

Exploring the contribution of neuroscientific approach to sustainable smart tourism

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Abstract. A recent development in the tourism industry is integrating smart technology into prominent destinations to provide personalized experiences for visitors and improve their satisfaction. As a result of smart destinations, knowledge and expertise are available to all parties involved, allowing for the constant transformation of activities by engaging tourists in actively co-creating their experiences. Significant beneficiaries, such as visitors, service providers, and destination marketing organizations, participate in the smart tourism ecosystem's combination of systems, structures, and technology to co-create value and experience its advantages. The application of neuroscience in smart tourism ecosystem can help to better understand the needs and expectations of tourists, to design more efficient and sustainable services, and to measure the impact of tourism on society and the environment. Sustainable value co-creation based on neuroscientific approach are the new building blocks of smart tourist ecosystems to attain visitor satisfaction and loyalty by establishing positive associations with the co-creation of tourist experiences. Considering neuroscience as a valuable tool for understanding how tourists interact with their environments and how ICTs can be used to enhance their experiences, this paper analyzed literature on smart tourism ecosystem and sustainable value co-creation to provide insights into how sustainable smart tourism can be improved through the use of the neuroscientific approach.

Keywords: Smart tourism ecosystem, Value co-creation, Sustainability, Neuroscientific approach.

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1. Introduction

Technology is the solution to enhancing a destination's competitiveness; smart technologies have been discovered to be vital in the tourist experience, beginning with trip planning and finishing with tourists vacationing at a specific location [1]. Tourism destinations can benefit from smart technology in three ways: first, by making better use of their resources; second, by encouraging their sustainable growth; and third, by raising the standard of living for locals and visitors. Smart tourism is gaining popularity as more and more places are improving their operations via interconnected technological infrastructures that allow all parties involved in the tourism industry to rapidly interact and share data about their activities [2].

Typically implemented at the destination level, smart tourism seeks to accomplish development objectives using the distinct features of smart technologies [3]. The objectives range from improving the smart tourism ecosystem's efficiency and competitiveness [4] and destinations to achieving more social, economic, and environmental sustainability [5]. A more dynamic service proposition and a more customized experience for visitors are two essential components of smart tourism that must be acquired [4]. The literature has begun to emphasize the multidisciplinary dimension of the tourist experience and its function in tourism development, particularly in promoting the sustainability and competitiveness of lodgings and destinations [6]. Smart experiences incorporate elements of both traditional and digital forms, with a focus on significant levels of engagement and interconnection to establish novel, personalized, and intuitive travel experiences [7].

In an ever-more international and demanding industry, destination managers must organize creative, long-term, and sustainable plans to ensure favorable outcomes [8]. By gathering, analyzing, and sharing information [6], smart tourism ecosystems facilitate the development and utilization of sustainable tourist value, which leads to unique experiences for visitors [9]. The interconnected structure of the tourism ecosystem aims to foster smart tourism at a destination through consumer, community, and private sector interaction. Value co-creation proposes that stakeholders and the business that made a product or provided a service collaborate to create value for tourists [10].

The concept of co-creation involves offering readily obtainable supplies to customers so they can cooperate with the service provider to build their own experiences [11]. Smart destinations and possibilities for the co-creation of emotions should be provided to ensure visitors have experiences they will never forget [12]. Tourists can participate in a smart tourism ecosystem, which allows them to enjoy tourism offerings, explore novel approaches to examining information, and even express their value-creation behaviors through communication with other stakeholders [13]. This method encourages visitors to engage with service providers actively, co-create their own experiences and the experiences of others, and generate new impressions [12]. It has become more critical for tourism researchers to look at how tourists create value and what they do to protect the environment, society, and culture [14]. At the same time, technology-based service sustainability has become more significant [12].

Consumer behavior in tourism and hospitality has evolved dramatically due to the rapid growth in Internet marketing and social media [15]. The use of psychophysiological approaches to analyze emotional reactions in advertising and marketing has grown significantly, partly due to the real-time features such measurements provide [16]. Consumer neuroscience and neuromarketing incorporate viewpoints from marketing, economics, decision theory, and psychology [17] as the concept of using neuroscience techniques in marketing [18]. Eye-tracking technology, Electroencephalography (EEG), and Functional Magnetic Resonance Imaging (fMRI) have been widely employed in the fields of marketing, tourism, and hospitality to analyze the efficacy in grabbing attention as well as identifying

the driving forces behind consumer behavior and anticipating their decision-making procedures [19].

Consequently, involving the service science and neuroscience approaches to tourism and hospitality as an integrated approach is vital. This approach evaluates the characteristics of tourist services and the cognitive and behavioral processes of tourists. Several aspects distinguish tourist services from other kinds:

- They are intangible and cannot be touched, seen, or heard;
- They are produced together with the tourists;
- They are significantly related to tourist preferences and environmental conditions.

These attributes make tourism services challenging to design, deliver, and measure. On the other hand, tourists make decisions based on various cognitive and behavioral facets. In particular, tourists are influenced by 1) Their *expectations* (internal factors, such as past experiences, and external factors, like advertising); 2) Their *emotions*; and, 3) Their *social behaviors*. Understanding these cognitive and behavioral processes is fundamental to designing tourism services that meet tourists' expectations and effectively generate positive emotions.

2. Methodological approach and research questions

This work analyzes multiple studies and concepts to provide an integrated examination of neuroscientific methodologies, sustainable value co-creation, and the smart tourist ecosystem. Thus, it aims to give insight into the interconnected nature of various fields, which is crucial for improving sustainable practices and creating well-planned smart tourist experiences. Presenting an integrated overview of the smart tourism ecosystem from a neuroscientific and sustainable value co-creation perspective, it sums up the significant results and research directions for further study in theory and practice. By outlining the most recent findings, this methodology provides a theoretical basis for comprehending the smart tourist ecosystem from the standpoints of neuroscientific research and sustainable value co-creation, which leads us to look into the following inquiries:

In the context of smart tourism, how could a neuroscientific approach enhance our comprehension of the cognitive behaviors, decision-making, and preferences of tourists?

Where do smart technologies stand in relation to the neurocognitive processes that visitors use while interacting with the tourism ecosystem?

In what way can the tourism industry overcome challenges and seize possibilities provided by the integration of smart technology and neuroscientific methodologies to co-create sustainable value?

3. Literature overview on Smart Tourism and Sustainable Value Co-creation

Smart cities are the primary promoters of innovative tourism applications, and many cities play a significant role as tourist destinations [20]. In this way, the smartness level of destinations—typically found in urban areas—is determined by the intelligence degree of cities [21]. Smart tourism is a systemic, enhanced, and all-encompassing kind that satisfies tourists' demands for rapid and thorough data collection and communication [22].

By bringing the physical and governmental aspects of tourism online, smart tourism represents a clear milestone in developing information and communication technology (ICT) in the tourism industry [23]. **Figure 1** depicts the various smart components and layers

underpinned by ICTs. Smart destinations are a subset of smart cities; these places apply smart city principles to urban and rural areas [24], considering both locals and tourists in their pursuit of sustainability, quality of life, and efficient use of resources [4]. Furthermore, merging information and communication technologies with the tourism experience has given rise to a social phenomenon known as smart tourism [25]. Smart business, as another component, is the intricate business environment that facilitates the creation and exchange of touristic materials and the co-creation of the tourism experience [4]. Notably, smart tourism extends to three layers across these three components: a smart information layer that aims at collecting data, a smart exchange layer that supports interconnectivity, and a smart processing layer that is accountable for the analysis, imagining combination, and intelligent use of data [26]. The figure shows the various intelligent components and levels supported by information and communication technologies (ICT) in the tourism sector. Smart destinations are a subset of smart cities; these places apply smart city principles to urban and rural areas.

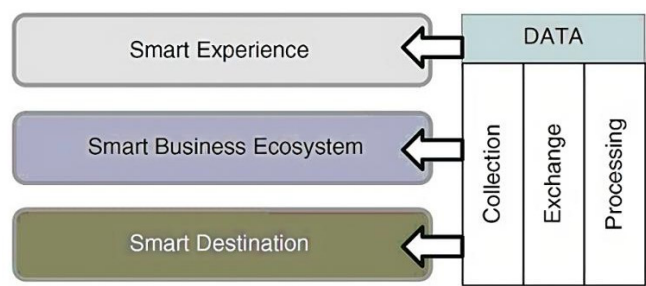


Fig.1. Components and layers of smart tourism. (Source: [4])

Improvements in data collection, resource management, and decision-making are all necessary for smart projects [27]. The physical and technology layers provide the groundwork for a data layer, supporting the business and governance layers necessary to enable a smart tourism experience layer. This model was initially proposed by [28] and later refined by [28] (**Figure 2**). Smart tourism requires analytical skills and a data-sharing mentality at the data layer [17]. In addition to creating friendly settings to open innovation, the business and governance layers play a crucial role in smart tourism growth by providing motivation and an initial push [28]. The most essential part of any tourist attraction is the experience that visitors have while there. Smart tourism enhances this cooperation by fostering communication between attractions and visitors, encouraging more active engagement from visitors [29]. The physical and technological layers provide the foundation for a data layer, supporting the business and governance layers needed to enable an intelligent tourism experience layer. In addition to creating environments conducive to open innovation, corporate and governance levels play a crucial role in the growth of smart tourism by providing motivation and initial impetus. The most essential part of any tourist attraction is the experience that visitors have while they are there.

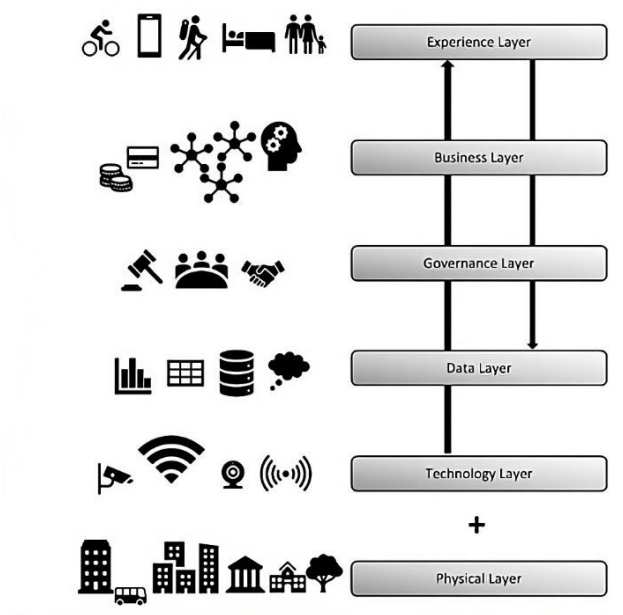


Fig. 2. Smart tourism layer model. (Source: [28])

3.1. Smart Service Experience

The nature of the service sector is constantly changing, which means that service experience is also constantly improving [30]. Customers benefit significantly from smart technology developments since they can elevate their service experiences beyond what was previously possible [31]. Researchers and industry experts agree that smart services provide a radically different experience for customers than traditional services. However, more is needed to know what makes up this unique offering [7]. Experiences in smart service, which center on service interactions mediated by technology, have smart service as their primary predecessor. Smart service experience is the result of customers’ direct contact with smart technology and its mental, emotional, and behavioral elements [31]; consequently, customers’ reactions to smart services are influenced by factors such as customer empowerment, charming experience, accuracy of service delivery, privacy and security, and general enjoyment (**Figure 3**) [7]. The figure illustrates how the intelligent service experience is the result of customers’ direct contact with intelligent technology and its mental, emotional and behavioral elements, consequently customers’ reactions to intelligent services are influenced by factors such as customer empowerment, l fascinating experience, the accuracy of service delivery, privacy and security, and overall enjoyment, and can interact at different levels of the service environment to create their own unique experiences.

The role of smart service in the provider-customer relationship is substantial, and it empowers users [32]. Customers are given more power and control over the service delivery process [33], and they can interact at different levels of the service environment to create their own unique experiences [7]. Service providers can now provide a consistent experience across all of the many touchpoints their customers use to communicate with them [7], thanks to smart services that use real-time data from customers to improve their on-site experience with location-based interactive information that is specific to the setting [4]. With the help of

many devices’ detecting, computing, communicating, and regulating capabilities, smart services enable different levels of self-directed decision-making [4], which allows for the provision of the appropriate service at the appropriate location and at the right time. Creating a smart service experience for clients is greatly influenced by the accuracy of service delivery [7]. Although smart services give users greater control over the services they receive, they also run the risk of making consumers wary of giving service providers access to personal data [34]. Thus, Customers must strike a balance between unveiling too much personal information and risking privacy invasion to reap the benefits of individualized services.

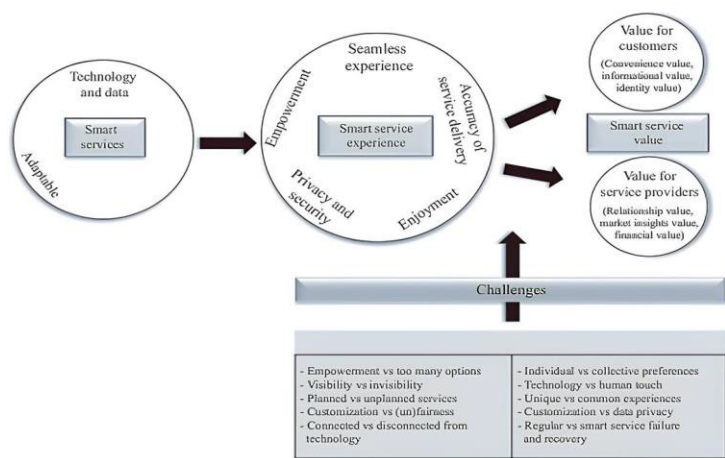


Fig. 3. Conceptual model of smart service experience. (Source:[7])

3.2. Smart Tourism Ecosystem

Smart tourism ecosystem is a framework that facilitates the development, management, and delivery of touristic services through advanced technology, which allows for the exchange of information and the generation of value [4]. A service ecosystem consists mainly of the following: service providers and consumers, supplementary services, technology, channels, non-governmental organizations, and businesses from different industries [12]. To facilitate the dynamic management of business models, companies in a smart tourist ecosystem offer smart services through accessible information systems and technological infrastructures [13]. Hence, businesses that want to give visitors comprehensive, cutting-edge service choices should consider leveraging intangible resources in a smart tourism setting to make visitors’ trips more memorable [35]. The primary components of the smart tourism service include attractions, transportation, lodging, food, and purchases to provide for tourists’ needs (**Table 1**) [13].

Table. 1. Dimensions of a smart tourism ecosystem (adapted from [13])(Source:[7])

Dimensions	Definitions
Smart attraction service	The instant services of tourist experience and decision support are realized by the interconnections between the attractions and stakeholders through the dynamic platforms with information intensive communication flows (Jovicic, 2019).
Smart transportation service	The supply of location-based information, quality public transport, as well as navigation and parking, is achieved through the integration of technology and transportation systems (Gonzalez et al., 2020).
Smart accommodation service	Tourists are provided with access to ICT-integrated accommodation information and convenient booking services, and may arrange accommodation appropriately based on their demands (Stankova et al., 2019).
Smart diet service	Tourists are provided with access to ICT-integrated dining information and solutions, as well as convenient ordering services with healthier and suitable meals (Okumus et al., 2018).
Smart purchase service	The purchase system incorporates ICT with e-commerce environments to extend into m-commerce consumption platforms. Tourists can obtain commodity information and purchase from anywhere and at any time (Flavián et al., 2020).

3.3. Smart Tourism Ecosystem and Sustainable Value Co-Creation

The concept of value co-creation is based on the premise that customers can significantly impact how new services and products are developed, aiming to ensure that their needs are met [12]. Each co-creation model has three main parts: the supplier, consumer, and shared spheres [36]. Customers’ expertise can be integrated into a company’s value-creation process, which can only occur when there is a direct connection between the supplier and the customer [37]. Value creation now occurs in the relationship between consumers and companies. These interactions increasingly involve more than just the company and the consumer; value is co-created by businesses, workers, shareholders, and even government agencies, but ultimately, it is up to the customers to decide what that value is [12]. Information and communication technology are essential parts of the value co-creation process at three stages: before, during, and after delivery [38]. Customers are very interested in utilizing intelligent and versatile technologies. Hedonic principles, like pleasure and satisfaction, are just as important as practical values, like simplicity of application, when it comes to the motivations for utilizing innovative tourism tools [12].

Sustainable co-creation encompasses a broad spectrum of customer-involved, more beneficial ways from an economic, social, and environmental perspective [39]. Regarding environmental sustainability, technology profoundly impacts how organizations think and act [40]. Examining the social environment in which ecosystems exist requires looking at both the technical and social realms as potential drivers of customer orientation [41]. Sustainable value co-creation is facilitated by tourists, who actively participate in the ecosystem. They prevail by having faster access to the data and cheaper travel. Furthermore, they help ensure the long-term viability of socio-cultural endeavors by learning the ins and outs of the local culture, ideas, and conventions whenever and wherever required. They actively participate in the value co-creation process as part of the smart tourist ecosystem and contribute to environmental sustainability [12]. As a result, there is a robust connection between a smart tourism ecosystem and sustainable value creation (**Figure 4**). The community, service providers, and tourists receive economic, social, and cultural benefits

from sustainable value co-creation [12]. The model schematizes the existence of a solid connection between an intelligent tourism ecosystem and the creation of sustainable value.

The co-creation of sustainable value is facilitated by tourists, who actively participate in the ecosystem. They prevail thanks to faster access to data and cheaper travel. Furthermore, they help ensure the long-term viability of socio-cultural endeavors by learning the details of local culture, ideas and conventions when and where required. They actively participate in the value co-creation process as part of the smart tourism ecosystem and contribute to environmental sustainability.

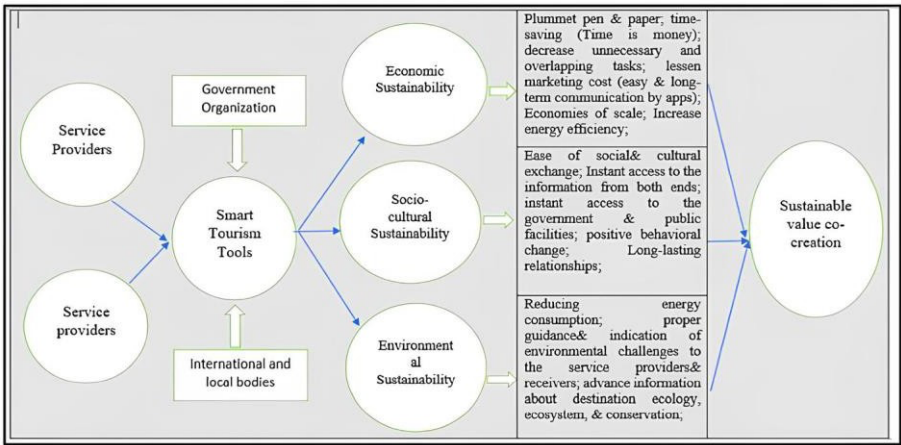


Fig. 4. Sustainable Value co-creation. (Source: [12])

4. Exploring the contribution of neuroscience to sustainable smart tourism

4.1. Neuromarketing and Neuroscience

The word “neuromarketing” was first proposed in 2002 by an Atlanta advertising company in the United States; in its report, a new department conducted marketing research using functional magnetic resonance imaging (fMRI) [42]. Neuromarketing, as described by [43], is the study of human behavior in relation to marketing through the use of neuroscience techniques. It aims to clarify the reactions of conscious and unconscious economic factors of the most diverse emotional, cognitive, physiological, and psychological types, and the behaviors and thoughts related to them [44]. Numerous neuroscience techniques are employed in neuromarketing to look into the emotions and psychological states of consumers. It makes use of two distinct methods (**Figure 5**): brain–computer interface (BCI) for (a) recording electrical brain activities such as EEG (electroencephalography) and fNIRS (functional near-infrared spectroscopy), or (b) recording metabolic brain activities such as fMRI (functional magnetic resonance imaging); the recording of biological body activities such as galvanic skin response (GSR), facial-action-coding (FAC), eye-tracking (ET), and heart rate (HR) [45]. The neuroscientific techniques used in neuromarketing to examine the emotions and psychological states of consumers. It uses two distinct methods: brain-computer interface (BCI) to (a) record electrical brain activities such as EEG (electroencephalography) and fNIRS (functional near-infrared spectroscopy) or (b) record metabolic brain activities such as fMRI (functional magnetic resonance imaging); recording

the body’s biological activities such as galvanic skin response (GSR), facial action coding (FAC), eye tracking (ET), and heart rate (HR).

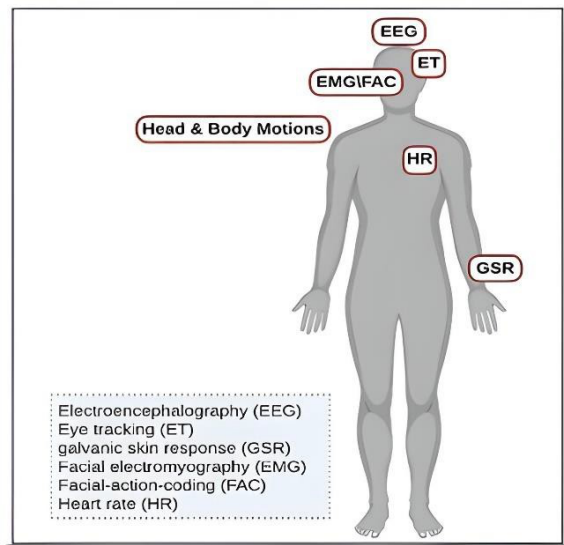


Fig. 5. Most widely employed modalities in neuromarketing. (Source: [45])

Each neuromarketing technique gathers different neural activity measurements. For example, fMRI specifies metabolic brain processes through variations in blood flow, while EEG records electrical changes in brain signals [46]; ET measures eye attention toward a stimulus [47]; and HT counts the number of heartbeats in a time and can be used to determine stress [48]. Neuromarketing differs from traditional marketing techniques, such as audio advertisements, television advertising, surveys, and questionnaires, where the customer’s input is based on their thoughts and beliefs (subjective responses); this approach has an impact on gathering accurate emotional assessment which will be used to improve customer experience and enhance products and services based on their objective judgments, (**Figure 6**). Some of the innovative techniques used in neuromarketing. For example, fMRI specifies brain metabolic processes through changes in blood flow, while EEG records electrical changes in brain signals; ET measures the eye’s attention to a stimulus and HT counts the number of heartbeats at a time and can be used to determine stress.

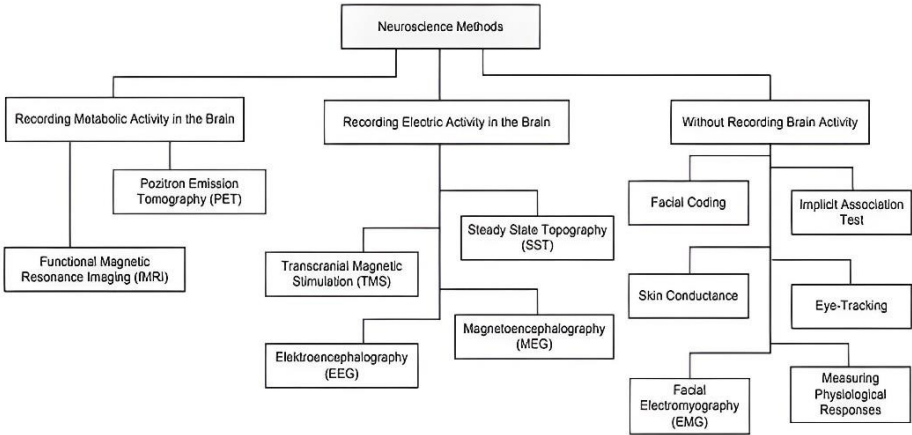


Fig. 6. Neuroscience Methods and tools. (Source: [49])

4.2. Neuroscientific approach in sustainable smart tourism

Applying a neuroscientific approach to analyzing the cognitive functions of tourists presents a wide range of prospects for the tourism industry. By utilizing technological advancements, it is possible to improve tourists’ experiences and ensure sustainable development. By studying neural processes, we may understand why certain destinations and activities captivate us and evoke specific emotions. This knowledge allows us to enhance the design of tourist experiences, create more meaningful connections with travelers, and ultimately elevate the tourism industry. Neuro-tourism or consumer neuroscience is the application of neuromarketing in the tourism context to enhance tourist marketing strategies; it integrates neuroimaging methods in tourism to analyze tourists’ cognitive, psychological, and emotional effects on marketing strategies [49]. Neuro-tourism can be facilitated by applying the same neuroscience methods utilized in neuromarketing. Furthermore, high-dimensional data gathered through neuro-tourism research, such as ET, can be put into machines to create advanced artificial intelligence (AI) systems that predict the preferences or intentions of tourists. With the use of neuro-tourism, we are able to get real-time information from tourists’ subjective reactions—their subconscious minds. Such data cannot be gathered using conventional marketing strategies, e.g., surveys. Traditional methods require respondents to answer closed or open-ended questions to reveal their feelings, known as a ‘self-report’ approach; neuroscience methods can overcome the limitations of self-report methods by reducing cognitive bias and measuring emotion in real time [50].

Neuro-tourism and hospitality have become prominent as potential implementations of neuroscience techniques to investigate tourists’ behavior and strengthen promotional strategies in the tourism and hospitality industry. Marketers/practitioners can obtain immediate and objective data from potential tourists’ subliminal thoughts and determine how they interact with advertisements, precisely the feelings underlying their choices and opinions regarding tourism/hospitality products and services. Accordingly, tourism and hospitality policy-makers and those involved in this industry may redesign the development planning and marketing methods to improve tourists’ experiences. Due to the emergence of Web 2.0, travelers’ preferences for organizing their trips have improved [51]. [52] used eye-tracking tests and questionnaires to scrutinize how different forms of social media advertising

affect visual attention and travel decisions; [51] confirmed that Facebook ads are the most successful, accompanied by blogs and TripAdvisor’s helpful information.

Neuroscientific research may be extensively utilized in tourism studies, allowing a better understanding of tourists’ physiological responses and an accurate evaluation of their favorites [53]. Furthermore, since unconscious emotional and cognitive brain reactions are influential in conscious preference and decision-making [54], a great feeling arising from positive images would result in a favorable evaluation of the destination and loyalty [55]. The context of “destination” is the most commonly used in real-life applications, in contrast, the “tourism maps/guidebooks” is the last considerations. Furthermore, the majority of neuro-tourism researchers are interested in employing eye tracking and EEG (**Figure 7**). To distinguish between different destination choices, [54] explored whether the direct emotional responses of visitors and the cognitive load toward various places may predict their stated preferences after monitoring them watching images and videos related to destinations using ET and EEG. [56] assessed how sustainability factors implemented by hotels improve consumers’ selection using three neuroscience tools: galvanic skin response (GSR), HR, and EEG. Sustainability here means using eco-friendly items that do not have negative impacts on the environment. As a result, applying a sustainability concept in accommodation services improves the satisfaction and personal experiences of tourists. The following model of the authors’ elaboration illustrates how neuroscientific research can be widely used in tourism studies, allowing for a better understanding of tourists’ physiological responses and an accurate assessment of their preferences. The “destination” context is the one most commonly used in real-life applications, in contrast, “tourism” maps/guides” is the last consideration.

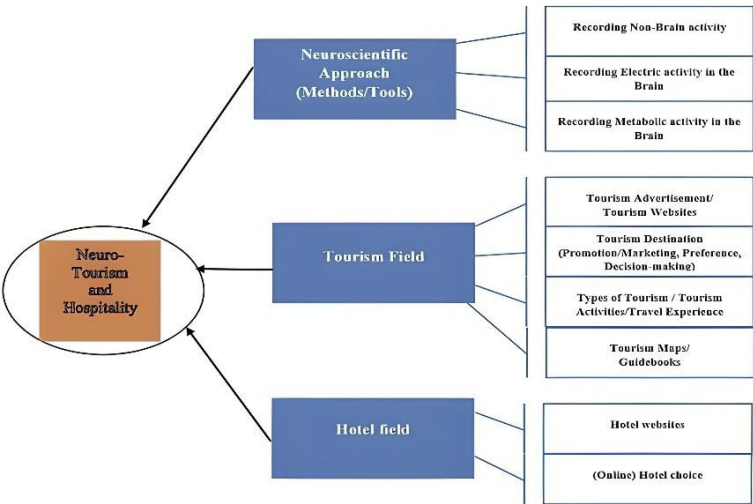


Fig. 7. Neuro-Tourism and Hospitality. (Source: Authors’ elaboration)

By leveraging neuroscience insights, destinations can engage tourists more meaningfully and interactively, fostering deeper links and a sense of society. For instance, destinations can use VR and AR technology to let tourists participate in virtual occurrences, such as cultural or historical events, and gamification procedures to inspire tourists to explore different parts of the destination and encounter local businesses and attractions. Neuroscientific research also indicates that people are more likely to pay attention to information presented as more

relevant to their appeals [57]. This information could be used to design ICTs that are more user-friendly and meet the needs of tourists to keep them engaged.

Interpreting the neurological motivation of decision-making can provide insights for practical tourism service management; it can be accomplished by analyzing the impact of cognitive biases on tourists' choices, which play an essential part in forming their experiences. By discovering the neural processes, we can optimize travel experiences and develop personalized offerings that align with travelers' preferences and emotions. Understanding the emotional drivers behind tourist behavior allows destinations to create specific experiences that evoke positive emotions and maximize visitor satisfaction which is fundamental for creating smart features that are both easy to use and emotionally engaging and helps visitors feel more connected to the place they are visiting. Responsible tourism may be achieved through the integration of neuroscientific techniques and sustainable value co-creation. The tourism sector can develop a more sustainable, ethical, and ecologically responsible model by putting an emphasis on sustainability and learning about visitors' neuropsychological reactions. Also, by using what we know about how the brain works, businesses can tailor their products and services to each customer's unique preferences, making their experience much more exclusive.

In light of the above, neuroscience can support both value co-creation and sustainability in smart tourism ecosystems. More specifically:

1. *Neuroscience support to smart tourism ecosystems' value co-creation:* Destinations and businesses can benefit from a more comprehensive knowledge of visitors' mental and emotional reactions when they study and build smart tourism ecosystems with a neuroscientific approach. As a result, this paves the way for the development of more intelligent, more customized, and culturally aware tourist experiences, which in turn lead to effective value co-creation for all parties involved. Additionally, by analyzing patterns of brain activity that are associated with particular experiences, researchers can determine which parts of the smart tourism environment are more appealing to tourists. So, to co-create value more effectively, businesses and destinations can tailor their services to match tourists' preferences. Neuroscientific methods can help designers create user-friendly smart technologies, which makes people more satisfied and more likely to co-create value. Neuroscientific research can also look into the reactions of visitors from various cultural backgrounds to smart tourism elements. Insights like these can guide the creation of culturally aware apps, which is crucial for a smart tourism ecosystem that respects various preferences and values.
2. *Neuroscience support to smart tourism ecosystems' sustainability:* Sustainable practices within smart tourism ecosystems can be better understood by incorporating neuroscience into their development and evaluation, which will help tourism businesses and destinations better understand how tourists make decisions about sustainable options and how to appeal to their environmental consciousness. In addition, they could spot eco-friendly behaviors that make people feel good, which would make tourism a more pleasurable and unforgettable experience for everyone and encourage them to stick with green choices. Destination Management Organizations (DMOs) might benefit from neuroscientific studies of how visitors think about and respond to content related to sustainability [45], which could help them better understand this content and make changes to smart tourism features that put sustainability first [8]. So, in a smart tourism environment, they can use neurofeedback processes to give visitors the latest information that will inspire them to engage in sustainable practices, raise their level of environmental consciousness, and, ultimately, make a positive impact on the world.

In conclusion, with reference to the paper's research questions, we argue that advancements in neuroscience have shed light on the cognitive functions of "smart tourists", allowing us to go beyond subjective methods by presenting objective metrics that can help reduce biases and provide more reliable evaluations. The design and effectiveness of smart technologies shape the tourist experience by improving or influencing cognitive processing, emotion, and decision-making. Better and more user-friendly smart tourism products can be developed through the connection between them. With the help of smart technologies, tourists can be more engaged and directed to see more of the attractions. By affecting the release of neurotransmitters and reshaping tourists' perceptions and memories, emotional engagement enriches the whole experience. When traveling to new places, smart navigation systems help with spatial cognition and make it easier on the brain. In addition, visitors will have a better experience navigating and interacting with smart devices thanks to well-designed interfaces that decrease cognitive load.

Smart technology and neuroscientific approaches can revolutionize the tourism industry by bringing long-term sustainability to destinations and the industry as a whole. To better comprehend and accept neuroscientific methods and their role in co-creating sustainable value, a feasible approach could be to launch educational programs aimed at both visitors and industry players. Accordingly, to make sure neuroscientific data is effectively incorporated into smart tourism applications, DMOs may think about collaborating with tech developers, neuroscientists, tourism experts, and research institutes and universities that focus on sustainable tourism and neuroscience. Deeper understanding and continued innovation can result from this partnership. Furthermore, utilizing neuroscientific data in sustainable tourism planning can help with continual improvement and adapting to ever-changing socioeconomic and environmental demands. Ultimately, it may be possible to coordinate an effort to use smart technologies and insights from neuroscience to promote sustainable tourism by involving industry players, government officials, and local communities.

5. Conclusions and future directions

This study provides an integrated review of how neuroscientific approaches, sustainable practices, and technology-driven tourism are reciprocally related. "Smart Tourism Ecosystem" refers to an all-encompassing analysis of the ways in which modern technology has revolutionized the travel sector, including a variety of advancements, including Internet of Things (IoT) devices, smartphone apps, and data-driven solutions that improve the whole vacation experience with interactive features, tailored suggestions, and real-time information. Due to digital technologies, smart destinations have cropped up where all parties involved have easy access to data and information that they may use to improve their operations and services over time. Access to accurate data, online booking, and assessing tourism trends before a trip are all part of smart tourists' preferences. Other aspects of smart tourism include convenient transportation, smart security precautions, an individualized itinerary plan, and effective administration of tourist attractions.

"Sustainable Value Co-creation" signifies a method of collaborating to design and implement tourist attractions that have a beneficial impact on local communities and the environment. Responsible and sustainable practices are prioritized in order to create benefits for all stakeholders in the tourist sector. The primary value request can be fine-tuned about tourists' actual demands when involved in the experience offer. Here, visitors play a pivotal role as leads in their own stories while at the site, making them primary co-creators of value. The comprehensive notion of sustainability is all about doing things in a way that considers the capabilities and requirements of all involved groups, combining the here-and-now with a perspective toward the future and focusing on immediate and distant results. Sustainable

principles, when applied to smart tourism, may improve tourist experiences while reducing adverse effects on local ecosystems. A more sustainable and responsible tourist sector is the result of incorporating environmentally conscious practices and technical advancements. To better understand how people experience, react to, and interact with smart tourism elements, the “Neuroscientific Approach” applies methodologies from neuroscience. In order to shed light on the mental components of traveler behavior, this field investigates the mental and emotional reactions to technological tools.

Future studies, including literature reviews and experimental investigations, are required concerning the uniqueness of the neuro-tourism and hospitality area regarding the smartness and sustainability of this industry. Although there are challenges in the area, it is evident that neuro-tourism and hospitality methodologies serve as advantages for capturing tourists’ thoughts and feelings and may present accurate and reliable information for analyzing smart tourists’ preferences and choices. Researchers should delve deeper into the distinctive neuroscientific tourism studies, exploring novel methodologies and expanding the scope of cross-cultural considerations, the long-term impacts of sustainable smart tourism practices and continuing to advance neuroscientific research methodologies in the context of smart tourism. Neuroscience devices are constantly becoming more sophisticated concerning their features and functionalities; consequently, researchers need instruction and skills before applying them. Furthermore, specialists from various fields, including neuroscience, psychology, and tourism/hospitality, must collaborate to construct efficient guidelines and models of smart neuro-tourism and hospitality. Neuroscience research in smart tourism and hospitality mainly concentrates on web efficiency and advertising/marketing performance.

Fortunately, removable and wearing neuroscientific equipment may be employed to investigate tourists’ reactions in contexts outside the typical laboratories, including smart city sightseeing and museum exhibitions. The tourism and hospitality industry may soon be transformed into a more intelligent network by combining neuroscientific methods and cutting-edge technologies, including artificial intelligence, blockchain/metaverse, and other digitalization concepts [58]. The investigation through the neuroscientific and sustainable value co-creational perspectives suggests a more considerate, inclusive, and accountable smart tourism ecosystem. In turn, industry actors can use such information to improve their strategies, which will eventually help the smart tourism environment evolve sustainably.

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