Scientific Research Publishing

Open Journal of Business and Management, 2025, 13(2), 985-999
https://www.scirp.org/journal/ojbm
ISSN Online: 2329-3292
ISSN Print: 2329-3284

The Role of Neurotechnology in Shaping Business Decisions: A Comprehensive Literature Review

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How to cite this paper: Musole, E. (2025). The Role of Neurotechnology in Shaping Business Decisions: A Comprehensive Literature Review. *Open Journal of Business and Management, 13,* 985-999.
https://doi.org/10.4236/ojbm.2025.132053

Received: January 22, 2025
Accepted: March 10, 2025
Published: March 13, 2025

Abstract

Neurotechnology, an interdisciplinary field merging neuroscience and technology, has emerged as a transformative tool in understanding and influencing human behaviour. This literature review examines the role of neurotechnology in shaping business decisions, focusing on its applications in consumer behaviour analysis, social media design, leadership development, employee productivity, and ethical considerations. By synthesising findings from peer-reviewed articles, the review highlights how tools like brain-computer interfaces (BCIs), neurofeedback, and neuroimaging are revolutionising organizational decision-making processes. Neurotechnology enables businesses to decode decision-making processes, predict consumer preferences, and enhance organisational efficiency. However, its integration raises significant ethical concerns, including privacy, consent, and the potential for misuse. The findings suggest that while neurotechnology has the potential to enhance business strategies, its adoption must be guided by robust ethical frameworks to ensure responsible use. This review contributes to the discourse on the intersection of neuroscience and business, offering insights for researchers and practitioners aiming to leverage neurotechnology ethically and effectively.

Keywords

Neurotechnology, Business Decisions, Neuroscience, Brain-Computer Interfaces, Neurofeedback, Neuroimaging, Ethics

1. Introduction

Over the past decade, neurotechnology has continued to open new avenues for gaining more profound understanding and insights into human cognition and be-

haviour (Cinel et al., 2019; Müller & Rotter, 2017; Schneegass et al., 2024). A transition from areas of healthcare to marketing, this interdisciplinary field has found applications in areas that require insight into the human mind (Alsharif & Isa, 2024; Khaneja & Arora, 2024; Naim, 2023). Businesses, in particular, continue to explore their potential at decoding decision-making processes, predicting consumer preferences and enhancing organisational efficiency (Balanagu & Boppisetty, 2024; Sengur & Goncalves, 2023). Neurotechnology thus encompasses tools such as Brain Computer Interfaces ("BCIs"), neurofeedback, and neuroimaging, offering insights into brain activity (Drigas & Sideraki, 2024). For the most part, such knowledge continues to expand the frontiers of better-integrating neurofeedback into business solutions and strategies. However, as its applications expand, so do ethical concerns. Issues such as neuroprivacy, informed neural consent, and equitable access to neurotechnology require as much attention as the benefits of these technologies. This review aims to understand neurotechnology's role in business decision-making by synthesising empirical findings while highlighting the moral and ethical implications for future directions.

Furthermore, there is growing recognition and appreciation of the benefits of integrating neuroscience and technology into the business domain as representative of a paradigm shift in the understanding of decision-making (Amunts et al., 2024; Cucino et al., 2021; Fayaz & Siddiqui, 2024). Traditional research approaches into human behaviour and decision-making are often limited by their reliance on self-reported data and inability to capture unconscious processes. Neurotechnology, however, offers more objective and direct insights into these phenomena (Brouwer, 2021; Eroglu & Kucun, 2020; Karmarkar & Yoon, 2016; Theodorakopoulos & Theodoropoulou, 2024). Integrating neurotechnology with advanced systems, such as Artificial Intelligence (AI), while harmonising its insights with traditional approaches presents a transformative alternative for understanding human decision-making. This convergence enables the acquisition of objective, real-time data on brain activity and, when combined with complementary tools, physiological responses such as heart rate, skin conductance, and pupil dilation. By bridging neural and physiological insights, these technologies provide a more comprehensive understanding of cognitive and emotional processes, enhancing the precision and applicability of decision-making models.

In marketing, neuroimaging and neural response techniques such as Functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG) are relied on to measure neural responses to advertising, product design, and branding (Alsharif et al., 2023; Gholami, 2024; Khurana et al., 2021). Similarly, emerging leadership development programs are beginning to explore neurofeedback to enhance cognitive and emotional skills, although widespread adoption remains limited (Edison et al., 2019; Lindebaum et al., 2017; Thatta et al., 2024). In education, pilot programs have reportedly employed neurotechnology in classrooms to improve students' concentration levels (Berdasco et al., 2022; Farahany, 2023; Juárez-Varón et al., 2023; Privitera & Du, 2022), though these initiatives are not yet glob-

ally implemented.

In the workplace, neurotechnology is being applied to monitor and enhance employee well-being and productivity. For example, wearable neurotechnology devices have been used to monitor concentration levels among high-speed train drivers in China for several years (Fan et al., 2022; Guo et al., 2024; Li et al., 2024; Peng et al., 2022). Among broader consumer markets, neurotechnology continues gaining traction, offering tools to improve sleep and relaxation, enhance productivity, and regulate emotions (Bonetti & Casoni, 2024). These applications point to the increasing accessibility and reliance on neural data to optimise human performance and well-being. Despite its promises, integrating neurotechnology into business practices raises significant ethical concerns. Issues such as neuro privacy, informed neural consent, and the management of sensitive neural data highlight the potential for misuse and exploitation. These concerns underscore the pressing need for robust ethical frameworks and regulations to guide the responsible adoption of neurotechnology. This review explores empirical recommendations for the ethical and effective integration of neurotechnology into business and related domains, balancing its transformative potential with the imperative for safeguarding human rights and autonomy.

2. Methodology

This review employs a systematic approach to analyse the role of neurotechnology in business decision-making. The research relied on data from Google Scholar and Semantic Scholar, utilising Boolean search terms such as "neurotechnology AND business decisions," "neuromarketing," "neuroleadership," and "neuroethics." The selection process was rigorous, focusing exclusively on peer-reviewed articles published in English between 2010 and 2024. From an initial pool of approximately 1000 articles, 150 were shortlisted based on relevance, and 50 were ultimately included in the review after eliminating duplicates and studies lacking direct applicability to the topic. This methodology ensures a comprehensive and transparent evaluation of the current state of research on neurotechnology in business contexts.

3. Empirical Literature

3.1. Consumer Behaviour Analysis

The application of neurotechnology in consumer behaviour analysis has changed how businesses understand and predict consumer preferences. Although traditional methods such as surveys and focus groups have benefited from self-reported data, neurotechnology has provided a direct window into consumers' subconscious, offering insights that are not accessible through conventional means. This responds to the challenges characterised by biases or inaccuracies in traditional research approaches. Hegde (2024) argues that the reliance on fMRI and EEG represents a cornerstone of consumer research, particularly in neuromarketing. fMRI measures brain activity by detecting changes in blood flow, providing

high-resolution spatial images of brain regions involved in decision-making processes (Xue et al., 2010), although its temporal resolution is limited. EEG, by contrast, records electrical activity in the brain, offering real-time temporal data on neural responses to stimuli (Beres, 2017), albeit with less spatial specificity. Complementary physiological tools, such as eye-tracking, heart rate monitoring, and body temperature measurements, provide additional insights into consumer reactions to advertising, product design, and branding (Cherubino et al., 2019). Combined with neuroimaging, these tools give businesses a richer understanding of consumer behaviour, helping to reveal how individuals respond to stimuli and what influences their preferences. However, interpreting this data requires careful consideration of broader privacy and ethical concerns.

As noted by Dutta (2023), neurotechnology tools have been used to study consumer reactions to advertising, product design and branding, providing businesses with valuable insights into what drives business consumer behaviour. For example, studies by (Casado-Aranda et al., 2022; Goncalves et al., 2023; Luis-Alberto et al., 2021) used fMRI to measure neural responses to different brands. They found that certain brands elicit stronger activation in the brain's emotional reactions to advertisements, allowing marketers to identify which elements of an ad are most effective in capturing attention and eliciting positive emotions.

Neurofeedback, another application of neurotechnology, has also been used to optimise marketing strategies. By providing real-time feedback on brain activity, neurofeedback allows marketers to test different ad or product design versions and select the one that elicits the most favourable neural responses. According to Azadravesh et al. (2024) the neurofeedback approach has been shown to improve the effectiveness of marketing campaigns, leading to higher engagement and conversion rates. However, despite such gains and advantages, neurotechnology in consumer research has challenges. One of the primary concerns is the ethical implications of collecting and interpreting neural data. Consumers may not fully understand how their brain activity is being used, raising questions about informed neural consent and neuroprivacy. Furthermore, there is the potential for misuse as businesses could use neurotechnology to manipulate consumer behaviour in ways that are not in the consumer's best interests. To address these concerns, it is essential to establish ethical standards and guidelines, as well as regulatory and legal frameworks that ensure the protection of neuro privacy and consumer rights, as well as ethical guidelines that provide transparency and the prevention of misuse of neurotechnology in business practices.

3.2. Neurotechnology in Social Media Design

Insights from neurotechnology and their ability to enhance user engagement have allowed researchers to rely on fMRI and EEG to examine how the brain responds to various stimuli, including colours, graphic and interface designs (Gaspar-Figueiredo et al., 2023). This approach reveals that certain design features can activate the brain's reward systems, particularly dopaminergic pathways, which are

closely linked to addiction behaviours seen in gambling (Hatfield, 2024). As such, using bold, attention-grabbing colours such as red for notifications stimulates arousal and urgency by activating emotional processing centres like the amygdala (Flusberg et al., 2024). There is no question, therefore, as to the invaluable insights that neurotechnology brings to social media design, and the quest for continuous consumer engagement with social media digital platforms.

Similarly, intermittent rewards, akin to the mechanisms of slot machines, are carefully embedded in social media platforms to sustain engagement and trigger dopamine release (Andreassen et al., 2016; Hunter & Morganstein, 2021; Montag & Walla, 2016). The concept referred to as variable reward reinforcement derives from behavioural psychology and neuroscience. It involves providing rewards on an unpredictable schedule, which has been shown to create more vigorous habits than consistent or predictable rewards (Khaneja & Arora, 2024). In slot machines, players are rewarded intermittently with monetary gains or visual stimuli, which keep them engaged and motivated to continue playing despite frequent losses (Chóliz, 2009; Ferrari, 2024; Habib & Dixon, 2010; Palmer et al., 2024). Social media platforms apply the same principle through likes, shares, comments and notifications. Users are unaware when they will receive positive reinforcement, such as a surge in likes on a post or unexpected comments, which creates a sense of anticipation and excitement (Anderson & Wood, 2020; Mujica et al., 2022; Siddiqa & Mahmood, 2024). This unpredictability triggers the brain's reward system, particularly the release of dopamine—a neurotransmitter associated with pleasure and motivation. Over time, the brain begins associating the platform with potential rewards, reinforcing habitual engagement. Examples include infinite scrolling, where users continually encounter new content, and algorithmically curated feeds, which present personalised posts or videos tailored to individual preferences. These features mimic slot machines' random "jackpot" nature, where users never know when they will come across particularly engaging or rewarding content.

Furthermore, this concept, known as variable reward reinforcement, is rooted in behavioural psychology and neuroscience. It involves providing rewards on an unpredictable schedule, which has been shown to create more vigorous habits than consistent or predictable rewards (Mehta et al., 2008). In slot machines, players are rewarded intermittently with monetary gains or visual stimuli, which keep them engaged and motivated to continue playing despite frequent losses. Social media platforms apply the same principle through features such as likes, shares, comments, and notifications. Users do not know when they will receive positive reinforcement, such as a surge in likes on a post or an unexpected comment, which creates a sense of anticipation and excitement (Alhabash et al., 2018). This unpredictability triggers the brain's reward system, particularly the release of dopamine—a neurotransmitter associated with pleasure and motivation. Over time, the brain begins associating the platform with potential rewards, reinforcing habitual engagement. This randomness taps into the brain's craving for novelty and

unpredictability, further enhancing the addictive qualities of the platform. The effectiveness of intermittent rewards in social media design has been supported by neuroscience and behavioural economics research (Clark & Zack, 2023). As such, the unpredictable nature of rewards leads to higher levels of engagement and repeated behaviour. This mechanism sustains user attention and increases the time spent on the platform, making it a powerful tool for driving user retention and profitability.

The further application of neuromarketing principles continues to revolutionise social media design. Neuromarketing combines neuroscience and marketing to optimise user experiences by deeply understanding subconscious consumer behaviours (Kalaganis et al., 2021). Social media companies continue to harness these principles by analysing neural responses to their platforms' features (Thakur & Pasha, 2024). As noted earlier using results from neuroimaging and physiological tools such as EEG and eye-tracking, developers can refine interface designs to maximise user retention. For example, EEG studies demonstrate how rapidly emotionally charged content maintains attention, a principle evident in the infinite scroll feature in leading social media platforms (Gogoi et al., 2024). Additionally, eye-tracking data informs the placement of visual elements, ensuring that the user's attention is drawn to features that drive interaction, such as comments, notifications, ads or content suggestions (Kohout et al., 2022). Social media platforms, therefore, function as massive real-time neuromarketing experiments by continuously analysing user behaviour. By doing so, companies refine their designs to benefit from neural and physiological mechanisms associated with habit formation. Furthermore, borrowing strategies from gambling machines, this approach aligns with neuroscientific findings on behavioural reinforcement, wherein variable rewards strengthen habits by creating anticipation and unpredictability, keeping users "hooked" on the platform.

There is, therefore, a justification for ethical approaches to integrating neurotechnology and neuromarketing in social media. Although the gains of gaining valuable insights into consumer behaviour can only serve companies well, it is equally important to ensure and emphasise the potential harms, as well as the urgent need for transparency, ethical standards, and regulatory frameworks to ensure these advancements are used responsibly.

3.3. Leadership Development and Decision-Making

Leadership development is an essential area that is looking to benefit from neurotechnology (Aithal & Satpathy, 2024). In recent years, there has been a need for leaders who have emotional intelligence, social intelligence, cultural intelligence, creative intelligence, practical intelligence, and creative intelligence, which are synonymous with effective leadership. Effective leadership is, therefore, cognisant of empathy and cognitive flexibility, both of which can be enhanced through neurofeedback and neurotechnological interventions (Patangia et al., 2024). Therefore, Neurofeedback training continues to improve leaders' emotional regulation,

resilience and decision-making skills.

Studies by (Jacques et al., 2024; Zhang & He, 2024; Guarnier & Chimenti, 2023) all explore the impact of neurofeedback training on leadership effectiveness. The researchers found that leaders who underwent neurofeedback training exhibited improved emotional regulation, which enhanced their ability to resolve conflicts and collaborate with team members. Such outcomes go to show that neurofeedback training leads to increased self-awareness, allowing leaders to understand better their emotional responses and how they impact their decision-making.

BCIs working with EEGs have the propensity to enhance cognitive development (Värbu et al., 2022). Such combinations are amply applied to cognitive development of leaders. BCIs can monitor cognitive load in real time, providing feedback on their mental state during decision-making (Beauchemin et al., 2024). This information can optimise performance, ensuring leaders operate at their cognitive peak when making critical decisions. For example, a leader experiencing high cognitive load may be at risk of making suboptimal decisions due to mental fatigue. By monitoring cognitive load, BCIs can alert leaders to take breaks or engage in stress-reducing activities, thereby improving decision-making outcomes.

Despite the potential benefits, neurotechnology in leadership development raises important ethical questions. One concern is how neurotechnology should be used to influence a leader's behaviour. While neurofeedback and BCIs can enhance cognitive and emotional skills, there is a fine line between enhancement and manipulation. Leaders must retain autonomy over their decision-making processes, and the use of neurotechnology should be guided by ethical principles prioritising the individual's well-being and autonomy.

Another ethical consideration is the potential for neurotechnology to exacerbate existing inequalities in leadership. Access to neurotechnological tools is often limited to those with the financial resources to afford them. This could lead to a situation where only a select few have access to neurotechnology's cognitive and emotional enhancements. To address this issue, efforts must be made to democratise access to neurotechnology, ensuring that all leaders, regardless of their financial resources, can benefit from these tools.

3.4. Employee Productivity and Well-Being

Employee well-being in the workplace is another domain in which neurotechnology is making a significant impact (Ackerman & Strickland, 2022). With the rise of wearable neurotechnology devices, employers can now monitor and enhance employee productivity and well-being in real-time (Thiruchanuru, 2024). Wearable EEG devices, for example, can track an employee's mental state, providing insights into focus, stress levels, and cognitive overload (Giorgi et al., 2021). This data can then be used to design interventions that promote optimal performance and reduce burnout.

Neurofeedback training has the potential to improve cognitive functions such as attention and memory (Wang & Hsieh, 2013). Research shows that employees

who undergo neurofeedback training exhibit improved task performance and job satisfaction (Tosti et al., 2024), further suggesting that neurotechnology is a valuable tool for enhancing workplace productivity. Neurofeedback training has also reduced stress and anxiety, improving

In addition to neurofeedback, is useful in high-stress environments where employees must make quick decisions under pressure (Joy et al., 2024). By monitoring cognitive load, BCIs can help employees identify when they are at risk of mental overload and mitigate it, such as taking breaks or engaging in stress-reducing activities. However, the use of neurotechnologies in the workplace, as noted earlier, raises ethical concerns. One primary concern arises from neuro, neural and brain privacy. Employees may feel uncomfortable with the idea of their brain activity being monitored by their employer, raising questions about consent (neural consent) and the potential to misuse neural data. Employers must, therefore, ensure that the use of neurotechnology in the workplace is transparent and that employees have the right to opt-out if they are uncomfortable with being monitored. Furthermore, the potential for neurotechnology to be used as a tool for surveillance and control is a genuine concern. Employers could use neurological devices to monitor employee behaviour and productivity in ways that infringe on their autonomy and privacy. To prevent this, it is essential to establish ethical, legal and responsible guidelines and laws that protect employee rights and ensure that neurotechnology is used to promote wellbeing and productivity.

4. Discussion

Integrating neurotechnology into business practices offers significant benefits, including enhanced and improved decision-making, improved and enhanced leadership, improved employee productivity and greater organisational efficiency. Neurotechnology provides insights into human behaviour, enabling businesses to tailor strategies in alignment with consumer needs and employee wellbeing. However, these advancements have challenges that must be addressed to ensure responsible use.

One of the primary challenges of the use of neurotechnology in varying contexts is the ethical implications of collecting and interpreting neural data. Using neurotechnology in business raises important questions about privacy, consent and potential misuse. For example, collecting neural data requires adequate safeguards to protect the individual's rights. Transparency and informed consent are essential in mitigating the risks of misuse. Businesses must ensure that individuals are well informed about the risks of using neurotechnologies, have a complete awareness of how their neural data is used and have the right to opt-out if they are uncomfortable with the process.

Another pressing issue is the overwhelming potential to manipulate neural data. Neurotechnology's ability to influence decision-making processes raises questions about autonomy and the ethical boundaries of its application. Businesses must prioritise accountability and adopt ethical guidelines to prevent ex-

ploitation. For example, the use of neurofeedback in marketing should be guided by principles that prioritise the consumer's well-being and autonomy rather than simply maximising profits.

Equity and access are also critical considerations. High costs and technical complexity may limit the availability of neurotechnology to large organisations, exacerbating disparities between businesses. Efforts must be made to democratise access to these tools to ensure inclusivity. This could involve developing more affordable neurotechnological devices or providing subsidies to smaller businesses to enable them to access these tools.

In addition to ethical considerations, technical challenges must also be addressed. Neurotechnology is still in its early stages and much about how the brain works are not yet understood. As a result, the interpretation of neural data can be complex and prone to error. Businesses must invest in research and development to improve the accuracy and reliability of neurotechnological tools, ensuring that they provide meaningful insights that can be used to inform decision-making.

Beyond immediate business applications, the widespread adoption of neurotechnology could fundamentally alter perceptions of human cognition, behaviour, and autonomy. Implications extend to education, healthcare, and legal systems, necessitating broader societal discourse on responsible innovation. Establishing regulatory oversight, ethical standards, and public engagement mechanisms is essential to ensuring that neurotechnology serves societal interests rather than becoming a tool for unchecked corporate influence.

Furthermore, while neurotechnology holds immense potential to transform business practices, a critical and balanced approach is necessary. As noted above, ethical considerations, accessibility concerns, technical limitations, and long-term societal impacts must be addressed to ensure responsible and equitable implementation. Businesses, regulators, and researchers must collaborate to develop frameworks that maximise benefits while minimising risks, ensuring that neurotechnology is harnessed for ethical and inclusive progress.

Finally, it is essential to consider the long-term implications of neurotechnology on society. As neurotechnology becomes more widespread, it has the potential to fundamentally alter the way we think about human behaviour and decision-making. This could have profound implications for education, healthcare, and even the legal system. We must engage in a broader societal discussion about the role of neurotechnology in our lives and how we can ensure that it is used to benefit society as a whole.

5. Conclusion

Neurotechnology represents a paradigm shift in how businesses understand and influence human behaviour, offering unprecedented insights into decision-making processes, consumer preferences, and organizational efficiency. Through tools such as BCIs, neurofeedback, and neuroimaging, businesses can optimize marketing strategies, enhance leadership development, and improve employee well-be-

ing. However, the integration of neurotechnology into business practices is not without challenges. Ethical concerns, including neuro privacy, informed consent, and the potential for manipulation, underscore the need for robust ethical frameworks and regulatory oversight. Additionally, issues of equity and access must be addressed to ensure that the benefits of neurotechnology are available to all organizations, regardless of size or resources. As neurotechnology evolves, businesses must prioritize transparency, accountability, and inclusivity to harness its potential responsibly. This review highlights the transformative potential of neurotechnology in shaping business decisions while emphasizing the importance of balancing innovation with ethical considerations. Future research and practice should focus on developing affordable and accessible neurotechnological tools, refining data interpretation methods, and fostering a broader societal dialogue on the implications of neurotechnology for human autonomy and well-being. Businesses can leverage neurotechnology to drive positive outcomes while safeguarding individual rights and societal values.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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