Future Business Journal

REVIEW

Open Access

# The potential of neuroscience in transforming business: a meta-analysis

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**Abstract**

Organizations that embrace innovative business strategies position themselves well for success. In this evolving technological landscape, businesses are increasingly focused on understanding consumer behaviors and preferences to tailor their products and services effectively. Notably, integrating neuroscience has become pivotal in achieving these goals, requiring its incorporation throughout various business processes. This comprehensive research review conducts a meta-analysis, synthesizing findings from numerous studies on applying neuroscience across diverse business domains. The primary objective is to identify innovative neuroscience approaches that can significantly revolutionize businesses. Through a meticulous literature exploration using PRISMA analysis, we discerned broad themes and further refined them into critical sub-themes. This thematic categorization enables a focused examination of each area of business research. The findings in this study uncovered vital intersections between neuroscience and business, offering valuable insights for corporations and researchers. In essence, the integration of neuroscientific techniques and artificial intelligence (AI)-based softwares into business practices is no longer optional, but a necessity for businesses to stay competitive in today's fast-paced world. This study, therefore, plays a crucial role in connecting the state-of-the-art tools and techniques in neuroscience and traditional business practices. It paves the way for a new era of business operations, where science and technology work hand in hand with commerce to create a more prosperous and sustainable future. In conclusion, the paper emphasizes the importance of incorporating neuroscience techniques and newly developed AI-based softwares into business practices. This integration can yield precise and favorable outcomes, offering businesses the tools to thrive in an ever-changing market environment.

**Keywords** Neuroscience, Business, Neuromarketing, Neuroaccounting, Neuromanagement, Artificial intelligence

## Introduction

Businesses that incorporate neuroscience and its methodologies into their operations gain a deeper understanding of human emotions, actions, and judgments, as well as the physical and cognitive processes of the brain. Researchers advocate for the application of neuroscience-derived techniques across various business divisions, including finance, marketing, and human resources (HR), aiming to enhance comprehension of both consumer behavior and organizational processes. Neuroscientific technologies and insights into brain processing contribute significantly to businesses, elevating their understanding of cognitive functioning in humans. Consequently, a collaborative synergy between neuroscience and business becomes essential for optimizing the design and delivery of products and services to customers.

Neuroscience, broadly defined, is a multidisciplinary field that investigates the structure and functioning of the brain, intersecting with biology, chemistry, mathematics, engineering, medicine, computer science, and more.

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A neuroscientist explores the triggering of activity in brain cells (neurons) in response to stimuli and examines how this activity influences behavior. Advances in tools available to neuroscientists, from molecular and cellular studies to whole-brain imaging and computational modeling of neurological systems, have marked significant progress in recent decades. This exploration delves into identifying the brain regions responsible for the perceived valence of commodities and decision-making processes revealing changes at molecular, cellular, and circuit level in the brain.

Neuroscientists utilize state-of-the-art techniques, animal models, and brain imaging tools to investigate the correlation between brain activity and decision-making. Notable among these are neuroscientific techniques such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), positron emission tomography (PET), steady state topography (SST), galvanic skin response (GSR), eye tracking, and facial expression analysis. These methods provide valuable insights into a consumer's response during experimental sessions, contributing to a more nuanced understanding of consumer preferences in the business realm [34].

In essence, these evaluation techniques play a crucial role in discerning a consumer reaction to a product within the confines of an experimental setting. The collected responses are not merely isolated observations; they are systematically juxtaposed against reactions to prior products or comparable offerings from competing brands. The assessment process is further fortified by incorporating questionnaires, wherein participants provide insights into their past experiences and interactions with the tested product. This amalgamation of quantitative and qualitative data establishes the foundation for a comprehensive analysis by a multidisciplinary team of molecular, systems, and computational scientists. Delving into the intricate workings of the human brain, this scientific scrutiny seeks to unveil the nuanced intricacies of consumer behavior and preference. Ultimately, the findings catalyze refining and enhancing products and services, fostering a continuous cycle of innovation and improvement within the market landscape.

While the potential of applying neuroscience across diverse business sectors is evident, there is a notable gap in comprehensive research that effectively integrates neuroscience into various business domains. Although some studies have explored specific areas such as neuromarketing, neuroaccounting, and neuromanagement independently, but there is a lack of comprehensive examinations regarding the broader integration of neuroscience across multiple business disciplines. For example, a recent study utilized co-citation analysis to evaluate the impact of neuroscience on business-to-business marketing research, emphasizing that integrating neuroscience is crucial for the success of companies and businesses [35]. Another study advocates for the use of neurobusiness as a tool to promote healthy longevity and enhance business performance [2].

Through a comprehensive literature review utilizing Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) analysis, this review is an attempt to uncover essential connections between neuroscience and business, offering valuable insights for both corporations and researchers. By pinpointing integration points between neuroscience and different business fields, this study provides crucial guidance for adapting strategies accordingly. Furthermore, it underscores the importance of incorporating neuroscience methodologies and newly developed artificial intelligence (AI)-based software into business practices. This integration can lead to positive outcomes, equipping businesses with the necessary tools to thrive in today's rapidly changing market environment. As businesses navigate a dynamic landscape shaped by AI and other emerging technologies, there is an urgent need to devise innovative strategies to maintain competitiveness and ensure future resilience, as emphasized in recent studies.

Overall, this study aims to compile and synthesize existing literature on the application of neuroscience in the evolution of business strategies. It seeks to understand how insights from neuroscience have been utilized to enhance business decision-making, marketing, and organizational behavior. Additionally, the study explores the potential future developments in business practices by leveraging neuroscience-based tools, offering a forward-looking perspective on how these tools could revolutionize various aspects of business operations, from leadership to customer engagement.

Despite our extensive efforts to compile the existing literature, there remains a pressing need for more data-driven empirical studies that directly assess the impact of neuroscience on various business practices. By generating robust, empirical data, future research can offer deeper insights and practical applications for integrating neuroscience into the business realm, ultimately driving innovation and competitive advantage.

## Methodology and data

This comprehensive study aims to provide an overview of prior research in various divisions of business that has used neuroscience as a tool. To ensure a thorough examination of the issue, the review encompasses

literature published within the span of 2009–2024. An assessment of a wide range of sources was done based on PRISMA 2020 statement [37]. PRISMA helped us prepare a thorough, transparent, and systematic review, making it easier for readers to follow. Additionally, it highlights gaps in the research and sets a foundation for future studies.

We conducted literature searches using various academic databases and gray literature. To gather more information, we also examined available web articles. The PRISMA flow diagram in Fig. 1 below shows the selection process for the literature. We excluded articles irrelevant to our research and did not help meet the research goals. Finally, the comprehensive search yielded 40 research articles and six informative web articles directly related to the topic of interest here. The literature we explored uncovered substantial linkages between neuroscience and diverse business domains, encompassing accounting,

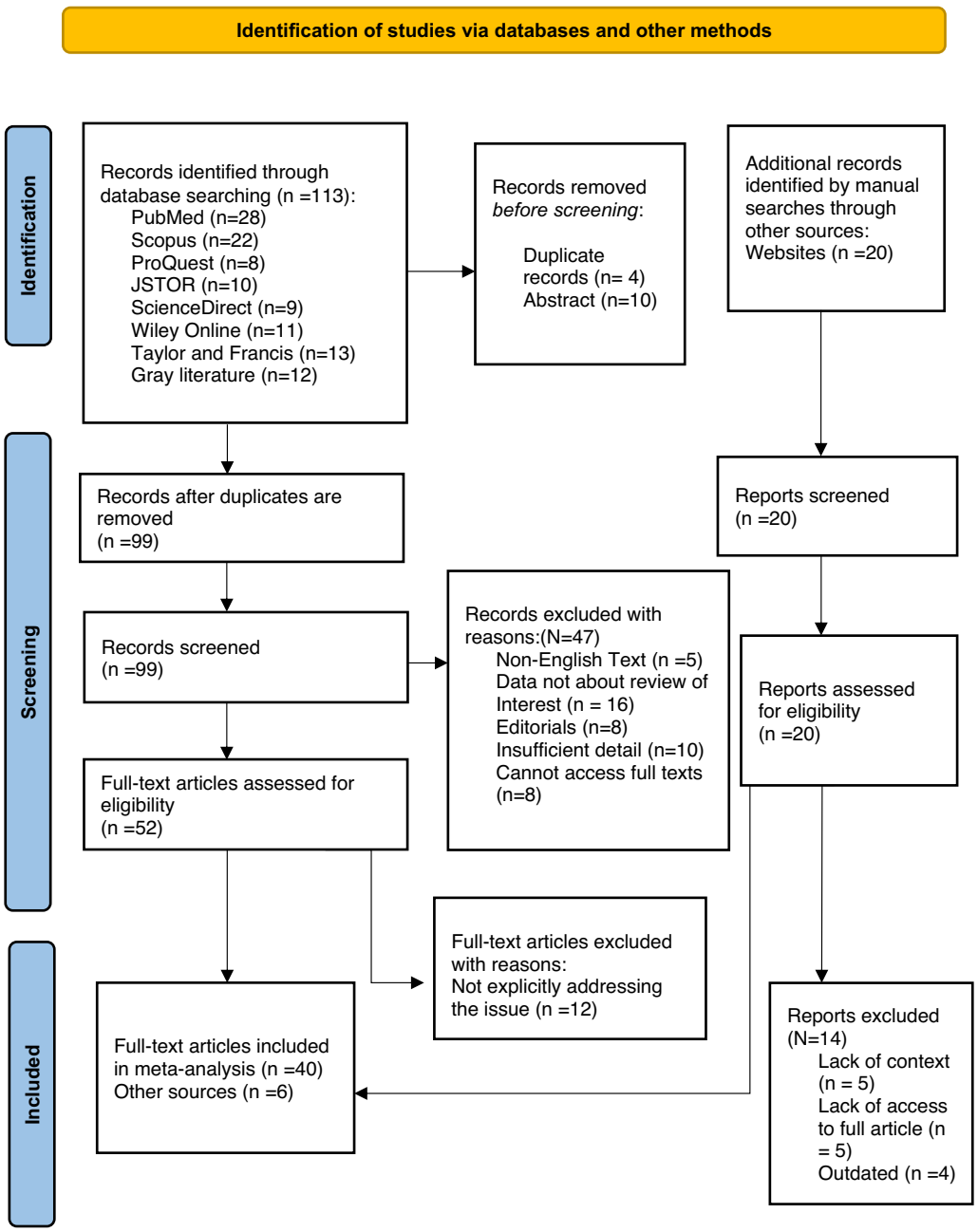


**Fig. 1** PRISMA 2020 flow diagram. *Source*: adapted from Page et al. [37]

marketing, company governance structures, and HR management practices.

After selecting and filtering the relevant full-text articles, our literature review was structured into following sections. Each section is then examined in detail.

I. Implications of Neuroscience on Accounting Division
II. Implications of Neuroscience on Human Resource Division
III. Implications of Neuroscience on Marketing Division

#### Implications of neuroscience on accounting division

For decades, accounting academicians have focused their research on exploring the utility of neuroscience in accounting practices due to the close relationship between economics and psychology. It's now been unfolded that there is a link between neuroscience and accounting because these two fields share some similarities [12]. Accounting researchers are incredibly fascinated by the potential of neuroscientific tools to provide critical insights into the cognitive processes of the brain that allow humans to make rational decisions. This led to the emergence of the '*Neuroaccounting*' field. Neuroaccounting is simply the fusion of neuroscience and accounting. In layman's terms, it is the integration of neuroscientific methodologies to understand the intricate mechanisms involved in financial decision-making. It allows the study of how the human brain processes and reacts to financial information. This innovative approach could revolutionize our understanding of economic decision-making, laying the groundwork for advancements in accounting principles, standards, and regulations. It is believed that neuroaccounting is still in its infancy stage. Birnberg and his group proposed fostering collaboration between neuroscience researchers and those in the accounting field [5]. Few others emphasized the need for more studies in this emerging field to reveal the underlying processes of the human brain, thereby shedding light on how people make decisions when performing complex accounting tasks and reporting [46].

Dickhaut et al. employed two neuroscientific approaches, fMRI and single-cell recordings, to decipher brain activities related to accounting. Briefly, fMRI is used to investigate brain-wide activity related to decision-making processes, and single-cell recording is used to detect neuronal firing at very specific areas in the brain while accounting functions are performed. Their research showed a robust parallel relationship between established accounting principles and human brain activities related to economic decision-making. The brain processes information about uncertain rewards in accordance with revenue realization, conservatism, and objectivity, and it matches efforts with rewards in accordance with expense matching and cost management [11]. Later, the same group also provided evidence for their hypothesis on principles of duality, revenue realization, expense matching and cost management, and conservatism, along with a description of the brain areas implicated in these studies. Through single-cell recordings, they pinpointed a comparable counting mechanism in the macaque monkey's brain. A screen with dots going left and right is what the monkey is watching. Some dots, like those traveling to the right, have more of them than dots moving to the left, for instance. By directing his eyes in the direction where more dots are moving, the monkey is rewarded. To complete this task, the monkey tracks the net movement of all dots left or right using neuronal activations, and the difference between the two at any given moment is recorded in the lateral intraparietal sulcus (a region in the brain). Both right and left movements are represented in positive amounts, just like credits and debits. When this difference hits a critical point, a signal is sent to the monkey's motor system, and the monkey's eye movement will indicate a decision. Like, how accounting balances can be used to determine whether loan provisions are adequate or documented inventory cost is excessive compared to realizable value, the monkey's brain uses these "*accounts*" as decision variables that cause an action [12].

In 2021 Basu, S. conducted a study exploring a potential correlation between brain's anatomical evolution and the introduction of double-entry bookkeeping. Through rigorous testing of these relationships, the researcher hypothesized and subsequently concluded that the implementation of double-entry bookkeeping has notable effects on accountants, influencing specific brain areas associated with processing rewards, sacrifices, pain/empathy, and social cognition. This impact leads to strengthened connections between these brain regions and decision-making centers. Because double-entry bookkeeping links changes in different accounts by cross-referencing, the brain and double-entry bookkeeping are consilient [4]. Carvalho et al. used brain mapping to explore how auditors and accountants made decisions regarding going concerns. They examined the brain mapping patterns of accountants and auditors in an experiment by constructing regression maps. They revealed that auditors and accountants arrive at a similar conclusion about going concern despite exhibiting distinct patterns in their brain processing, suggesting decisions were based on analog reasoning processes.

During the initial judgment phase, accountants consistently downplayed their estimates, and this behavior was associated with the activation of specific brain regions. This highlighted that the consideration of social risk influenced decision-making. In the subsequent round of judgment, accountants exhibited similar signs, mainly through the lens of social distance. The findings also showed that accountants engaged in more cognitive effort, demonstrating a more profound thought process and a tendency toward conservative decisions [7]. Barton et al. scanned investors in publicly traded businesses using fMRI to learn how the brain interprets earnings surprises. Investors predicted the earnings per share for each company before imaging and either adopted a long or short position in its stock. They used blood-oxygen-level-dependent (BOLD) signals to record neural activity in the ventral striatum (a brain region) to test their theory that earnings surprises are processed there. The findings indicated that when earnings exceed investors' expectations, striatal BOLD signals increase, whereas when earnings fall short of expectations, activity decreases. When people see a bad earnings surprise, the BOLD signal is twice as strong as when they see a good one. They observed a strong correlation between the BOLD signal and two measures of the market's reaction to earnings news: abnormal stock returns and abnormal trading volume around the earnings announcement [3].

In addition to aiding businesses in analyzing financial decision-making, neuroscience can play a crucial role in fostering robust corporate governance and guiding organizations toward ethical behavior. Companies can use neuroscientific methods to examine instances of corporate fraud, investigate the underlying causes of fraudulent activities within organizations, and explore a myriad of related aspects. Leveraging neuroscientific tools can contribute to reducing the occurrence of high-profile corporate frauds witnessed over the years. Such efforts protect the global reputation and mitigate substantial economic losses and job insecurity that often accompany such fraudulent activities. Ivascu et al. [24] also suggest that neuroaccounting can improve the standard of corporate governance in organizations by interviewing managers of corporate offices. They discovered that managers who engage in unethical and illegal maneuvering are driven primarily by the human nature traits of greed, selfishness, and financial rewards. The results suggest that managers lacking moral principles, exhibiting emotional instability, and holding unfavorable moral intuitions or personal beliefs may have a greater propensity to prioritize their interests over others [24]. Waymire also recommends further investigating the traits of individuals more prone to engaging in fraudulent activities, the factors influencing their behavior, and the role of financial data in such actions [48].

There is no doubt that neuroscience has contributed to and will continue to guide accounting researchers in better understanding brain activity and the role of brain regions involved in decision-making and other cognitive processes. By harnessing the insights and data provided by neuroscientific methods, corporations are empowered to make more informed and sound financial decisions, prevent fraudulent activities, and foster ethical conduct within the workplace. Improved insights into decision-making factors help companies predict and mitigate risks, ensuring financial stability. Additionally, it helps forensic accountants and risk management teams identify and address potential issues, contributing to a more secure financial future.

Although it is evident that neuroscience and its techniques can help in understanding cognitive processes related to financial decision-making. However, more research is needed to explore how neuroscience can be applied in practical settings. While some studies have investigated the relationship between brain activities and accounting principles, there remains a pressing need for more thorough and nuanced research. This entails conducting detailed assessments to understand how various accounting tasks and principles impact our decision-making processes, leveraging insights from neuroscience. Furthermore, there is a necessity for more targeted research aimed at refining accounting principles, addressing existing loopholes within accounting systems and standards. In our view, existing studies have been somewhat limited in their scope, failing to comprehensively integrate neuroscience with business domains and lacking specificity beyond theoretical frameworks. Thus, there is a clear need for further empirical studies, fostering collaboration between business and neuroscience researchers to drive advancements in the field. While literature has touched upon the role of neuroscience in preventing unethical behavior and fraud, there is also a need to explore how neuroaccounting can contribute to the development of robust corporate governance frameworks and policies. Such endeavors hold significant potential for enhancing business practices and fostering ethical conduct within organizations.

### Implications of neuroscience on human resource division

To support and uplift organizations, neuroscience can also offer valuable insights into workplace behavior. It has the potential to assist organizations across various HR-related domains, including but not limited to employee training, motivation, development,

performance, leadership, and analysis of employee behavior.

The concept of '*Neuromanagement*,' which evolved over the past few years, uses cognitive neuroscience to understand an organization's managerial, economic, and behavioral challenges. Compared to conventional management techniques that use reason and authority to control people's behaviors and outcomes through strict discipline and rules, neuromanagement considers emotions, respect, involvement, connection, communication, and motivation. It aims to accomplish these goals by engaging emotional brains, forging bonds with others, fostering confidence, and igniting employee motivation [38]. By analyzing employees' emotions and actions, managers and businesses can create new HR trends to boost an employee's motivation, training, on-the-job performance, and overall organizational growth. Managers and supervisors may also exercise effective leadership, foster stronger relationships within the workforce, and provide better training and rewards for them using their knowledge of brain science. With a more dedicated workforce, the organization's production and efficiency will be further improved. If businesses know human social and biological underpinnings, they may better manage people and design appropriate staff training and education programs. Therefore, embracing neuroscience will shortly be the cornerstone of organizational human resources management.

Kuhlmann, N. & Kadgien, C. A. suggested that businesses can strengthen their HR procedures and leadership skills using neuroscientific tools and knowledge of underlying neural circuitry [27]. Hills, J. suggested the implementation of a certainty, options, reputation, equity (CORE) model that could assist leaders in successfully managing change. This CORE model identifies varied factors that can result in a reward or a threat. The study also recommended developing new policies and reward schemes and incentivizing the adoption of new behaviors to promote change inside the organization [21]. Gocen, A. emphasized 'neuroleadership' to better manage change. He proposed that educational leadership researchers and policymakers should also conduct neuroleadership research by integrating neuroscience with leadership [17]. Zwaan et al. investigated the role of neuroleadership in improving work engagement. They used qualitative research approaches, including case studies, meta-triangulation approaches, semi-structured interviews, and focus groups. The case study revealed how organizations gauge and address work engagement by employing following strategies:

1. Organizations measure engagement through job satisfaction surveys.
2. Organizations implement comprehensive interventions to address concerns.
3. Organizations adapt to environmental changes without proactively managing their impact on engagement.

Researchers then created the 'EngageInMind framework' for neuroleadership and work engagement with meta-triangulation and bracketing. The research suggests that neuroleadership positively influences work engagement through psychological, neurobiological, sociological, and organizational dimensions [50].

*Neuroplasticity*, an essential concept in neuroscience, refers to the ability of the nervous system to adapt in response to a dynamic environment by reorganizing its structure and functional connections. By rearranging the brain's neural connections, unlearning old connections, and forming new ones, neuroplasticity allows us to adapt to unique circumstances, making humans resilient. But neuroplasticity is not simply about adjusting to new circumstances; it also significantly impacts how we behave and think. It is a significant phenomenon in the brain that allows individuals to interpret and respond to stimuli, form associations between different stimuli, or link stimuli to specific behaviors for optimal outcomes. On similar lines, plasticity, or flexibility, is also crucial for enhancing leadership within an organization. It may encourage more excellent leadership within a business and improved teamwork through neuroleadership. By understanding neuroplasticity, companies can also train employees to deal with and adapt to change efficiently. Neuroplasticity offers excellent potential for improving HR activities within organizations. HR professionals can create and implement strategies that optimize employee training and overall performance by understanding and applying neuroplasticity concepts. Additionally, it could encourage employee creativity, stimulate innovation, and foster overall organizational growth. Through active participation in leadership roles, neuroplasticity can improve leadership skills by investing in continuous learning of new strategies and techniques and adopting a growth mindset. Through neuroplasticity, we may be able to alter certain brain areas' structure and function to change our behavior and abilities [45].

To effectively train employees and managers, Hill et al. [20] recommends:

- An agile thinking approach.

- Utilizing teaching-to-vary (T2V).
- A pedagogy based upon an understanding of neuroplasticity and specifically designed to develop variability in thought.

They included the practice of varying T2V to pursue a different kind of plasticity than that provided by teaching to repeat (T2R). They contend that this kind of plasticity enables stronger creative thinking and flexibility in thought and approach, and with experience, it is possible to build a tendency or propensity toward change [20].

Additionally, researchers often highlight the role of neuroscientific tools in increasing employee motivation and performance, deciphering their behavior, and efficiently designing employee training and reward systems. With the backing of neuroscience, managers can more effectively assess employees who lack motivation and display sluggishness, potentially leading to layoffs and workforce disciplinary measures. Petrou and Rammata conducted a study examining workplace behavior within the public sector through the lens of neuroscience. The research emphasized using neuroscientific approaches to support and improve HR management policies. They discussed the effects of cerebral mechanisms while focusing on the stages of human growth. The study also revealed the uncovered elements like cognitive bias, experiences, beliefs, and emotions that impact people's behavior in professional situations [40]. Kłos utilized brain imaging to examine employee motivation levels. She performed a pilot study on adult education using brain-friendly techniques. The study showed that respondents were unaware of brain friendly learning techniques, and misconceptions about brain function prevented them from achieving improved results in terms of personal growth. The study concluded that individuals are intrinsically motivated because their brains have a powerful reward system, and learning is necessary for motivation to exist [25]. Menon and Bhagat underlined applying neuroscientific methods to guide managers and businesses with new perspectives, which can improve job outcomes regarding staff training, rewards, and motivation [30].

Zito et al. used the EEG technique to measure how engaged and stressed candidates were during job interviews. They recorded the EEG and skin conductance data of 30 candidates throughout a structured 40-min job interview to track their engagement and stress levels in real-time. They determined from the findings which parts of the interview were the most stressful and exciting and which interviewing strategies could help candidates feel less stressed and more engaged. Engagement was measured using frontal alpha asymmetry (FAA), and stress was measured using skin conductance level (SCL). The EEG data were processed using iMotions and B-Alert software development kits (SDKs). They randomly assigned the candidates to five interviewers with different interview styles. Two interviewers (A and E) used a style with many stressful questions; while, the other three interviewers (B, C, and D) used a more focused, warm, and humorous approach. The interviews were divided into four phases, each characterized by varying levels of engagement and stress: the icebreaker (P1), explanation of the work (P2), career possibilities (P3), and agency mandate (P4). The findings revealed that the most engaging phases of the interview were the ice breaker (P1) and the career opportunities (P3). In contrast, explaining the job (P2) and the agency mandate (P4) was the most stressful phase. The study supported the researcher's hypothesis that an interview style based on many questions for the candidates (A and E) generated higher stress levels in candidates. Conversely, a calm and peaceful interview style (B, C, and D) induced lower stress levels, thereby potentially reducing stress in candidates, and improving the overall assessment process. Moreover, the research emphasized the value of understanding the psychological and physiological implications associated with different stages of the hiring process, not only to enable companies to attract and select suitable employees but also to plan for future organizational implications [49]. Huber, Marsha et al. also offer suggestions on how firms, their managers, and CEOs should use neuroscience to train employees, recruit new hires, and foster overall development. They employed the EEG procedure to assess the growth associated with developing new cognitive abilities. They proposed that people learn at different speeds. Therefore, if managers or trainers in businesses had acknowledged this, they could have offered their staff more effective training and advancement opportunities. Their research also recommended that less experienced accountants should be allotted sufficient time for learning, and supervisors should formulate both proactive and reactive training strategies [23].

The review of these studies unequivocally demonstrates that advancements in neuroscience have significantly influenced how companies manage and treat their employees. The use of metrics to assess employee dedication and commitment has improved the processes of hiring and layoffs, ultimately leading to enhanced and sustained productivity within firms. This increase in satisfaction is not confined to employers; employees also experience heightened satisfaction with their work and project assignments. The integration of neuroscience fulfills this requirement by providing companies with insights into their human resources in terms of productivity, commitment, and motivation, which

collectively impact a firm's growth and sustainability. In a nutshell, neuroscience has demonstrated relevance for many facets of HR within an organization and possesses an infinite capability to transform human behavior.

#### Implications of neuroscience on marketing division

Marketers are investigating novel marketing approaches to gain insights into consumers' brains. Amidst intense competition and constant innovation, modern marketing goes beyond conventional marketing tactics, emphasizing on the use of neuroscientific instruments in marketing. Marketing researchers have utilized various neuroscientific techniques, including brain mapping, eye tracking, and skin conductance tests, to understand their expected actions and preferences better. They aim to develop new marketing practices that can assist them in better understanding their customers' attitudes and preferences and aligning their products accordingly. Insights gained from neuroscience in the marketing world can assist organizations in improving their overall profitability and performance. The progress in brain imaging technology in the early 2000s paved the way for exploring the neural foundations of consumer behavior, leading to the emergence of neuromarketing. Professor Gerald Zaltman, a pioneer in neuromarketing from Harvard Business School, catalyzed the rise in the field's prominence with his revolutionary book titled "*How Customers Think: Essential Insights into the Mind of the Market*." In this book, he highlighted that traditional market research methods, such as surveys and focus groups, were insufficient to fully understand consumer behavior. Since then, neuromarketing has expanded its applications across diverse domains, empowering marketers to understand consumer behavior and decision-making deeply. Neuromarketing, also known as '*Consumer Neuroscience*,' is a field that applies neuroscientific techniques in marketing to know how consumers respond to marketing stimuli. By using a variety of neuroscientific tools, including facial electromyography (fEMG), skin conductance, ECG, fMRI, and transcranial magnetic stimulation (TMS), marketing researchers can gain insights into the intricate world of consumer emotions, preferences, and decision-making processes. This knowledge empowers them to make strategic decisions about product design, pricing, communication, and retail strategies. Moreover, it paves the way for developing targeted marketing strategies, enhancing product offerings, and delivering exceptional services tailored to customer needs and desires [8].

Furthermore, neuroscience has strong potential to improve decision-making in the marketing profession across the 7Ps framework, encompassing product, price, promotion, place, people, packaging, and process. Lim, W. M. suggests that by utilizing neuroscientific techniques, neuromarketing can substantially contribute more to marketing theory and practice [29]. Alvino, L. et al. convey the same perspective and assert that businesses have evolved and will continue developing more successful product designs using neuroscientific tools. These approaches have enhanced their product designs and provided effective branding and advertising strategies [1]. Fugate, D. L. added that these methods can be used to test the appeal of a product, efficacy of advertising, the choice of a logo or brand, and the media for the advertisement. Moreover, companies cannot create high-quality products or effectively manage their design, marketing, pricing, and packaging without the aid of neuroscience [15]. Several studies utilized popular neuroscientific methods used in marketing and customer research, like EEG, PET, facial expression analysis, eye tracking, electrodermal response, and heart rate [1, 6, 15, 16, 31, 36]. However, the Plassmann et al. [41] study concluded that for advertising studies, the most effective neuroscience techniques are EEG, MEG, and fMRI.

Furthermore, Lim conducted content analyses and suggested the most suitable neuroscientific tools for neuromarketing. The study divided it into three categories: neuroscientific methods that record neural activity inside the brain, i.e., EEG, MEG, SST, fMRI, PET; neuroscientific methods that record neural activity outside the brain, i.e., ECG, eye tracking, fEMG; and neuroscientific methods that manipulate neural activity, i.e., transcranial magnetic stimulation (TMS) and deep brain stimulation (DBS). Further, he discussed the ethical considerations associated with the use of these tools. He emphasized the need for formulating policies and suggested establishing ethical committees to ensure responsible learning and practices [28]. Sung, B. et al. also stressed using neuroscientific methods to study customer behavior considering brain as an integral part of neuromarketing research. It involved nervous system measurements, such as eye movement analysis, functional near-infrared spectroscopy, fEMG, and eye muscle activity [44]. Harris, J. M. et al. conducted an fMRI study to measure brain activity to analyze various aspects of marketing research, including consumer behavior, attention, memory, decision-making and other marketing experiments. They suggest implicit association testing, eye monitoring, and EEG as the least expensive tools in the armor of a marketing researcher [18].

Studies in the literature have indicated the potential of neuroscience in predicting consumer choices, behavior patterns, and decision-making processes. Companies can use neuroscience tools to delve deeply into the role of attention and memory processes in consumer behavior. It can be done more effectively using neuroscientific

methods than conventional marketing strategies [22]. Schultz, W. conducted research on the reward system in the brain and how it affects decision-making. He talks about the dopamine (a neurotransmitter in the brain) signals and how they can be used to comprehend phasic dopamine activities related to reward delivery. Neurophysiological studies in animals suggested that the dopamine reward prediction error signal drives neuro-behavioral learning and reflects subjective reward representations beyond explicit contingency [43]. Konovalov, A. & Krajbich, I. explained how fMRI technology will help researchers understand the various decision-making processes in the human brain [26]. Cesar et al. proposed a way to accurately assess the decision-making process using two theoretical models based on cognitive psychology and neuroeconomics. They researched several factors, such as selective attention, memory, reasoning, expertise, and intuition, that are crucial in their proposed model's depiction of the decision-making process [9]. Wang, B. recommended the use of neuroscientific tools to elucidate the complex behaviors of business decision-makers. To better understand their behavior, he also addressed various theories, such as preference theories in risk decision-making and reversal of values [47]. Waymire, G. B. expanded upon the research conducted by Dickhaut and colleagues [12], highlighting the application of state-of-the-art neuroscientific methods to explore and gain a comprehensive understanding of the inner workings of the brain during the process of making economic decisions within any organization [48]. Alvino, L. et al. review showed that neuroscience tools are often used to study consumer preferences and behaviors in marketing domains such as advertising, branding, online experience, pricing, and product development. They further suggested iMotions and GRAIL, two readily available platforms that may evaluate behavioral, physiological, and neurophysiological responses. With the help of these ready-to-use technologies, consumer neuroscience trials might be more trustworthy, effective, and economical. Additionally, firms will benefit from reduced training time and costs for such trials [1].

Although it is widely recognized that neuroscience has brought significant benefits to the marketing field, ethical issues still demand attention. Numerous studies have underscored the ethical concerns associated with incorporating neuroscientific insights into marketing. Plassmann, H. et al. also discussed the moral dilemma surrounding using marketing techniques based on neuroscience. It includes the potential for bias in research, the potential for some methods to be invasive and induce claustrophobic anxiety, and the potential for abuse as well [41]. Fortunato, V. C. R. et al. also discovered that there are several ethical concerns with neuromarketing research, including the invasion of consumers' privacy, unreliable and biased results, the involvement of academicians and doctors performing the research for profit, and the exploitation of weaker populations and expensive technologies [14].

Despite these ethical concerns and limitations, we may still claim that neuroscience as a tool offers great potential to revolutionize the marketing field. Therefore, it is up to the user or marketeer to decide how to handle or make good use of this tool. The tool is unlikely to harm marketing if marketers use it sensibly and responsibly. There is no denying that businesses today are concealing that they use neuroscientific methods to examine consumers' brains and study underlying processes that occur when they are exposed to their products and services. A neuromarketer can monitor the electric waves associated with emotion and memory-related brain regions using EEG readings. The prefrontal cortex, a brain region that controls high-level cognitive abilities; the hippocampus, where memory resides; and the amygdala, which is specifically related to the valence and salience of stimuli, all together play a role in storing emotionally charged memories and help trigger physical reactions on exposure to a specific stimulus (e.g., a product) or situation (e.g., a specific environment). Besides mainstream products and services, numerous major brands use neuroscientific tools to examine how consumers perceive a product's branding, packaging, and promotion.

Major corporations such as PepsiCo, Google, Microsoft, ESPN, eBay, and Intel have embraced neuromarketing strategies. They aim to comprehend how consumers perceive their products and services, identify elements that resonate or fail to appeal and refine their marketing strategies accordingly. One key player, neuromarketing research firm Neurofocus, has significantly influenced the advertising industry. In collaboration with PepsiCo, Neurofocus helped create a new advertising campaign and packaging design for Baked Lays by analyzing women's responses. The founder of Neurofocus believes that neuromarketing is superior to traditional focus groups, citing its ability to provide more accurate and reliable results. Through brain mapping techniques, neuromarketing reveals the subconscious reactions of consumers to advertisements or products, enabling real-time data monitoring and recording. In partnership with CBS, it gauged audience reactions to new shows, ensuring alignment with advertisements supporting the programs. Similarly, ESPN sought Neurofocus's assistance in optimizing the visibility of corporate advertisers' logos on air. Intel also utilized its services to better understand global branding

and consumer perception, informing advertising adjustments and strategy shifts. A study disclosed that the words 'achieve' and 'opportunity' resonated strongly with consumers across diverse backgrounds, prompting Intel to adapt its marketing approach accordingly. In a specific case, Frito-Lay, a division of PepsiCo, enlisted Neurofocus to enhance sales of snacks among women. Neurofocus's research, involving brain scans of selected consumers, unveiled a unique response to the product's 'icky' coating, generating a sense of enjoyable subversion. Leveraging this insight, Frito-Lay incorporated the messy appeal into the advertising campaign for Cheetos, turning the perceived flaw into a distinctive brand characteristic [39].

The application of neuroscientific tools has empowered companies to assess consumer needs, preferences, and purchasing behaviors with greater precision. This capability enables them to strategically launch products and services targeted at specific consumer segments. The evaluation of brain-wide neural activity provides profound insights into brain function, allowing researchers to analyze activation patterns in brain regions associated with reward processing.

For example, the nucleus accumbens, commonly referred to as the brain's reward center, becomes activated when an unexpected reward is presented. This activation can be observed when rewarding stimulus such as ice cream are introduced. By presenting different kinds of stimuli and utilizing fMRI/EEG scans researchers can measure the level of activation in various brain regions. The variation in neural responses to different stimuli (product/service) can reveal detailed information about consumer preferences and the emotional impact of different products.

Furthermore, these neuroscientific techniques extend beyond simple preference analysis. It enables the study of complex emotional and cognitive responses to marketing stimuli, advertisements, and product designs. By understanding how consumers' brains react to different marketing strategies, companies can tailor their approaches to maximize engagement and satisfaction. This scientific approach to consumer behavior analysis ensures that marketing strategies are not only effective but also aligned with the underlying neurological responses of the target audience.

Consequently, the tools available to neuroscientists can significantly aid companies in scientifically understanding and predicting consumer behavior. This integration of neuroscience into business practices not only enhances the precision of market research but also fosters the development of products and services that truly resonate with consumers, leading to increased customer satisfaction and business success.

## Discussion

Our meta-analysis demonstrated critical connections between neuroscience and various business divisions, including accounting, HR, and marketing. For better understanding, we crafted a visual diagram illustrating the utilization and application of neuroscience, neuroscientific tools, and potential future challenges (Fig. 2).

Our original hypothesis posited a positive correlation between the use of neuroscientific tools and a firm's success. To rigorously test this hypothesis, we conducted a comprehensive review of existing literature, systematically sorted using the robust PRISMA methodology. This methodical approach ensured that our review was thorough, transparent, and reproducible.

Overall, this review highlights that the integration of neuroscientific methods into business practices offers a scientific foundation for improving decision-making processes, enhancing employee well-being, and optimizing marketing efforts. This interdisciplinary approach not only supports the original hypothesis but also underscores the transformative potential of neuroscience in driving a firm's success across multiple facets of its operations.

Our findings confirm that the application of neuroscience significantly impacts various business domains. In accounting, neuroscientific tools help in understanding cognitive biases and decision-making processes, leading to more accurate financial forecasting and risk assessment. The literature studies on neuroscience and accounting clarified that single-cell recordings and brain mapping are the most widely used techniques in accounting research. Merging neuroscience with accounting can uncover the brain's secrets and unveil hidden factors influencing decision-making during accounting tasks and reporting. Studying their brains with neuroscientific tools demonstrated how auditors and accountants efficiently solve accounting problems. Additionally, it can help reduce creative accounting and fraud in organizations by revealing human nature traits that drive unethical behavior, aiding organizations in developing sound corporate governance. Corporations can gain insights into the factors influencing financial decision-making and enhance risk management. This will also enable corporations to make more informed decisions, predicting and mitigating risks for a financially secure future. However, their collaboration might have some challenges, such as employing neuroscientific methods being expensive and accounting researchers needing to be trained in using neuroscientific tools.

According to Tank, A. K. & Farrell, A. M., further obstacles may hinder us from conducting additional research on neuroaccounting, including costly

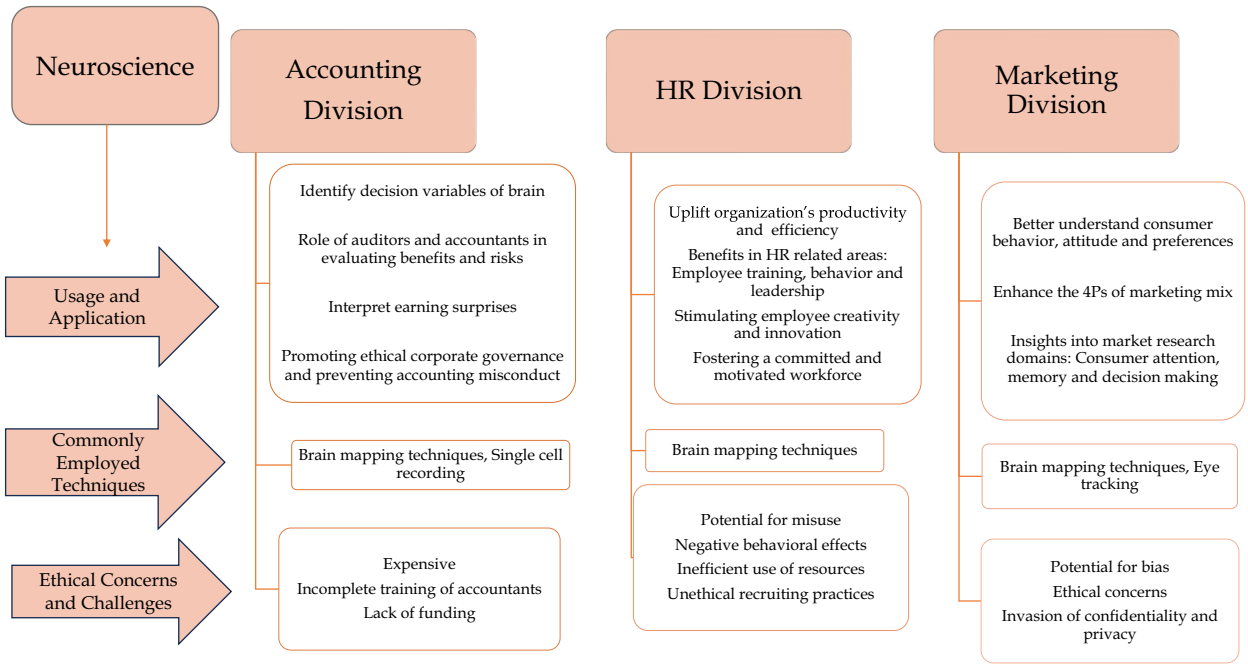


**Fig. 2** Implications of neuroscience on accounting, HR and marketing division. *Source*: Author's compilation

start-up costs, lack of funding, and faculty incentives that discourage such expenditures [46]. But despite these difficulties, we keep hoping that the area of accounting will benefit from discoveries in neuroscience. HassabElnaby, H. R. et al. suggested new avenues for future accounting research to improve the efficiency of managers' decision-making processes by using neuroscientific approaches. Researchers also proposed that neuroscience can improve accounting theory and practice [19].

In human resources, these tools are used to evaluate employee engagement, motivation, and satisfaction, resulting in more effective hiring practices, enhanced employee retention, and improved workplace productivity. Research linking HR management and neuroscience has revealed the use of brain mapping methods in deciphering workplace behavior. These methods have aided organizations in improving productivity and efficiency. Additionally, neuroscience offers insights into workplace dynamics, employee training and development, leadership, motivation, and behavior analysis. However, some ethical issues could arise in neuro-human resources. Ethical issues could involve the improper use of neuroscientific techniques, adverse behavioral effects on employees, infringement upon the mental privacy and confidentiality of observees', unethical hiring processes, lack of consent, biases, and similar issues. For certain people, the results of neuroscience research might not be accurate. Kuhlmann, N. & Kadgien, C. A. also imply that workplace neuroscience techniques might be exploited. The results could be harmful behavioral impacts, inefficient use of resources, and unethical hiring procedures in the company. They also recommended resolving ethical concerns by learning to apply neuroscientific techniques efficiently to develop HR [27].

In marketing, neuroscientific techniques provide deep insights into consumer behavior, preferences, and emotional responses, allowing for the development of targeted marketing strategies and product designs that resonate more effectively with consumers. The incorporation of neuroscience into marketing can identify various aspects of consumer brains. Researchers have previously utilized neuroscientific tools like fMRI, EEG, ECG, FEMG, PET, and eye tracking to uncover hidden factors influencing consumer brains. In addition to revealing these elements, it also makes consumer behavior, attitude, preferences, and decision-making processes clear. Additionally, it assists in a better understanding of product experiences by assessing a product before its launch and testing its advertising effectiveness.

Amidst the array of studies considered within this analysis, alongside those omitted based on our scrutiny, a conspicuous gap emerges: the scarcity of empirical investigations harnessing cutting-edge neuroscientific methodologies. This dearth underscores the necessity for a collaborative dialog between neuroscientists and

business stakeholders, aiming to explore and leverage the potential of state-of-the-art tools in diverse realms of commerce.

The imperative is clear: concerted efforts are warranted to delve deeper into this interdisciplinary terrain. Thus, there arises an urgent call to action for the initiation of additional studies, characterized by meticulous attention to detail. Such endeavors are poised to illuminate the intricate interplay between neuroscience and business, ultimately paving the way for innovative solutions and transformative insights that can drive organizational success and societal progress.

## Conclusion

This comprehensive review highlights the transformative potential of neuroscience across various business domains. By synthesizing existing literature, our analysis unveils insights with significant implications for companies, potentially catalyzing improvements in their overall operational efficacy and strategic decision-making processes. The elucidated findings serve as a valuable resource for both scholars and practitioners engaged in disciplines such as marketing, consumer behavior, accounting, and human resources. Armed with a deeper understanding of the neuroscientific underpinnings of human cognition, emotion, and behavior, stakeholders across these domains stand to gain actionable insights and novel perspectives that can inform more informed and effective approaches to business practices and management strategies.

### Potential limitations and future research

The paper's final section discusses the study's possible limitations and the future research possibilities. This study only considered journal articles and web pages, excluding books and editorials. The limited data collection allows future research to expand on it. Regarding the research design, selecting articles depends on keyword searches, which limits the study's scope. However, we have not purposely excluded any relevant articles and web pages from our search results using the keywords.

Undoubtedly, soon we will inhabit an automated world where robots will be ubiquitous, showcasing the extensive potential of AI across various industries. Consequently, there is a promising future for exploring machine learning and AI applications in the realm of business. The combination of AI and neuroscience holds tremendous potential to transform how we make financial decisions by enabling quick and efficient decisions. Their integration allows avenues for analyzing neuroimaging scans such as fMRI or EEG using advanced AI tools. This will not only provide valuable insights into the emotional and cognitive processes underlying human decision-making but also empower humans to make more precise and timely financial decisions. By merging data analytics and machine learning with neuroscience, we can uncover hidden patterns and sentiments to predict market trends better. This can also enable us to predict and manage risks more effectively, enhancing overall financial security. Additionally, leveraging this data allows for the development of personalized financial advice tailored to predicting an individual's financial decisions. In fraud prevention, the collaborative efforts of AI and neuroscience are particularly pertinent. AI's ability to identify anomalies plays a significant role in spotting and preventing fraudulent activities in the corporate world. AI can shield corporations and businesses from financial risk by anticipatorily detecting anomalies and averting possible losses in the future.

To the best of our knowledge, existing studies have investigated the impact of neuroscience on business, but none have specifically delved into the intricate relationship between AI, neuroscience, and ethics. In today's world, dominated by advanced AI, businesses are increasingly adopting AI. AI-integrated neuroscientific tools can be utilized by businesses to maintain a competitive edge. The fusion of AI and neuroscience introduces exciting opportunities across various business domains, offering insights into marketing, HR, accounting practices, and more. This integration can enable businesses to gain a profound understanding of consumer behavior and preferences, enhancing their marketing, accounting, and HR strategies. According to Drăghici, D. E. et al., incorporating AI in neuromarketing can bring about transformative changes in market research by extracting significant insights into consumer preferences through the analysis of brain waves. Organizations can gain valuable insights by customizing their products to align with consumer tastes, fostering more effective and integrated approaches [13]. Many companies have already developed internal AI tools to motivate their employees. Moreover, AI-driven analysis of neuroimaging data can empower businesses to predict consumer preferences accurately. Nevertheless, it is imperative to address the ethical considerations associated with applying AI-infused neuroscientific methods in the business domain, along with potential challenges such as privacy concerns, data security issues, and biases in AI algorithms.

A thorough understanding of the underlying mechanisms of AI models is also crucial for their utilization in business. In today's competitive market, where retaining customers' attention is a significant challenge, AI-powered chatbots offer an easy and convenient solution to this problem. These chatbots serve

as virtual assistants interacting with customers, providing real-time assistance, answering inquiries, and resolving issues efficiently. By utilizing chatbots, companies can streamline customer retention and effectively generate new leads [10]. Integrating neuromarketing with AI could improve the precision of the data collected by these tools. This amalgamation facilitates more accurate mass data analysis, improving user experience [32].

Neuroscience and digital technology have found numerous applications in HR. Many companies have integrated these advancements into their operations. For instance, as highlighted in research, AI-driven face detection systems are employed in hiring and recruiting processes. These face recognition systems are inspired by the way the brain processes and recognizes faces, drawing on principles from neuroscience [33].

As we move closer to the AI future, the integration of AI predictive analytics and neuroscience can enable corporations to make quicker decisions and mitigate risks effectively. Neuroscience can play a crucial role in preventing burnout and fostering a more productive and motivated workforce. AI is crucial for processing massive amounts of data and gaining greater understanding of how the brain functions. By leveraging AI, we can also produce intricate neural process simulations and improve our comprehension of intricate brain mechanisms which are frequently difficult to investigate through experimentation. AI algorithms are utilized in the analysis of intricate neuroimaging data, facilitating the faster and more precise identification of patterns and brain activity.

With AI-powered neurofeedback interventions, organizations can now conduct more refined assessments of brain signals. This advancement benefits HR departments across all companies, as it equips them with insights to handle workforce stress more efficiently, devise effective motivational techniques, and address other HR-related aspects [42]. In a nutshell, neuroscientific techniques, along with the forthcoming AI applications, offer immense potential to revolutionize the fields of accounting, HR, and marketing and, therefore, impact the strategies employed by companies and businesses in delivering a successful product or service.

**Abbreviations**

| | |
|---|---|
| AI | Artificial intelligence |
| BOLD | Blood oxygen level dependent |
| CORE | Certainty options reputation equity |
| DBS | Deep brain stimulation |
| EEG | Electroencephalography |
| FAA | Frontal alpha asymmetry |
| fEMG | Facial electromyography |
| fMRI | Functional magnetic resonance imaging |
| GSR | Galvanic skin response |
| HR | Human resource |
| MEG | Magnetoencephalography |
| PET | Positron emission tomography |
| SCL | Skin conductance level |
| SDKs | Software development kits |
| SST | Steady state topography |
| T2R | Teaching to repeat |
| T2V | Teaching to vary |
| TMS | Transcranial magnetic stimulation |

**Acknowledgements**
Not applicable.

**Author contributions**
All the authors equally contributed to writing the manuscript.

**Funding**
The authors of this manuscript solemnly declare that no funding from any agencies was received for this study.

**Availability of data and materials**
Not applicable.

## Declarations

**Ethics approval and consent to participate**
Not applicable.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare that they have no competing interests.

Received: 15 January 2024 Accepted: 25 June 2024
Published online: 05 July 2024

**References**

1. Alvino L, Pavone L, Abhishta A, Robben H (2020) Picking your brains: where and how neuroscience tools can enhance marketing research. Front Neurosci 14:577666
2. Avila E, Rodrigues FDAA (2024) Neurobusiness: Técnicas de rejuvenescimento para uma melhor performance nos negócios. Ciencia Latina Revista Científica Multidisciplinar 8(1):8162–8168
3. Barton J, Berns GS, Brooks AM (2014) The neuroscience behind the stock market's reaction to corporate earnings news. Acc Rev 89(6):1945–1977
4. Basu S, Waymire GB (2021) The evolution of double-entry bookkeeping. Available at SSRN 3093303
5. Birnberg JG, Ganguly AR (2012) Is neuroaccounting waiting in the wings? An essay. Acc Organ Soc 37(1):1–13
6. Butler MJ (2008) Neuromarketing and the perception of knowledge. J Consumer Behav Int Res Rev 7(4–5):415–419
7. Carvalho CVDO, Cornacchione E, Rocha AFD, Rocha FT (2017) Cognitive brain mapping of auditors and accountants in going concern judgments. Revista Contabilidade & Finanças 28:132–147
8. Casado-Aranda LA, Sanchez-Fernandez J (2022) Advances in neuroscience and marketing: analyzing tool possibilities and research opportunities. Span J Mark ESIC 26(1):3–22
9. Cesar AMRVC, Perez G, Vidal PG, Marin RDS (2010) Neuroaccounting contribution to understanding the decision making: an example from an innovative company. In: CONGRESSO ANPCONT, vol 4
10. De Vivo M (2018) How chatbots can refine the customer acquisition process
11. Dickhaut J (2009) The brain as the original accounting institution. Acc Rev 84(6):1703–1712
12. Dickhaut J, Basu S, McCabe K, Waymire G (2010) Neuroaccounting: consilience between the biologically evolved brain and culturally evolved accounting principles. Acc Horiz 24(2):221–255

13. Drăghici DE, Orîndaru A, Constantinescu M, Zelezneac A (2023) Revolutionizing marketing research through AI: comprehensive review of the past, present, and future. J Emerg Trends Mark Manag 1(1):39–45
14. Fortunato VCR, Giraldi JDME, de Oliveira JHC (2014) A review of studies on neuromarketing: Practical results, techniques, contributions and limitations. J Manag Res 6(2):201
15. Fugate DL (2007) Neuromarketing: a layman's look at neuroscience and its potential application to marketing practice. J Consum Mark 24(7):385–394
16. Fugate DL (2008) Marketing services more effectively with neuromarketing research: a look into the future. J Serv Mark 22(2):170–173
17. Gocen A (2021) Neuroleadership: a conceptual analysis and educational implications. Int J Educ Math Sci Technol 9(1):63–82
18. Harris JM, Ciorciari J, Gountas J (2018) Consumer neuroscience for marketing researchers. J Consum Behav 17(3):239–252
19. HassabElnaby HR, Abdel-Maksoud A, Said A (2017) Debt covenant violation and earnings management: a neuroscience approach and future directions—a research note. In: Advances in accounting behavioral research, vol 20. Emerald Publishing Limited, pp 63–78
20. Hill ME, Cromartie J, McGinnis J (2016) Applying neuroplasticity to educating agile-thinking managers. Int J Manag Educ 14(1):39–49
21. Hills J (2012) Neuroscience and talent: How neuroscience can increase successful execution of talent strategy. Hum Resour Manag Int Dig 20(3):34–37
22. Hsu M, Yoon C (2015) The neuroscience of consumer choice. Curr Opin Behav Sci 5:116–121
23. Huber M, Kassawat P, Roby AL, Chen C, Phillips A (2021) Neuroaccounting: What management accountants can learn from neuroscience to develop talent and expertise. Manag Acc Q 22(3):1–9
24. Ivascu L, Pavel CD, Sarfraz M, Arulanandam BV, Tan HY (2022) An exploratory study on corporate governance from neuro-governance lenses in the Malaysian context. Front Psychol 13:911907
25. Kłos M (2018) Neuro (management) through the prism of brain research. Mod Manag Rev 23(254):81–93
26. Konovalov A, Krajbich I (2019) Over a decade of neuroeconomics: What have we learned? Organ Res Methods 22(1):148–173
27. Kuhlmann N, Kadgien CA (2018) Neuroleadership: themes and limitations of an emerging interdisciplinary field. In: Healthcare management forum, vol 31, No 3. Sage, Los Angeles, pp 103–107
28. Lim WM (2018) Demystifying neuromarketing. J Bus Res 91:205–220
29. Lim WM (2018) What will business-to-business marketers learn from neuro-marketing? Insights for business marketing practice. J Bus Bus Mark 25(3):251–259
30. Menon S, Bhagat V (2022) Exploring the research on neuroscience as a basis to understand work-based outcomes and to formulate new insights into the effective management of human resources in the workplace: a review study. Res J Pharm Technol 15(8):3814–3820
31. Morin C (2011) Neuromarketing: the new science of consumer behavior. Society 48(2):131–135
32. Mouammine Y, Azdimousa H (2019) Using neuromarketing and AI to collect and analyse consumer's emotion: literature review and perspectives. Int J Bus Econ Strategy 12(2):34–38
33. Nawaz N (2020) Artificial intelligence applications for face recognition in recruitment process. J Manag Inf Decis Sci 23:499–509
34. The Bitbrainteam (2019) The seven most common neuromarketing research techniques and tools. https://www.bitbrain.com/blog/neuromarketing-research-techniques-tools
35. Öberg C (2023) Neuroscience in business-to-business marketing research: a literature review, co-citation analysis and research agenda. Ind Mark Manag 113:168–179
36. Orzan G, Zara IA, Purcarea VL (2012) Neuromarketing techniques in pharmaceutical drugs advertising. A discussion and agenda for future research. J Med Life 5(4):428
37. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Moher D (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Int J Surg 88:105906
38. Parincu AMT, Capatina A, Varon DJ, Bennet PF, Recuerda AM (2020) Neuromanagement: the scientific approach to contemporary management. In: Proceedings of the international conference on business excellence, vol 14, No 1, pp 1046–1056
39. Penenberg A (2011) NeuroFocus uses neuromarketing to hack your brain
40. Petrou F, Rammata M (2021) The emerging impact of neuroscience in human resource management and in the public sector
41. Plassmann H, Ramsøy TZ, Milosavljevic M (2012) Branding the brain: a critical review and outlook. J Consum Psychol 22(1):18–36
42. Plotnikov SA, Lipkovich M, Semenov DM, Fradkov AL (2019) Artificial intelligence-based neurofeedback. Cybernet Phys 8(4):287–291
43. Schultz W (2019) Recent advances in understanding the role of phasic dopamine activity. F1000Research 8:66
44. Sung B, Wilson NJ, Yun JH, Lee EJ (2020) What can neuroscience offer marketing research? Asia Pac J Mark Logist 32(5):1089–1111
45. Tan A (2023) Neuroplasticity and the brain science behind exceptional leadership
46. Tank AK, Farrell AM (2022) Is neuroaccounting taking a place on the stage? A review of the influence of neuroscience on accounting research. Eur Acc Rev 31(1):173–207
47. Wang B (2018) Analysis of corporate social responsibility decision-making behavior based on cognitive neuroscience. NeuroQuantology 16(6):66
48. Waymire GB (2014) Neuroscience and ultimate causation in accounting research. Acc Rev 89(6):2011–2019
49. Zito M, Bilucaglia M, Fici A, Gabrielli G, Russo V (2021) Job assessment through bioelectrical measures: a neuromanagement perspective. Front Psychol 12:673012
50. Zwaan LA, Aiken D, Viljoen R (2019) The role of neuroleadership in work engagement. SA J Hum Resour Manag 17(1):1–9


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