of EI can excel in establishing mutual beneficial relationships, on contrary to that, those who have lower EI may find it struggling in building such relationships. The relevance of EI spread across different fields including finance and economics, where it can significantly influence the investment decision making.

Research suggests that the emotional intelligence can significantly impact the investment decisions, people having higher emotional intelligence can potentially make more well-versed and effective choices in financial matters. This has given a dominant variation in trading behaviors, with some individuals in extensive trading while others are more conservative in their trading activities (Barber and Odean, 2000). Moreover, the influence of emotions on economic behaviors and decision-making has been a topic of interest for both psychologists and economists, as demonstrated in studies by researchers such as Loewenstein (2000), Hopfensitz and Wranik (2008), Thaler (2000). Emotions play a substantial role in shaping attitudes, judgments, and, consequently, decisions, as evidenced by studies like (Gutnik et al., 2006).

In a broader sense, Emotional Intelligence (EI) encompasses a set of skills that enable individuals to engage in complex processing of emotional information and emotion-related stimuli. These skills are employed to influence one's decisions and actions (Mayer et al., 2008). Moreover, the neurobiology of emotions reveals that specific brain regions are associated with distinct primary emotions. However, research has also indicated that a single primary emotion may be linked to multiple brain regions, while others may be associated with specific regions. For example, the amygdala has been identified as a central hub for processing negative emotions like fear and anger (Gu et al., 2019). The concept of three primary emotions—happiness, sadness, and anxiety—associated with three neurotransmitters—dopamine, serotonin, and norepinephrine—has been introduced in previous studies.

Furthermore, Wang et al. (2020) have explored the role of some neurotransmitters as core components of emotions and emotional substrates. Similarly, (Kosonogov et al., 2019) have examined neurotransmitter system genes, including those related to dopamine and serotonin receptors, which have been associated with emotional intelligence. Considering this body of research, this study proposes the following hypothesis.

Hypothesis 4: Emotional Intelligence has a significant relationship with investment decisions.

Hypothesis 5: Emotional intelligence moderates the relationship between information sources and investment decisions in such a way that the relationship becomes stronger or weaker.

Hypothesis 6: Neurotransmitters have a significant relationship with emotional intelligence.

Hypothesis 7: The relationship between neurotransmitters and investment decisions has been moderated by emotional intelligence.

2.2.3. Information source and investment decision

Investors often take various factors into account when making investment decisions. The utilization of different information sources, whether fundamental or non-fundamental, can offer valuable insights into the attractiveness of an investment opportunity (Arnswald, 2001). Understanding how information acquisition affects various aspects of trading, risk-taking, portfolio diversification, and portfolio performance (Abreu and Mendes, 2010; Anagol and Gamble, 2013; Abreu and Mendes, 2012; Tauni et al., 2020) is pivotal because it can directly impact an investor's portfolio.

Arnswald (2001) highlights the practice of fund managers seeking information from colleagues and other market participants to validate fundamental information and reinforce their own decisions. This collaborative approach can be considered a competitive advantage, as it leads to a more comprehensive market understanding and, consequently, more informed investment choices. Additionally, the use of direct relational interactions, such as word-of-mouth communication and other significant stimuli, can play a substantial role in influencing an investor's decision-making (Ivković and Weisbenner, 2007). Therefore, the selection of information sources and the extent of their impact on investment decisions are intricately linked, making it crucial for investors to thoroughly evaluate and analyze available information sources to make well-informed investment decisions.

Hypothesis 8: Information sources have a significant relationship with Investment decision-making.

3. Material and methods

3.1. Analytical method

In the empirical model evaluation, this study employed Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach to analyze the data and verify the adequacy of the measurement model by validating the proposed constructs' reliability and validity. PLS is a strategic tool that simultaneously tests regression and Confirmatory Factor Analysis (CFA) (Hair et al., 2018). Having said that Principal Component Analysis (PCA) technique can be used to create composite variables, in general. However, PLS is recommended approach when the composite variables are used as independent or explanatory variables in regression analysis on a dependent variable (Liu et al., 2022).[1] Notably, PLS-SEM elucidates both direct and indirect outcomes, offering a comprehensive explanation of dependent variables' variances. Consequently, PLS 3.0 was chosen for data analysis in this research.

[1] We thank the anonymous referee comments to incorporate the reason for the proposed mechanism.

3.2. Measures

Table 1 - Measurement of Key Variables

Constructs	Sub-Dimensions	Items	Source
Neurotransmitters	Adrenaline or epinephrine Noradrenaline or Norepinephrine Dopamine Serotonin GABA (gamma-aminobutyric acid) Acetylcholine Glutamate Endorphins	58	(Khan and Mubarik, 2020)
Investment Decision	Investment horizon Risk attitude Personalization of loss Confidence Control	21	(Wood and Zaichkowsky, 2004)
Emotional Intelligence	Self-emotions appraisal Regulation of Emotions Use of Emotion Others-emotions appraisal	16	(Law, Wong and Song, 2004)
Information Source	Fundamental facts Technical indicators Economic statistics and ratio Statements of economic opinion Leaders Historical returns Press and bulletin Commentary in the news/magazine/ TV/internet Discussion with colleagues Decisions of other market players Statements of opinion leaders	10	(Warther, 1995, Lutje and Menkhoff, 2007; Menkhoff and Schmidt, 2005, (Abreu and Mendes, 2010, 2012)

Table 1 details variable measurements: neurotransmitter metrics (58 items across eight sub-dimensions), investment decisions (21 items), emotional intelligence (16 items over four sub-dimensions), and information sources (ten items). Employing a five-point Likert scale ranging from "Strongly disagree" (1) to "Strongly agree" (5), the survey is bifurcated: the initial section delves into demographic specifics - years in stock market investment and investment magnitude - while the latter focuses on variable measurement items.

3.3. Data collection

Data was amassed from Pakistan Stock Exchange's (PSX) retail and institutional investors. As of June 2022, Central Depository Company (CDC) statistics highlight 299,451 account holders transacting in 1059 securities, valued at PKR 5 trillion. Out of these, 69,459 are retail accounts.

The study's population was pegged at 298,942 account holders. In order to find out the sample size, we use different established metrics provided by websites such as Raosoft and Qualtrics.[2] The recommended sample size with 95% confidence level and 5% margin of error comes to around 384. In this regard, we approached 1000 respondents, of which 719 participated, leading to a 71.9% response rate, as shown in Table 2. The respondents' demographic profile indicates a male predominance (91%) with a majority being retail investors (69.68%). The portfolio values and trading experience of these respondents varied widely. To curb biases, a standardized set of randomized questions was presented to all participants.

4. Results

This study employed twofold techniques: the measurement model and the structural model. The measurement model was assessed based on CFA (Hair et al., 2014). At the same time, the relations between the latent constructs are determined in the structural model assessment. If the evaluation of the measurement model determines reliability and validity, it is appropriate to examine structural model estimates.

Table 2 - Respondent Profile

Gender		n(719)
	Male	91%
	Female	9%
Nature of Investor		
	Retail Investor	69.68%
	Institutional Investor	30.32%
Value of Portfolio		
	Less than 1,000,000 (1million)	43.25%
	1,000,000 (1million) to 3,000,000 (3Million)	13.07%
	3,000,000 (3million) to 6,000,000 (6Million)	10.01%
	6,000,000 (3million) to 9,000,000 (9Million)	14.05%
	More than 9,000,000 (9million)	19.61%
Number of Experience in Trading		
	Less than 1 Year	5.56%
	2 – 5 years	10.29%
	6 - 10 years	16.55%
	11 – 15 years	10.57%
	16 – 20 years	17.94%
	More than 20 years	39.08%

4.1. Measurement model

The reliabilities for each construct's composite of measures (i.e., internal consistency reliability) and the convergent and discriminant validities of measures are both examined in the measurement model assessment. The internal consistency was checked through composite reliability and Cronbach's Alpha; as shown in Table 3, the values of Cronbach's alpha and composite reliability for all the constructs are 0.7 or greater than 0.7, which indicates that all the

[2] http://www.raosoft.com/samplesize.html, https://www.qualtrics.com/blog/calculating-sample-size/
We thank the anonymous referee comments to incorporate this suggestion.

constructs are reliable (Chin, 2010; Hair et al., 2019). Factor loadings of items were obtained to calculate convergent validity at the item level. Some items were dropped gradually because the factor loadings were below the threshold. Based on this, one item of acetylcholine, dopamine, endorphins, emotional appraisal, self-emotions appraisal, and information source, two items of investment horizon and noradrenaline, three items of control, and four items of glutamate were dropped from the analysis. The remaining items were retained as the loading values were≥ 0.7 (Hair et al., 2014). To measure the convergent validity at the construct level, the value of AVE was obtained, and the value of AVE for all the constructs is≥ 0.5, per the minimum accepted threshold (Hair et al., 2014). Lastly, discriminant validity was gauged through the Fornell-Larcker criterion (Fornell and Larcker, 1981). The results are exhibited in Table 3, which shows that the squared root of AVE is higher than inter-constructs. (See Table 4)

Table 3 - Reliability

Variables	Cronbach's Alpha	Composite Reliability	(AVE)	Factor Loadings (Min-Max)
Information Source	0.919	0.933	0.607	0.74-0.81
Neurotransmitters				
Acetylcholine	0.863	0.902	0.648	0.71-0.85
Adrenaline	0.926	0.938	0.602	0.72-0.81
Dopamine	0.814	0.870	0.573	0.72-0.78
Endorphins	0.756	0.844	0.576	0.70-0.80
GABA	0.867	0.904	0.652	0.79-0.82
Glutamate	0.904	0.923	0.600	0.70-0.80
Noradrenaline	0.868	0.886	0.519	0.71-0.73
Serotonin	0.833	0.881	0.599	0.73-0.83
Emotional Intelligence				
Emotion Appraisal	0.715	0.840	0.637	0.75-0.83
Regulation of Emotion	0.786	0.862	0.609	0.76-0.80
Self-Emotions Appraisal	0.750	0.857	0.666	0.81-0.82
Use of Emotions	0.806	0.873	0.626	0.76-0.83
Investment Decision				
Confidence	0.892	0.916	0.608	0.75-0.80
Control	0.649	0.806	0.582	0.70-0.83
Investment Horizon	0.788	0.904	0.825	0.90-0.91
Personalization of Loss	0.742	0.886	0.795	0.88-0.90
Risk Attitude	0.728	0.880	0.786	0.88-0.89

Table 4 - Fornell-Larcker Criterion

Latent Constructs	AD	ACE	CONF	CONT	DA	EA	END	GABA	GLU	IH	IS	NOR	PL	RA	ROE	SEA	SE	UOE
Acetylcholine	**0.805***																	
Adrenaline	0.180	**0.776***																
Confidence	0.123	0.052	**0.780***															
Control	-0.138	-0.060	-0.057	**0.763***														
Dopamine	0.606	0.224	0.208	-0.100	**0.757***													
Emotion Appraisal	0.090	-0.057	0.429	-0.026	0.140	**0.798***												
Endorphins	0.509	-0.024	0.091	-0.120	0.405	0.096	**0.759***											
GABA	0.451	0.658	0.000	-0.070	0.309	-0.008	0.158	**0.808***										
Glutamate	0.248	0.526	0.044	-0.100	0.096	0.044	0.282	0.576	**0.774***									
Information Source	0.077	0.026	0.827	-0.042	0.167	0.421	0.102	-0.040	0.038	**0.779***								
Investment Horizon	0.155	0.118	0.694	-0.051	0.208	0.267	0.108	0.065	0.085	0.701	**0.908***							
Noradrenaline	0.471	0.342	0.152	-0.139	0.608	0.057	0.360	0.193	0.007	0.105	0.216	**0.721***						
Personalization of Loss	0.050	0.064	0.753	-0.001	0.127	0.345	0.014	-0.004	0.078	0.680	0.584	0.025	**0.891***					
Regulation of Emotions	0.086	0.005	0.552	-0.048	0.167	0.528	0.116	-0.027	0.079	0.496	0.400	0.129	0.414	**0.780***				
Risk Attitude	0.102	0.081	0.729	-0.017	0.198	0.310	0.089	0.033	0.076	0.723	0.657	0.118	0.720	0.448	**0.887***			
Self-Emotion Appraisal	0.056	0.032	0.518	-0.069	0.133	0.596	0.081	-0.034	0.096	0.520	0.338	0.057	0.396	0.608	0.396	**0.816***		
Serotonin	0.583	0.211	0.217	-0.025	0.737	0.159	0.426	0.412	0.184	0.160	0.217	0.541	0.132	0.145	0.197	0.137	**0.774***	
Use of Emotion	0.042	-0.071	0.527	-0.045	0.082	0.603	0.083	-0.084	0.057	0.462	0.274	0.007	0.432	0.647	0.369	0.657	0.114	**0.795***

4.2. Structural model

The Structural model analysis measured the direct and indirect relationship among the latent constructs through their path coefficients, t-statistics, and significance values. In Table 5, the structural model assessment results indicate that the five main paths are significant. Table 5 also shows that the path relationship between information source and neurotransmitters is significant $\beta = 0.112$, $p = 0.002$. It indicates that information source has a significant positive relationship with neurotransmitters. It means that neurotransmitters significantly transmit simulated financial information. Thus, hypothesis 1 is accepted. This study also examined each neurotransmitter's role in transmitting information separately. The results revealed that information sources have a significant relationship with all the neurotransmitters, including dopamine $\beta = 0.081$, $p = 0.002$, serotonin $\beta = 0.083$, $p = 0.002$, acetylcholine $\beta = 0.081$, $p = 0.002$, noradrenaline $\beta = 0.075$, $p = 0.002$, adrenaline $\beta = 0.075$, $p = 0.002$, GABA $\beta = 0.082$, $p = 0.002$, glutamate $\beta = 0.063$, $p = 0.001$, and endorphins $\beta = 0.055$, $p = 0.001$. Therefore, all the sub-hypothesis from hypotheses 1a to 1h are accepted.

On the other hand, neurotransmitters positively affect investment decisions, $\beta = 0.082$, $p = 0.000$. It means that neurotransmitters play a significant role in investment decisions based on which H2 is accepted. Additionally, this study estimated the effects of each neurotransmitter on investment decisions to assess the individual effects. The results indicate that six neurotransmitters play a significant role in investment decisions, such as dopamine $\beta = 0.064$, $p = 0.001$, serotonin $\beta = 0.080$, $p = 0.000$, acetylcholine $\beta = 0.060$, $p = 0.004$, noradrenaline $\beta = 0.057$, $p = 0.005$, adrenaline $\beta = 0.071$, $p = 0.030$, GABA $\beta = 0.058$, $p = 0.008$, glutamate $\beta = 0.083$, $p = 0.029$. Thus, the results indicate that all the neurotransmitters are significantly involved in the investment decision. While endorphins $\beta = -0.004$, $p = 0.863$ have an insignificant effect on investment decisions.

Emotional intelligence also showed a positive significant effect on investment decisions, with $\beta = 0.143$, $p = 0.000$. It indicates that strong emotional intelligence can lead to effective investment decisions. As a result, hypothesis 4 is accepted. In addition, neurotransmitters showed a positive significant effect on emotional intelligence as well, $\beta = 0.098$, $p = 0.029$. Therefore, neurotransmitters play an important role in emotional intelligence; thus, H6 is accepted. Furthermore, the separate effect of each neurotransmitter on emotional intelligence indicates that dopamine β = 0.174, p = 0.001, serotonin β = 0.184, p = 0.000, acetylcholine β = 0.102, p = 0.040, noradrenaline β = 0.114, p = 0.008, glutamate β = 0.291, p = 0.000 and endorphins β = 0.145, p = 0.000 are significantly involved in investment decisions. Whereas adrenaline β = 0.006, p = 0.947, and GABA β = -0.049, p = 0.249 have an insignificant effect on emotional intelligence. It means that GABA and adrenaline are not involved in emotional intelligence. On the other hand, information sources positively affect investment decisions, with β = 0.762, p = 0.000. It shows that information obtained from various sources plays an important role in investment decisions. It means that more authentic information leads to more effective decisions. Hence, hypothesis 8 is accepted.

Table 5 - Structural Model

Hypothesis	Path Coefficient	Coefficient	T Statistics	p-values	Decision
H1	Information Source → Neurotransmitters	0.112	3.288	0.002	Supported
	Information Source → Dopamine	0.081	3.250	0.002	Supported
	Information Source → Serotonin	0.083	3.243	0.002	Supported
	Information Source → Acetylcholine	0.081	3.248	0.002	Supported
	Information Source → Noradrenaline	0.075	3.324	0.002	Supported
	Information Source → Adrenaline	0.075	3.324	0.002	Supported
	Information Source → GABA	0.082	3.318	0.002	Supported
	Information Source → Glutamate	0.063	3.484	0.001	Supported
	Information Source → Endorphins	0.055	3.553	0.001	Supported
H2	Neurotransmitters → Investment Decision	0.082	4.398	0.000	Supported
	Dopamine → Investment Decision	0.064	3.541	0.001	Supported
	Serotonin → Investment Decision	0.080	4.382	0.000	Supported
	Acetylcholine → Investment Decision	0.060	2.992	0.004	Supported
	Noradrenaline → Investment Decision	0.057	2.966	0.005	Supported
	Adrenaline → Investment Decision	0.071	2.230	0.030	Supported
	GABA → Investment Decision	0.058	2.772	0.008	Supported
	Glutamate → Investment Decision	0.083	2.250	0.029	Supported
	Endorphins → Investment Decision	-0.004	0.173	0.863	Not-Supported
H4	Emotional Intelligence → Investment Decision	0.143	4.561	0.000	Supported
H6	Neurotransmitters → Emotional Intelligence	0.098	2.253	0.029	Supported
	Dopamine → Emotional Intelligence	0.174	3.662	0.001	Supported

	Serotonin → Emotional Intelligence	0.184	5.235	0.000	Supported
	Acetylcholine → Emotional Intelligence	0.102	2.112	0.040	Supported
	Noradrenaline → Emotional Intelligence	0.114	2.777	0.008	Supported
	Adrenaline → Emotional Intelligence	0.006	0.066	0.947	Not-Supported
	GABA → Emotional Intelligence	-0.049	1.165	0.249	Not-Supported
	Glutamate → Emotional Intelligence	0.291	2.776	0.000	Supported
	Endorphins → Emotional Intelligence	0.145	5.275	0.000	Supported
H8	Information Source → Investment Decision	0.762	27.354	0.000	Supported

4.3. Mediating and moderating analysis

In this part, neurotransmitters were mediators between information sources and investment decisions. For mediation analysis, this study employs the mediation approach of (Hair et al., 2014). They suggest bootstrapping the indirect effect to test the mediation effect of the study. Table 6 presents the results of the mediating analysis. Hypothesis 3 tests the mediation of neurotransmitters in the relationship between information sources and investment decisions. The results indicate a β=0.009 while the p-value = 0.010, which means neurotransmitters significantly mediate the relationship between information sources and investment decisions. Furthermore, this study also checked the individual mediating effect of each neurotransmitter on the relationship between information sources and investment decisions. As shown in Table 6, dopamine significantly mediates the relationship between information sources and investment decisions, as the β=0.031 with p = 0.030 is less than 0.05. Similarly, serotonin significantly mediates the relationship between information sources and investment decisions. The β coefficient value is 0.013, and the p-value is 0.002, which is less than the acceptable threshold.

On the other hand, the β coefficient of acetylcholine is 0.006, and the p-value is 0.048, which indicates that acetylcholine mediates the relationship between information sources and investment decisions. In addition, the significance levels of the direct and indirect effects are less than 0.05, indicating partial mediation since the p-values for indirect effects are 0.002 and 0.004, and the p-value for direct effects is 0.000. In the same way, the coefficient and significance values for noradrenaline and adrenaline are β = 0.008 and p = 0.041, β = 0.008, and p = 0.043, which means noradrenaline and adrenaline also play a significant mediating role in the relationship between information source and investment decision. In addition, the β coefficient of glutamate is 0.011, and the p-value is 0.029, which shows that glutamate significantly mediates the relationship between information sources and investment decisions. Besides, as shown in Table 7, the p-values for GABA and endorphins are 0.466 and 0.869. The insignificant p-values indicate that GABA and endorphins play an insignificant role in the relationship between information sources and investment decisions.

Table 6 - Mediating Analysis

Hypothesis	Path Coefficient	Coefficient	T Statistics	P Values	Decision
H3	Information Source →Neurotransmitters →Investment Decision	0.009	2.666	0.010	Supported
	Information Source → Dopamine → Investment Decision	0.031	2.239	0.030	Supported
	Information Source → Serotonin → Investment Decision	0.013	3.269	0.002	Supported
	Information Source → Acetylcholine → Investment Decision	0.006	1.978	0.048	Supported
	Information Source → Noradrenaline → Investment Decision	0.008	2.097	0.041	Supported
	Information Source → Adrenaline → Investment Decision	0.008	2.079	0.043	Supported
	Information Source → GABA → Investment Decision	-0.003	0.734	0.466	Not-Supported
	Information Source → Glutamate → Investment Decision	0.011	2.342	0.023	Supported
	Information Source → Endorphins → Investment Decision	0.000	0.166	0.869	Not-Supported

The research model has proposed one mediating path and two moderating paths. The first moderating path predicted a moderating effect of emotional intelligence on the relationship between neurotransmitters and investment decisions. On the other hand, the second path predicted a moderating effect of emotional intelligence on information sources and investment decisions. Table 7 presents the results of both moderating paths. This first moderating path exhibited a negative insignificant effect ($\beta = -0.023$; $p > 0.409$). Furthermore, the second moderating path is also insignificant ($\beta = 0.006$; $p > 0.800$), which means both moderating hypotheses (H7 and H5) are rejected.

Table 7- Moderating Analysis

Hypothesis	Path	Coefficient	T Statistics	P Values	Decision
H7	Neurotransmitter*Emotional Intelligence → Investment Decision	-0.023	0.833	0.409	Rejected
H5	Information Sources*Emotional Intelligence → Investment Decision	0.006	0.255	0.800	Rejected

4.4. Multi-group analysis

This study used multi-group analysis to determine whether differences in path coefficients exist. There will always be differences in path coefficients generated by different samples, but the multi-group analysis determines whether differences are statistically significant (Hair et al., 2018). A multi-group analysis null hypothesis is that path coefficients between groups are not significantly different. However, the alternative hypothesis is that path coefficients are significantly different. Table 8 reports the results of PLS-MGA. The results indicate that four

(Information source and neurotransmitters, emotional intelligence and investment decisions, information sources, and investment decisions, information source* emotional intelligence and investment decisions) paths have insignificant p-values (p> 0.05). It implies that the difference is insignificant, implying that the same PLS structural path model applies to institutional and retail investors.
On the other hand, the other four paths (Neurotransmitters and investment decisions, neurotransmitters and emotional intelligence, information sources, neurotransmitters, and investment decisions, neurotransmitters*emotional intelligence, and investment decisions) have significant p-values (p<0.05), which means that there was a significant difference across nature of investors (Institutional vs. Retail). The study also compared the bootstrapping result to assess the difference between the investors' path coefficients. The results indicate that for H2 and H3 the institutional investors (β = 0.182, β =0.038) have stronger path coefficients than retail investors (β = 0.051, β =0.004). While, for H6 and H7 the retail investors (β = 0.116, β = -0.009) have strong path coefficients than institutional investors (β = 0.060, β =-0.167).

Table 8 - PLS-MGA

Hypothesis	Path Coefficient	PLS-MGA		BOOSTRAPPING			
		Path Coefficients - diff	p-Value new	Path Coefficients		P-values	
		(Retail - Institutional)	(Retail vs Institutional)	Institutional	Retail	Institutional	Retail
H1	Information Source → Neurotransmitters	-0.134	0.132				
H2	Neurotransmitters →Investment Decision	-0.131	0.005	0.182	0.051	0.000	0.032
H4	Emotional Intelligence →Investment Decision	0.111	0.155				
H6	Neurotransmitters → Emotional Intelligence	0.056	0.475	0.060	0.116	0.253	0.047
H8	Information Source →Investment Decision	-0.048	0.520				
H3	Information Source → Neurotransmitters → Investment Decision	-0.034	0.039	0.038	0.004	0.032	0.445
H7	Neurotransmitter*Emotional Intelligence → Investment Decision	0.158	0.010	-0.167	-0.009	0.002	0.785
H5	Information Sources*Emotional Intelligence → Investment Decision	-0.202	0.078				

5. Discussion

To address the objectives of the study. This study examined the role of neurotransmitters in investment decisions by transmitting simulated information about the financial market. Therefore, the study uses PLS-SEM to analyze the data. The results support the reliability and validity of the measurement model (Table 3 and Table 4). From the structural model evaluation, it was observed that the R^2 coefficient is 0.748, which is adequate. According to hypothesis testing, the empirical results for the H1 showed that information sources have a significant positive relationship with all the neurotransmitters (dopamine, serotonin, acetylcholine, noradrenaline, adrenaline, GABA, glutamate, and endorphins).

Hence, this finding complies with (Srivastava et al., 2020), who states that the reward system's information-carrying neurons predominantly send information via neurotransmitters. On the other hand, H2 reveals that all the neurotransmitters have a significant relationship with investment decisions, except endorphins. After checking the significant relationship between information sources and neurotransmitters with an investment decision, the study also finds the significant mediating role of all neurotransmitters except GABA and endorphins in information sources and investment decisions. It indicates that when an investor is depressed or excited, because of loss or gain, the mood regulation is not stable, and they cannot become calm, that is negative emotions cannot be controlled.

More clearly, these neurotransmitters are involved in different functions, such as adrenaline being involved in a "flight or fight" response which helps the brain to make quick decisions in the face of danger (Tank and Wong, 2015). Noradrenaline is involved in a person's mood and ability to concentrate; it is a stress neurotransmitter that affects the heart rate and blood pressure when the brain perceives a stressful event. Dopamine is a pleasure or reward neurotransmitter, and the brain releases dopamine during pleasurable activities (Arias-Carrián et al., 2010). Serotonin is the mood regulator; it plays a critical role in depression and anxiety, and increasing serotonin levels in the brain can relieve depression (Albert et al., 2014). GABA helps regulate calming; it has an inhibitory action that stops neurons from becoming overexcited. A low level of GABA can cause anxiety, irritability, and restlessness, increasing the action of GABA and anxiety attacks.

Acetylcholine plays an important role in learning; a low level of acetylcholine increases the issues related to thinking and learning. Glutamate plays a critical role in cognitive functions such as memory. A high level of glutamate can cause cellular death due to overexcitement (Wang and Reddy, 2017). Endorphins constrain pain signals and create an energized and euphoric feeling, also known as natural pain relievers. The low level of endorphins causes headache disorders. Therefore, the above findings reveal that all the neurotransmitters are responsible for a specific function, which may involve decision-making. The balance of neurotransmitters is essential for investors' mental health—the abnormality in the level of neurotransmitters due to risk, rewards, and ambiguity related to trading or financial information can cause overexcitement, stress, depression, anxiety, irritability, mood irregularity, panic attacks, and headache, which may affect their decisions.

Thus, the results of this study manifest that, neurotransmitters play an important role in investment decisions by simulating or transmitting financial information, and the findings of the study significantly fill the gap of Srivastava et al. (2020), Who identified that researchers are required to study the role of neurotransmitters in investment decision making. Further, the study also finds that the neurotransmitters possess a strong relationship with emotional intelligence except for adrenaline and GABA. In view of these findings, hypothesis 6 was accepted. The earlier findings validate this study findings, implying that the neurotransmitters system is associated with an individual’s emotional intelligence (Kosonogov et al., 2019; Wang et al., 2020).

In addition, the findings discover that the information source has also a significant relationship with investment decisions, based on which the hypothesis 8 was accepted. This study suggests the insignificant moderating role of emotional intelligence first played by the neurotransmitters and investment decisions and then by the information sources and investment decisions. Hypothesis 5 and 7 were rejected based on this finding. Moreover, this finding is contradictory to earlier literature because of the presence of anxiety, depression, stress, and personality disorder which may increase the difficulties in managing the emotions, dominant reason for low EI. Having said that, it is surprising to observe that the insignificance of EI as a moderator may be due to the influence of the institutional investor vs retail investor. Hence, the results showed that there was no material difference across different type of investors (retail vs institutional) (Downey et al., 2008; Lizerettic et al., 2014; Obeid et al., 2021; Tannous and Matar, 2010). [3]

In conclusion, this study underlines the vital role of neurotransmitters in shaping investors' mental stress and consequently, their decision-making processes. Anomalies in neurotransmitters levels are elevated by the factors such as financial risks, rewards, and ambiguity associated with trading or financial information which can lead to various negative emotions and mood irregularities and ultimately impacting an investor's ability to make decisions effectively. Furthermore, the study underlines the significant mediating effect of neurotransmitters in the relationship between information sources and investment decisions. This suggests that the presentation and perception of financial information can influence the balance of neurotransmitters, subsequently affecting investment choices. In a competitive financial market, the availability of accurate and reliable financial information becomes pivotal for investors in making well-informed decisions that can influence their competitiveness.

The research also delves into the differences between institutional and retail investors, shedding light on the unique dynamics at play. It reveals that the emotional intelligence of institutional investors significantly mediates the relationship between neurotransmitters and investment decisions. Institutional investors, characterized by their ability to control emotions and engage in long-term investment strategies, exhibit higher emotional intelligence. In contrast, retail investors, who often directly invest their funds, are more vulnerable to market fluctuations and emotional influences on their decisions. The superior emotional intelligence of institutional investors contributes to their financial competitiveness and their capability to make sound investment choices, even in the face of market volatility. Additionally, the expertise of professionals managing institutional investments, coupled with a deep understanding of financial markets and a long-term perspective, further solidifies their competitive advantage (Valaskova et al., 2021; Kristóf and Virág, 2022).

6. Conclusion

This study used eight well-known neurotransmitters that can carry out different functions and play a critical role in investment choices by transmitting the simulated information. The study's findings indicate that all the neurotransmitters except endorphins are significantly involved in investment decision-making by transmitting information about investment magnitudes. Furthermore, the study finds the significant mediating role of all neurotransmitters except GABA and endorphins linking information sources and investment decisions. Some of the reasons for this insignificant relationship are many investors feared pressure on the currency and stock market, continuing spikes in international commodity prices, and fuel prices (Venditti and Veronese, 2020).

[3] We thank the anonymous referee comments to incorporate the reason focusing on different investor types.

Moreover, the study's finding shows that endorphins did not have an insignificant relationship with investment decisions and an insignificant mediating role in information sources and investment decisions. Some reasons for this insignificant relationship are that endorphins are produced when a person engages in physical activity; they interact with brain receptors to reduce pain (White, 2019). Based on this, it can be concluded that endorphins are not directly involved in the investment decision-making process. Because endorphin levels decrease when an investor is depressed, stressed, or anxious.

Additionally, the study's findings also find an insignificant mediating relationship between GABA and noradrenaline in information sources and investment decisions. GABA's primary function is to calm the brain, but the level of GABA is thrown down when a person is depressed or stressed (Ruggiero, 2024). Therefore, it can be concluded that investors become anxious or depressed due to continuous economic instability, which is why GABA was also found to have a non-significant relationship. Moreover, this study discovers the insignificant moderating role of emotional intelligence during investment decisions by considering the presence of neurotransmitters.

Consequently, this indicates that whenever the disturbance in the neurotransmitters is due to the simulated financial information, the investor may become overexcited, depressed, irritable, or stressed, which may create an emotional disorder. Thus, investors cannot manage their emotional intelligence skills due to this disorder, affecting their decision-making power. Therefore, given the highly competitive nature of financial markets, the role of neurotransmitters in shaping investment decisions becomes even more crucial. Investors who can regulate their neurotransmitter levels effectively may have a competitive advantage over those who cannot, as they may be better able to process and evaluate financial information, make rational decisions, and manage their emotions in the face of market volatility.

6.1.1. Practical implications

The study underscores the practical significance of understanding the role of neurotransmitters in investment decision-making. Investors who incorporate this knowledge into their decision-making processes can potentially gain a competitive edge in the financial market. By considering how different neurotransmitters influence their choices, investors may make more informed and rational decisions, ultimately leading to better financial outcomes. Financial institutions and organizations can leverage these insights by providing tools and resources to help investors manage their biases and emotions during investment decisions. Recognizing the importance of emotional intelligence and offering strategies for its management can attract more clients and foster stronger relationships.

6.1.2. Managerial implications

Understanding how contextual factors influence risk preferences, as highlighted in this study, is crucial for staying competitive. Investors and financial institutions must remain updated on market trends and adapt their investment strategies accordingly. The ability to adapt and respond to changes in the market can position them more effectively in the competitive landscape. Additionally, the potential use of artificial neural networks in investment decision-making emphasizes the importance of technology and innovation. Organizations that harness emerging technologies to enhance their investment processes may gain an advantage over those relying solely on traditional methods.

6.1.3 Theoretical implications

The study's findings have theoretical implications for the fields of neuroeconomics and behavioral finance. They contribute to a deeper understanding of how neurotransmitters and emotional intelligence interact in shaping investment decisions. The investigation highlights the intricate neural mechanisms involved in decision-making and offers insights into the role of emotions and biases in financial contexts. The research lays the groundwork for further exploration of the cognitive and neurobiological aspects of investment decision-making, opening avenues for future research in this interdisciplinary field.

7. Limitations

While this study provides valuable insights, it is not without limitations. Common method bias was a concern, as data was collected from a single source. To mitigate this limitation, future research should employ multi-source data collection methods, ideally at multiple points in time to capture a more comprehensive picture. Additionally, future researchers may consider replacing the emotional intelligence variable with specific emotions to investigate how neurotransmitters shape emotional responses and their subsequent impact on investment decisions. Triangulating results from natural settings with spatial data collection could further enhance the validity of findings.

References

Abreu, M., Mendes, V. (2010). Financial literacy and portfolio diversification. *Quantitative Finance*, 10(5), 515–528.

Abreu, M., Mendes, V. (2012). Information, overconfidence and trading: do the sources of information matter? *Journal of economic psychology*, 33(4), 868–881.

Albert, P. R., Vahid-Ansari, F., Luckhart, C. (2014). Serotonin-prefrontal cortical circuitry in anxiety and depression phenotypes: Pivotal role of pre-and post-synaptic 5-HT1A receptor expression. *Frontiers in Behavioral Neuroscience*, 8(6), 1–13.

Anagol, S., Gamble, K. J. (2013). Does presenting investment results asset by asset lower risk taking? *Journal of Behavioral Finance,* 14(4), 276–300.

Arias-Carrión O., Stamelou M., Murillo-Rodríguez E., Menéndez-González M., Pöppel E. (2010). Dopaminergic reward system: A short integrative review. *International Archives of Medicine*, 3(1), 1–6.

Arnswald, T. (2001). Investment Behaviour of German Equity Fund Managers. *Deutsche Bundesbank Discussion Paper*, 08/01.

Assadi, S. M., Yücel, M., Pantelis, C. (2009). Dopamine modulates neural networks involved in effort-based decision-making. *Neuroscience and Biobehavioral Reviews*, 33(3), 383–393.

Barber, B. M., Odean, T. (1999). The Courage of Misguided Convictions. *Financial Analysts Journal*, 55(6), 41–55.

Barber, B. M., Odean, T. (2000). Trading Is Hazardous to Your Wealth: The Common Stock Investment Performance of Individual Investors. *The Journal of Finance*, LV(2), 46–47.

Bihari, A., Dash, M., Kar, S. K., Muduli, K., Kumar, A., Luthra, S. (2022). Exploring behavioural bias affecting investment decision-making: a network cluster based conceptual analysis for future research. *International Journal of Industrial Engineering and Operations Management*, 4(1/2), 19–43.

Chin, W. W., Vinzi, V. E., Henseler, J., Wang, H. (2010). *Handbook of Partial Least Squares*, Springer Link.

Dewitt, E. E. J. (2014). Neuroeconomics: A formal test of dopamine's role in reinforcement learning. *Current Biology*, 24(8), R321–R324.

Downey, L. A., Johnston, P. J., Hansen, K., Schembri, R., Stough, C., Tuckwell, V., Schweitzer, I. (2008). The relationship between emotional intelligence and depression in a clinical sample *European Journal of Psychiatry*, 22(2), 93–98.

Fornell, C., Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18(1), 39.

Goleman, D. (1995). *Emotional Intelligence*. Bantam Books.

Gowdy, J. M. (2008). Behavioral economics and climate change policy. *Journal of Economic Behavior and Organization*, 68(3–4), 632–644.

Gu, S., Wang, F., Cao, C., Wu, E., Tang, Yi-Y., Huang, J. H. (2019). An integrative way for studying neural basis of basic emotions with fMRI. *Frontiers in Neuroscience*, 13(6), 1–12.

Gutnik, L. A., Hakimzada, A. F., Yoskowitz, N. A., Patel, V. L. (2006). The role of emotion in decision-making : A cognitive neuroeconomic approach towards understanding sexual risk behavior. *Journal of Biomedical Informatics*, 39, 720–736.

Hair, J. F., Sarstedt, M., Ringle, C. M., Gudergan, S. P. (2018). *Advanced Issues in Partial Least Squares Structural Equation Modeling (PLS-SEM).* Thousand Oaks: Sage.

Hair Jr, J. F., Sarstedt, M., Hopkins, L., G. Kuppelwieser, V. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, 26(2), 106–121.

Hair, J. F., Risher, J. J., Sarstedt, M., Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2–24.

Hopfensitz, A., Wranik, T. (2008). Psychological and Environmental Determinants of MLA. *Netspar, Discussion Paper*, (9305).

Ivković, Z., Weisbenner, S. (2007) Information diffusion effects in individual investors' common stock purchases: Covet thy neighbors' investment choices. *Review of Financial Studies*, 20(4), 1327–1357.

Khan, A., Mubarik, M. S. (2020). Measuring the role of neurotransmitters in investment decision: A proposed constructs. *International Journal of Finance and Economics*, 01, 258–274.

Kahneman, D., Tversky, A. (1973). On the psychology of prediction: Whose is the fallacy?. *Psychological Review*, 7(4), 385–407.

Kahneman, D., Tversky, A. (1979). Prospect theory: an analysis of decision under risk. *Econometrica*, 47(2), 263–291.

Kosonogov, V., Vorobyeva, E., Kovsh, E., Ermakov, P. (2019). A review of neurophysiological and genetic correlates of emotional intelligence. *International Journal of Cognitive Research in Science, Engineering and Education*, 7(1), 137–142.

Kristóf, T., Virág, M. (2022). What drives financial competitiveness of industrial sectors in Visegrad Four countries ? Evidence by use of machine learning techniques. *Journal of Competitiveness*, 14(4), 97–116.

Kunnanatt, J. (2004). Emotional intelligence: The new science of interpersonal effectiveness. *Human Resource Development Quarterly,* 15, 489-495.

Law, K. S., Wong, C. S., Song, L. J. (2004). The construct and criterion validity of emotional intelligence and its potential utility for management studies. *Journal of Applied Psychology*, 89(3), 483–496.

Lerner, J. S., Li, Y., Valdesolo, P., Kassam, K. S. (2015). Emotion and decision making. *Annual Review of Psychology*, 66, 799–823.

Liu, C., Zhang, X., Nguyen, T. T. Liu, J., Wu, T., Lee, E., Tu X. M. (2022). Partial least squares regression and principal component analysis: similarity and differences between two popular variable reduction approaches. *General Psychiatry,* 35(1), e100662.

Lizeretti, N. P., Vázquez Costa, M., Gimeno-Bayón, A. (2014). Emotional Intelligence and Personality in Anxiety Disorders. *Advances in Psychiatry*, 1, 1–7.

Loewenstein, G. (2000). Emotion in Economic Theory and Economic Behavior. *American Economic Review*, 90(2), 426–432.

Lutje, T., Menkhoff, L. (2007). What drives home bias? Evidence from fund managers' views. *International Journal of Finance and Economics*, 12(1), 21–35.

Markett, S., Reuter, M. (2014). Neuroeconomics: Individual differences in behavioral decision making. *Personality and Individual Differences*, 60(2014), S10.

Mayer, J. D., Salovey, P., Caruso, D. R. (2008). Emotional Intelligence: New ability or eclectic traits. *American Psychologist.* 63(6), 503–517.

Menkhoff, L., Schmidt, U. (2005). The use of trading strategies by fund managers: Some first survey evidence. *Applied Economics*, 37(15), 1719–1730.

Miendlarzewska, E. A., Kometer, M., Preuschoff, K. (2019). Neurofinance. *Orgnizationl Research Methods.* 22(1), 196–222.

Nixon, P. (2023a). Practical Application of Neuroeconomics in Financial Planning. *Perspectives in Financial Therapy*, 57–69.

Nixon, P. (2023b). The Brain and Financial Decision-Making', *Perspectives in Financial Therapy*, 33–56.

Obeid, S., Haddad, C., Fares, K., Malaeb, D., Sacre, H., Akel, M., Salameh, P., Hallit, S. (2021). Correlates of emotional intelligence among Lebanese adults: the role of depression, anxiety, suicidal ideation, alcohol use disorder, alexithymia and work fatigue. *BMC Psychology*, 9(1), 1–12.

Pavlov, P. I. (2010). Conditioned reflexes: an investigation of the physiological activity of the cerebral cortex. *Annals of Neurosciences*, 17(3), 136–141.

Pirtošek, Z., Georgiev, D., Gregori, M. (2009). Decision Making and the Brain: Neurologists' View. *Interdisciplinary Description of Complex Systems*, 7(2), 38–53.

Rangel, A., Camerer, C., Montague, P. R. (2008). A framework for studying the neurobiology of value-based decision making. *Nature Reviews Neuroscience*, 9(7), 545–556.

Ruggiero, M. (2024). Effects of a Topical Composition of GABA and Microbial Chondroitin Sulfate on Mental Calmness and Brain Function. *American Journal of Immunology,* 19, 1–10.

Sahi, S. K. (2012). Neurofinance and investment behaviour. *Study in Economics and Finance*, 29(4), 246–267.

Shannon, C. E. (1948). A Mathematical Theory of Communication', *The Bell System Technical Journal*, 27(3), 379–723.

Shefrin, H., Statman, M. (1985). The Disposition to Sell Winners Too Early and Ride Losers Too Long: Theory and Evidence. *Journal of Finance*, 40(3), 777–790.

Singh, M., Xu, Q., Wand, S. J., Hong, T., Ghassemi, M. M., Lo, A. W. (2022). Real-time extended psychophysiological analysis of financial risk processing. *PLOS ONE*, 17(7), 1–15.

Srivastava, M., Sharma, G. D., Srivastava, A. K., Kumaran, S. S. (2020). What's in the brain for us: a systematic literature review of neuroeconomics and neurofinance. *Qualitative Research in Financial Markets*, 12(4), 413–435.

Srivastava, M., Sharma, G. D., Srivastava, A. K. (2019). Human brain and financial behavior: a neurofinance perspective. *International Journal of Ethics and Systems*, 35(4), 485–503.

Takahashi, H. (2012). Monoamines and assessment of risks. *Current Opinion in Neurobiology*, 22(6), 1062–1067.

Tank, A. W., Wong, D. L. (2015). Peripheral and central effects of circulating catecholamines. *Comprehensive Physiology*, 5(1), 1–15.

Tannous, A., Matar, J. (2010). The relationship between depression and emotional intelligence among a sample of Jordanian children. *Procedia - Social and Behavioral Sciences*, 5, 1017–1022.

Tauni, M. Z., Yousaf, S., Ahsan, T. (2020). Investor-advisor Big Five personality similarity and stock trading performance. *Journal of Business Research,* 109, 49–63.

Thaler, R. H. (2000). From homo economicus to homo sapiens. *Journal of Economic Perspectives*, 14(1), 133–141.

Toma, F. M. (2023). A hybrid neuro-experimental decision support system to classify overconfidence and performance in a simulated bubble using a passive BCI. *Expert Systems with Applications,* 212.

Valaskova, K., Androniceanu, A., Zvarikova, K. (2021). Bonds Between Earnings Management and Corporate Financial Stability in the Context of the Competitive Ability of Enterprises. *Journal of Competitiveness*, 13, 167–184.

Venditti, F., Veronese, G.F. (2020). Global Financial Markets and Oil Price Shocks in Real Time. *ECB Working Paper No. 20202472*

Wang, F., Yang, J., Pan, F., Ho, R. C., Huang, J. H. (2020). Editorial : Neurotransmitters and Emotions. 11(1), 10–12.

Wang, R., Reddy, P. H. (2017). Role of Glutamate and NMDA Receptors in Alzheimer's Disease. *Journal of Alzheimer's Disease*, 57(4), 1041–1048.

Warther, V. A. (1995). Aggregate mutual fund flows and security returns. *Journal of Financial Economics*, 39(2–3), 209–235.

White, S. (2019). Essays in Health Economics. *Doctoral dissertation, Harvard University, Graduate School of Arts & Sciences*

Wood, R., Zaichkowsky, J. L. (2004). Attitudes and Trading Behavior of Stock Market Investors: A Segmentation Approach. *Journal of Behavioral Finance,* 5(3), 170-179.

Yaghoubian, M. M. (2024). Modeling the Behavior of Individual Investors in the Stock Market Based on the Neuro-Finance Approach. *International Journal of Finance & Managerial Accounting,* 9(32), pp. 101–112.

Zhang, W., Yang, D., Jin, J., Diao, L., Ma, Q. (2019). The neural basis of herding decisions in enterprise clustering: An event-related potential study', *Frontiers in Neuroscience*, 13(10), 1–9.