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Shaping the Future of Destinations: New Clues to Smart Tourism Research from a Neuroscience Methods Approach

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Abstract: In the context of the technological era, the smart tourism construct serves as a bridge between human and the artificial worlds, combining social sciences and neurosciences. This study aims to explore smart tourism through neuroscientific methods in order to shape the future of tourism destinations, using a hybrid methodology combining bibliometric techniques and content analysis. The findings reveal the integration of diverse scientific domains, highlighting a transdisciplinary approach. They offer clear evidence that neuroscientific methods in smart tourism integrate multiple areas of scientific knowledge, surpassing disciplinary boundaries. "Destination" stands out alongside "emotion", "visual attention" and eye tracking (ET). The collaboration network reveals the emergence of a new school, called neurotourism in the 21st century, formed mainly by actors and organizations from the Global North, evoking the need to include the Global South in the research scenario. The predominant methods include ET, heart rate (HR), and electroencephalography (EEG), suggesting triangulation with traditional methods for robust results. Virtual reality emerges as the primary immersive technology, promising insights when integrated with neurosciences. This study's practical and theoretical contributions guide smart tourism strategies and enhance destination experiences through neuroscientific methods, addressing a gap in the scientific literature while advancing ontological and epistemological understanding.

Keywords: smart tourism; neuroscientific methods; transdisciplinary approach; shaping destinations; emotions in tourism experience

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1. Introduction

In the 21st century, the notion of the smart construct serves as a bridge between two realms: the human and the artificial. According to Spillman (2020), this construct facilitates the connection between human intelligence and artificial intelligence by incorporating adaptive structures capable of adjusting to changing environmental conditions. On the other hand, the neuroscientific methods and tourism require knowing more about technologies. For instance, Kohli et al. (2022) provided a review on the Brain–Computer Interface (BCI) and focused on virtual reality (VR) and augmented reality (AR) for smart cities. They explained: "A BCI acquires and analyses bio-signals obtained from sensors, and translates them into commands that are forwarded to devices that give feedback to the users or complete desired actions" (Kohli et al. 2022, p. 1). Therefore, one of the first steps towards understanding the future of destinations is to look for neuroscientific approaches in order to unravel new avenues for smart tourism.

The smart construct, in tourism, is linked to the concept of a smart destination, a tourism destination where smart management is implemented, including technology, data, sustainability, and innovation to provide smart tourism experiences (Soliman et al. 2021). Thus, for a tourism destination to be labeled smart, it must be equipped with internet of things (IOT), mobile applications to provide tourists real-time information, big data analytics to analyze tourism behavior, and smart transportation (Duran and Uygur 2022). So, digital signage to provide real-time information on events, blockchain technology, smart accommodations, environmental monitoring, social media platforms for destination image communication and engagement with tourists, digital ticketing systems, virtual reality (VR) and augmented reality (AR) to improve tourists' experiences (Wise and Heidari 2019).

Platov et al. (2021) goes further and states that smart technologies influence tourist behavior throughout the travel process and the tourist experience in destinations. Reinforcing this, Anita et al. (2021) argue that the virtual has an enormous weight in smart tourism experiences. Furthermore, research into VR and AR has a high impact on emotional responses and engagement with the destination (Genç 2018; Yung et al. 2021). Well, when it comes to emotions we enter in another field of science, in neuroscience and in neuroscientific methods. That is, by integrating neuroscientific methods with VR and AR technologies, also called immersive technologies, researchers gain a deeper understanding of how these technologies impact memory, perception, cognition, and behavior (Beck and Egger 2018; Flavián et al. 2020).

Thus, the neuroscientific theories and methods could contribute to the new interdisciplinary epistemological pathway. For instance, if the core of a touristic experience is an emotion (Moyle et al. 2019; Bastiaansen et al. 2019), Nieuwenhuis (2017) explained that emotions work as a label in the brain, signaling importance, like a little tag saying 'keep'. In this way, Coelho et al. (2023) emphasize including the memory in the context of the tourism experience. In this follow-up, among the initial stages is the allocation of attention, as advocated by Garcia-Garcia (2017), where attention is measured in the brain through methodologies such as ET, EEG, biometrics and brain imaging. Therefore, smart destinations must have in-depth knowledge and include neuroscientific methods in smart destination models. These can help to provide new clues for shaping the future of tourism destinations, i.e., smart tourist experiences.

Furthermore, research into VR and AR has a high impact on emotional responses and engagement with the destination (Genç 2018; Yung et al. 2021). Well, when it comes to emotions, we enter another field of science, neuroscience and neuroscientific methods. That is, by integrating neuroscientific methods with VR and AR technologies, also called immersive technologies, researchers gain a deeper understanding of how these technologies impact memory, perception, cognition, and behavior (Beck and Egger 2018; Flavián et al. 2020). Thus, neuroscientific theories and methods could contribute to the new interdisciplinary epistemological pathway. If the core of a touristic experience is an emotion (Moyle et al. 2019) to produce a memory experience, and the type of attention is what starts this process, the smart destinations should have a deep knowledge about it in order achieve smart characteristics of tourist destinations. In this way, Scott (2020) explained that neuroscience is part of the future of tourism research.

Neurosciences is an interdisciplinary field, and application in tourism recently received the name neurotourism/neurotourism (Cardoso et al. 2024). Neurotourism can be defined as a new paradigm or new subdiscipline (see Giudici et al. 2017). The role of technology in neuroscience studies has been more than VR and AR, although it includes either. For instance, the advances in affective computation (AC) are a turning point. AC considers that computer "(. . ..) should have the skills to recognize its user's affective expressions, and to respond intelligently (. . .)" (Picard 2000, p. 247). Nevertheless, on tourism destinations, the interaction between computing and human affective perspectives still needs more investigation, notably by smart tourism approaches.

Jovicic (2019) highlights that smart destination is a systemic concept. In this way, the interdisciplinary approach is an important part of the new keys to understanding the smart tourism experiences in the 21st century. However, despite the numerous bibliometric and literature review studies published recently on the application of neuroscientific methods to tourism (e.g., Al-Nafjan et al. 2023; Li et al. 2023; Cardoso et al. 2024), a gap persists in approaches, with none of them connecting the constructs with a holistic and interdisciplinary perspective to answer the following question: How do neuroscientific methods contribute to advancing smart tourism and shaping the future of tourism destinations?

Following on from the above, the main aim of this study is to explore how neuroscientific methods can reinforce smart tourism and influence the future development of tourism destinations, providing insights for the advancement of smart destinations. To fulfil the research question and the main objective, three sub-objectives were defined: (1) To map the interconnection of the most prominent topics that use neuroscientific methods in smart tourism; (2) to map the research collaboration network that use neuroscientific methods in smart tourism; (3) to identify the components or dimensions of emotional experiences that use neuroscientific methods in smart tourism.

Moreover, to ensure scientific soundness, this research interconnects social sciences and neurosciences through technology. This connection is made possible by the accessibility of neuroscientific metrics like EEG and ET, as defended by Cerf (2017), opening up a new path of understanding about the bridge between the human and the artificial fields.

Following this, after the introduction, the systematic review section addresses the theoretical approach to the research. To fulfill the research sub-objectives, the third section presents the methods and techniques employed for data acquisition. The research applies a hybrid methodology, mixing the quantitative component of bibliometric with the qualitative component of content analysis. Subsequently, the fourth section describes and discusses the main findings. Lastly, the fifth section includes the conclusion revealing the neuroscientific methods emerging as a key element in shaping smart tourism's future, promoting multidisciplinary collaboration across diverse fields. Moreover, it stresses the five emotional elements/constructs identified through neuroscientific methods as a guiding principles for developing smart tourism strategies for shaping the future of destinations.

2. Theoretical Background

2.1. Neuroscientific Methods and Tourism—The Role of Technology

The new avenue of knowledge from neuroscience perspectives is large. Kandel (2020) explained that neuroscience itself is interdisciplinary. In the historical timeline of neuroscience, it, as a modern discipline, arose with anatomist Santiago Ramon and Cajal (1852–1934) with Neuronal Doctrine. Moreover, the advances in technology (such as EEG and functional magnetic resonance imaging (fMRI)) allowed the new perspective from in vivo research (Rooney 2018).

Nowadays, the advances in technology—implying artificial intelligences—has been to another level the discussions on the relationship between human beings and technologies. If before the role of smartphone to intelligence, touristic experiences were the measure by smartphone uses (Wang et al. 2012). today, the wearables (smartwatch, glass among others) dominate the scene. For instance, the use of eye tracking allows a new understanding of attention on time. Facial coding opens a way for learning more about emotions (Fraga and Rodrigues 2021). According to Bear et al. (2017), the behavioral and cognitive are some of the analysis' dimensions of neurosciences research. Thus, it is a hot topic to understand the role of the physiological aspect of attention, emotions, and memories captured by technology (such as EEG and ET) in order to develop a new framework to smart tourism experience contexts.

In the tourism field, Scott (2020) showed us that neuroscience is part of the future of tourism research. Neurosciences is an interdisciplinary field, and application in tourism receives the name neurotourism/neurotourism (Cardoso et al. 2024). Neurotourism can be defined as a new paradigm (see Panyik and Gonçalves 2017) or new (sub)discipline (see Giudici et al. 2017). Hence, in the 21st century, the notion of the smart construct serves as a bridge between two realms: the human and the artificial. According to Spillman (2020), this construct facilitates the connection between human intelligence and artificial intelligence by incorporating adaptive structures capable of adjusting to changing environmental conditions. The smart construct, in tourism, is linked to the concept of a smart destination, a tourism destination where smart management is implemented, including technology, data, sustainability, and innovation to provide smart tourism experiences (Soliman et al. 2021).

Moreover, the convergence relationship between real and virtual paths (Lévy 1996) has changed in the 21st century. It happens because of two main reasons: (1) the advances in the web (1.0, 2.0, 3.0, 4.0, see Latorre 2018); (2) the COVID-19 pandemic (initially in March of 2020 and then the end of sanitary international emergence in May of 2023—according to Pan American Health Organization (PAHO 2023)). According to Latorre (2018), in 2016, web 4.0 is more smart and predictive. On the other hand, the pandemic had the social distancing as an imperative to break the expansion of new coronavirus. Thus, the use of digital technologies by the internet has become an important tool to work, study and have fun in lockdown times. It challenges the perception of time and space, and favors the advances in hybrid relationships between the present and virtual nowadays. Hence, the notions of intelligences (artificial and human) converge in several social practices, including tourism as people-centered phenomena.

The role of technology in neuroscience studies has been more than VR and AR, although it includes both. As mentioned, the advances in AC are a turning point. On tourism destinations, technology topics such as big data analysis, the structure, management and governance of data lakes are recurrent; moreover, smart destination is a systemic concept (Jovicic 2019). In this way, the interdisciplinary approach is an important part of the new keys to understanding the smart tourism experiences in the 21st century.

Although research about smart tourism experiences by perspectives of intention behavior (Jeong and Shin 2020) and topics of satisfaction, happiness and revisit intention (Pai et al. 2020) is reported in the scientific literature of tourism, the role of neuroscience applied in tourism (or neurotourism) is scarce. The construct to refer to a smart or smart tourism experience should be discussed in light of a neurosciences theories and methods context. Tourism is a consumer experience and Table 1 shows the neuroscientific methods and their applicability based on the study proposals according to Cerf (2017, pp. 76–77).

Table 1. Methods: what can be studied and mobility.

Method	What Can Be Studied	Mobility (for Marketing Studies)
EEG with many electrodes (>32)	Emotion, memory, attention, engagement	Not optimal, but possible
EEG with few electrodes	Emotion, engagement	Possible
fMRI	Emotion, memory, attention, engagement, pricing, reward, pain	Impossible
TMS [transcranial magnetic stimulation]	Accessibility to functions such as emotions, cognition, and executive functions	Not used previously; possible but is not necessary
Surveys	Subjective/perceived emotion, memory, subject/perceived engagement, estimated willingness to pay and answer to any possible question involving self-perception, response time	Possible
IAT [Implicit Association Test]	Associations, response time	Impossible
Eye tracking [ET]	Arousal, engagement, response time, attention, low-level features, recognition content-salient features	Possible
Facial coding	Emotion	Possible
Skin conductance [SC]	Arousal	Possible
Wearable devices	Location, movement, as proxies for some emotion; ultimately, non-neural	Possible
Electrophysiology	Emotion, attention, memory, engagement, pain, reward, willingness to pay, associations, decision-making processes, unconscious processes	Impossible

Source: Cerf (2017, pp. 76–77).

First of all, tourism is a mobility phenomenon, hence the mobile methods third column of Table 1 is a step relevant to understanding the tourism experience on time, if we consider the ecological experiments research using glasses of ET, wearable devices, and headband of EEG, among others. In general, to shape the future of destinations from smart tourism knowledge, we should consider the mobile methods as part of a new path of knowledge. And it requires deep discussions of ethics, as Tham et al. (2021) highlight. To understand the measure of constructs (such as emotions, attention, and memory) by technology (such as EEG and ET) and answer the question "what can be studied?", it is important to start from the theoretical perspective of construction, but include a theoretical perspective of hardware and software either. For instance, the emotions as a construct involve valence and arousal (see Russell 1989). On the other hand, the EEG methods have two perspectives of measurement acquisition and processing of their signals for psychophysiological responses: (a) time (amplitude, mean, variance, skewness and kurtosis); and (b) frequency. Thus, if the goal is to study the brain waves (alpha, beta, delta, theta), it is a frequency subject. But, if the goal is to achieve the event-related potentials (ERP), it is a research of time perspective (see Li et al. 2022b).

In this sense, Li et al. (2022a) explained the prospects of using EEG from methods and indices but they evoked theories and concepts approaches. Another of the main researchers that contributed to advances is Bastiaansen from Breda University of Applied Sciences, Netherlands (see Bastiaansen et al. 2019, 2022a, 2022b). For instance, the research group he leads specializes in EEG and physiological correlates of emotions. These initiatives are powerful because they highlight the role of neurosciences in understanding the construct as emotions, have to cross a border of science discipline and require additional effort combining knowledge of technology, statistics as well as human, social and health science. Therefore, the fetish of technology is a large problem when research applies neuroscientific methods without an interdisciplinary view that encompasses theories and methodology approaches.

In this perspective, tourism researchers have to ask themselves frankly if apply tools and methods from neuroscience whether, in fact, they can help to advance scientific knowledge of their research before considering use without the deepest knowledge about it. Still, tourism researchers should consider the complex process of translation concepts among several disciplines and the standpoint of the relationship between traditional methods and neuroscience methods before moving forward. Fraga and Rodrigues (2021) highlight one point about the neuroscience methods applied to solve problems of tourism: the relevance of triangulation among traditional methods (undeclared) and neuroscientific methods. In this way, the first question when the researchers intend the use of the neurosciences methods is to ask yourself about which characteristics of phenomena can be observable. There is a lot of complexity, as emotion is not the same as feeling. According to Damásio (2004) "(. . .) feeling depends on perception of a changed body state alongside the perception of a certain style of mental processing and producing of thoughts with themes consonant with emotion" (p. 52), whereas if the answer is emotion, some tools are more relevant; if the answer is attention, other tools are better. So, the understanding of the types of attention, emotions, and memories as complex constructs is the first step in line to solve any problem of smart tourism experience by the theoretical and methodological neurotourism context.

2.2. Shaping Future Destination—Smart Tourism Experiences and Neuroscientific Methods Approaches

The concept of "smart tourism experiences" was introduced by academia and is linked to smart destinations and the co-creation of the tourist experience in these destinations (Buonincontri and Micera 2016). With regard to building a sustainable experience in smart destinations, Platov et al. (2021) argue that smart technologies influence consumer behavior in smart destinations. In this vein, Hunter et al. (2015) have previously called for the introduction of a tool to explain the social implications of tourists' experiences in the context of smart destinations. In fact, as Buonincontri and Micera (2016) argue, the word smart in the context of the tourist experience in smart destinations is linked to the co-creation of tourism experiences.

The study by Soliman et al. (2021) identified the smart tourism experiences topics and their connectivity with subtopics. The study revealed a connection between the concept of smart tourism experience and hedonic technology. Given that "hedonic" is associated with pleasure and happiness, it can be deduced that hedonic technology is designed to provide enjoyment and well-being, aiming for positive emotions. If we consider hedonic technology with the co-creation of the tourist experience, we are looking at a more engaging collaborative approach to the tourism experience (Nohutlu et al. 2022). These experiences are influenced by the fulfillment of psychological needs, such as relationship, popularity and stimulation, which are linked to positive affect (Hassenzahl et al. 2015).

In the context of smart destinations, the smart technologies, hedonic technologies and also called immersive technologies, encompass virtual technologies. As Anita et al. (2021) argues, they influence smart tourism and smart experiences. This group of technologies applied to tourism includes virtual and augmented reality. According to several authors, these technologies can evoke more positive emotional reactions (Beck and Egger 2018; Flavián et al. 2020; Yung et al. 2021). Discussing emotions in the tourism context, Bastiaansen et al. (2019) considers that emotions are the focal point of the tourist experience in destinations, playing a crucial role in shaping memorable tourism experiences.

To understand the above, it is necessary to realize that the affective component of the tourist experience is expressed in the form of a succession of emotions, positive and/or negative, which occur during the anticipatory phase, the phase of the experience at the destination and its subsequent encoding in memory (Bastiaansen et al. 2019; Hosany et al. 2020).Various metrics have been devised over the years to categorize human emotions, which are generally divided into two perspectives: dimensional and discrete (Dabas et al. 2018). The most popular approach in the tourism scientific literature is the 2D Emotional Model (Dabas et al. 2018), by Russell (1989), which allows emotions to be distributed into four quadrants (Lang 1995) made up of two orthogonal axes (pleasure versus displeasure; low stimulation versus high stimulation). Each quadrant is dominated by a set of emotions, in which the following emotions dominate: 1st quadrant—Enthusiasm (valence: pleasure; emotional activation: high); 2nd quadrant—Relaxation (valence: pleasure; emotional activation: low); 3rd quadrant—Depression (valence: displeasure; emotional activation: low); 4th quadrant—Stress (valence: displeasure; emotional activation: high). So, arousal refers to the level of activation or alertness in response to a stimulus or situation and valence is the positive or negative nature of an emotional experience.

More recently, Hosany et al. (2020) emphasized the need to measure emotions in tourism experience considering the complexity of tourism, presenting a new theoretical model, Emotionapps, proposing three dimensions for measuring emotions: salience, valence and awareness. Authors had previously attempted to suggest a model asserting that satisfaction is a mediator in the correlation between tourists' emotional experiences and behavioral intentions. However, the study results did not support this proposed relationship Prayag et al. (2013).

Bastiaansen et al. (2019) brings to tourism studies the theoretical models of cognitive psychology and behavioral sciences, bridging the gap for the potential of neuroscientific methods for the practical, real-time measurement of tourist experiences. The authors contend that, in neuroscience, experiences do not exist; instead, emphasis is placed on the emotions felt during an experience, documented in episodic memory. They argue that emotions stem from biological responses to situations and manifest across three dimensions: (1) subjective experience (individual feelings), (2) expressive behavior (outward actions), and (3) physiology (bodily changes like heightened heart rate, blood pressure, and hormonal fluctuations). Even more, each experience is lived in very different real-time intervals, in just a few seconds or hours. The authors propose that by introducing an immersive experience through virtual reality, it becomes possible to access memory in real time and post-experience. Therefore, with the integration of immersive technologies with neuroscientific methods, a new research line opens the door to tourism experiences research in the context of shaping the future of destinations from new clues to smart tourism. Furthermore, El Archi et al. (2023) highlight the role of digital technologies to sustainable destinations. On the other hand, Tham et al. (2021) explained the relevance of the further discussion of the role of ethics in order to use technologies (ET, EEG, among others).Thus, innovations on destination by smart tourism perspectives for *pari passus* sustainable development and ethics precepts.

3. Methods, Techniques and Procedures

To address the research question, and fulfill the main objective of this study—to explore how neuroscientific methods can reinforce smart tourism and influence the future development of tourism destinations, providing insights for the advancement of destinations—three sub-objectives were delineated, as outlined in the introduction section. To achieve these sub-objectives, the present study adopts a hybrid methodology which comprises bibliometric and qualitative methods.

3.1. Methods and Techniques Used

To comply the research objectives, this study adopted a hybrid review approach, which includes bibliometric and qualitative/quantitative methods. Bibliometric methods were employed for the systematic literature review in the Scopus database and used on relational techniques for data analysis (co-word and network analysis). The qualitative component involved content analysis. As with other emerging topics in tourism, bibliometric were employed because they are an effective tool to highlight unknown patterns in specific research fields (Cardoso et al. 2022, 2024). Content analysis was due to its capacity for both, deductive analysis (based on theories), and deductive (emerging themes from the data) (Štreimikienė et al. 2020).

The hybrid approach, as used in analogous studies in the field of tourism (Lima Santos et al. 2020), combines bibliometric analysis with systematic review. The systematic review, on the one hand, allows for the identification of relevant databases considering the research objectives, the development of search strings with appropriate keywords to ensure comprehensive coverage, the screening of search results based on predefined criteria for the selection of studies and the extraction of relevant data (Köseoglu et al. 2016; Pahlevan-Sharif et al. 2019; Cardoso et al. 2024). The combination with content analysis, on the other hand, allows one to determine the unit of analysis (e.g., texts) and establish themes to accomplish the research objectives and develop a framework to guide the analysis process (Cheng et al. 2018).

To fulfill the first objective, we used Iramuteq version 0.7 Alpha 2 software to produce two outputs by the textual corpus formed by 117 abstracts: (1a) factorial correspondence analysis (FCA), by class of words on cartesian graph, using a hypergeometric law, and (1b) similitude analysis (SA), based on graph theory. On the textual corpus, the adverb was adjusted to supplement. According to Salviati (2017), a hypergeometric law is a discrete probability distribution. For the first, in similitude analysis, we used a frequency equal to (f = 40) or greater than, and for the second, in factorial correspondence analysis, the frequency used was equal to 10 or greater than. On the other hand, graph theory is part of mathematics to understand the relationship between objects (in this case frequency and co-occurrence of active words from the textual corpus).

In the second objective, the relational technique was employed to cross authors' keywords' collaboration network structure. This procedure was performed in R 4.3.1 Bibliometrix through Biblioshiny, which provides a web interface for R Bibliometrix. The collaboration network parameter used was the Louvan Clustering Algorithm by association. The outcome included 50 nodes after excluding isolated nodes. For the network map, the map parameters used were min edges 1. This stage also involved deductive content analysis because the research started from the objective of identifying: (2a) research networks with country collaboration map; (2b) neuroscientific methods in tourism experiences research networks; (2c) top 10 of the most relevant authors affiliations.

In the third objective, the inductive content analysis was applied oriented by the components of emotional experiences studied by neuroscientific, immersive and biometric methods, inductive content analysis was also applied, as categories were not selected because they emerged from the data itself (Cardoso et al. 2020). This stage identifies (2d) Neuroscientific methods and metrics applied to tourism experiences and emotional components.

3.2. Data Collection and Organization

In data collection, the Scopus database was chosen as a data source, as it is the largest top-quality abstract and citation dataset of peer-reviewed literature and there is not much fluctuation in the journals between the quartiles (Soliman et al. 2021).

The data collection procedures took place on 22nd March 2024. The search was performed in English using keywords derived from Cardoso et al.'s (2024) study and by adding a strategic craft query. The radical used included words related to tourism ("touris*" OR "hotel*"), with the aim of covering both sectors of tourism, tourism and hospitality, complementing with by adding neuroscientific methods and immersive technologies, with the objective of selecting only empirical articles. The systematic review protocol used in the database download phase follows the methodology used by Cardoso et al. (2020, 2022) and Lima Santos et al. (2020) and is shown in Figure 1.

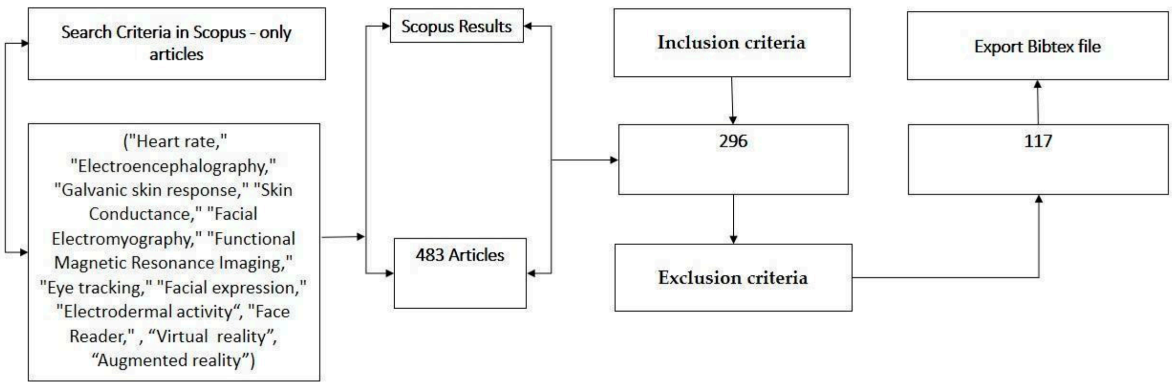

Figure 1. Search criteria in Scopus and organization procedures.

The global first search produced 483 papers. Then, only articles were included as search criteria, excluding book chapters and books, conference papers and editorials. So, a total of 296 papers were obtained. In the inclusion criteria, after a careful reading of the abstracts, articles not related to tourism were excluded, resulting in 117 papers that were exported into a BibTeX file.

4. Findings and Discussion Results

4.1. The Interconnection of the Most Relevant Topics That Use Neuroscientific Methods in Smart Tourism

The use of neuroscientific methods in tourism experiences from Iramuteq 0.7 Alpha 2 software outputs' delivered an important key to open the discussions to build a new school of thought on tourism in the 21st century. In this sense, Figure 2 shows us the distribution of the textual corpus (n = 117) in the cartesian plane (formed by two perpendicular real lines, that is, the angle between them is 90°) using a hypergeometric law with frequency equal to 10 or more. As mentioned in the methodology of the present study, the goal of this law is the probability of the existence of correlation between forms or words and corpus variables. In this case, it became evident that: (1) most of the variables (abstracts) were concentrated in 2nd and 3rd quadrants'. It demonstrates a strong correlation between most of the abstracts analyzed. (2) In contrast, the 1st and 4th quadrants have some variables (abstracts) that differ from the concentration and provide a reflexive counterpoint. Therefore, to shape the future of destinations and determine new clues to smart tourism, it is pertinent to examine the two conditions through neuroscientific methods, as illustrated in Figure 2.

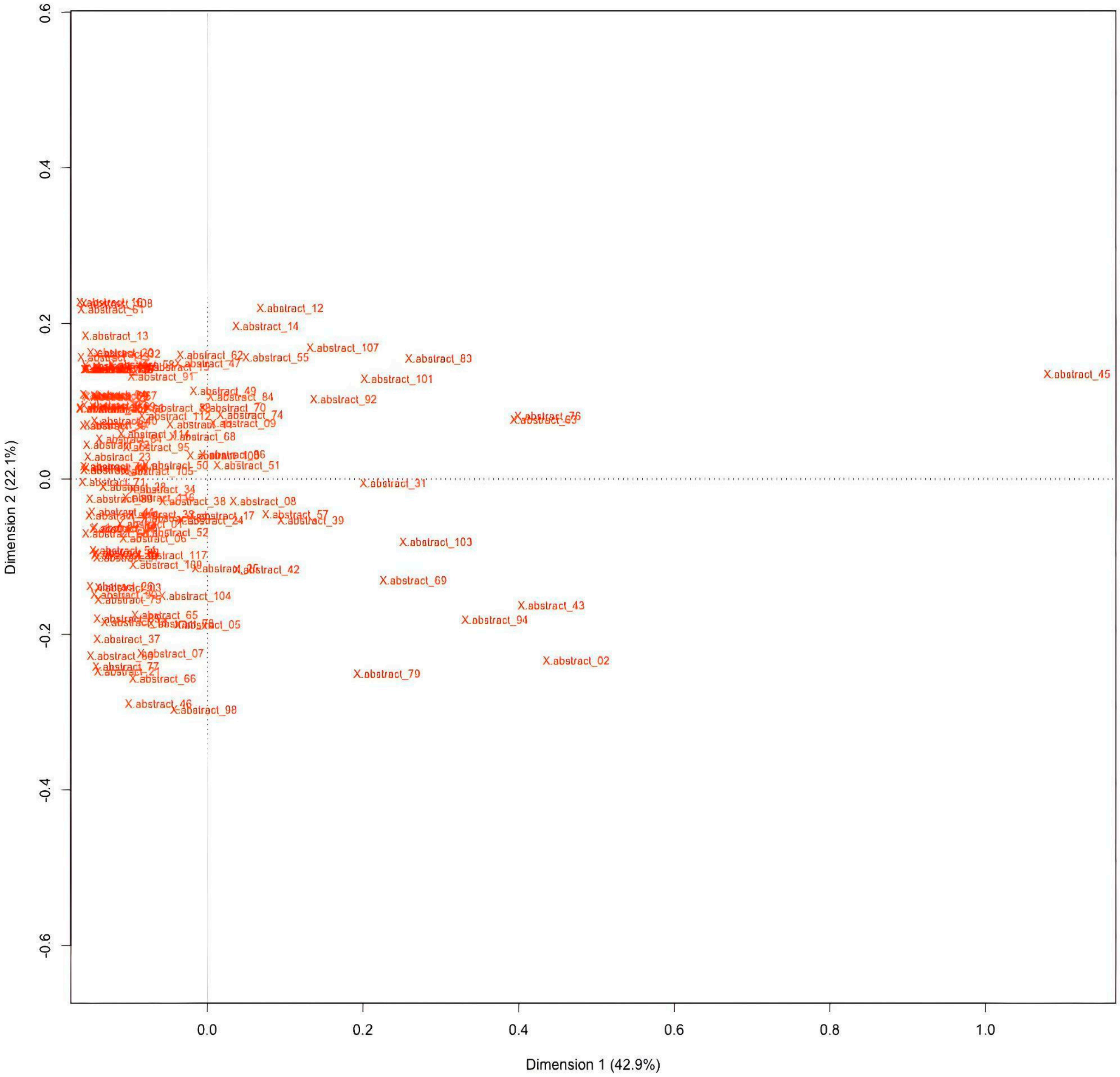

Figure 2. Factorial correspondence analysis.

From Figure 2, for instance, Fu et al. (2023) (abstract_45) analyzes the influence of visual elements of arcade buildings and streetscapes in the port area of Shantou Small Park in Guangdong (China) combined two methods: (1) ET and (2) semantic differential methods. In this perspective, the paper is distant from others because the main goal was to analyze the emotion of places from a tourist's perspective. However, in the context of smart tourism research, the authors introduce novel directions for future research through a triangulation of methods. Reinforcing the above argument, for example, while Urry and Larsen (2021) emphasize the importance of tourists' gazes from a sociological perspective, the advancement of smart tourism research involves studying the role of eye tracking, integrated with other methodologies, such as the semantic differential methods proposed by Fu et al. (2023). This new vision aims to improve scientific understanding of the evolution of tourism destinations in the future.

As another example, Dinh-Dang et al. (2023) (abstract_02), publishing in the journal Applied Ergonomics, crossed the line of interdisciplinary research involving tourism and ergonomics with the topic of medicine. They used the HR to investigate the assessment of cardiovascular load in the hotel context. The focus on hotel room cleaners demonstrated the importance of studies going beyond the tourist and also focusing on human resource management. Thus, to shape the future of destinations in the context of smart tourism, it is essential to use other methods of research (as HR) and to look at the other players in the tourism system, including the health of people working in the tourism and hospitality industries. An additional example is presented by Podstawski et al. (2022) (abstract_43), who published an article in a hospitality journal discussing the application of Finnish sauna tourism as a form of spa therapy in Europe, incorporating HR as part of analysis. Thus, it reinforces the transdisciplinarity as a turning point to shape the future of destinations in the context of smart tourism.

Going even further, we used the magnifying glass (mediated by graph theory), which was helped to understand the role of term co-occurrences from the textual corpus (n = 117) through similarity analysis (see Figure 3). To expand the debate on shaping the future of destinations looking for new clues to smart tourism research from neuroscientific methods approaches, in Figure 3, we have five halos of word communities. Table 2 explained the main points based on scientific evidence.

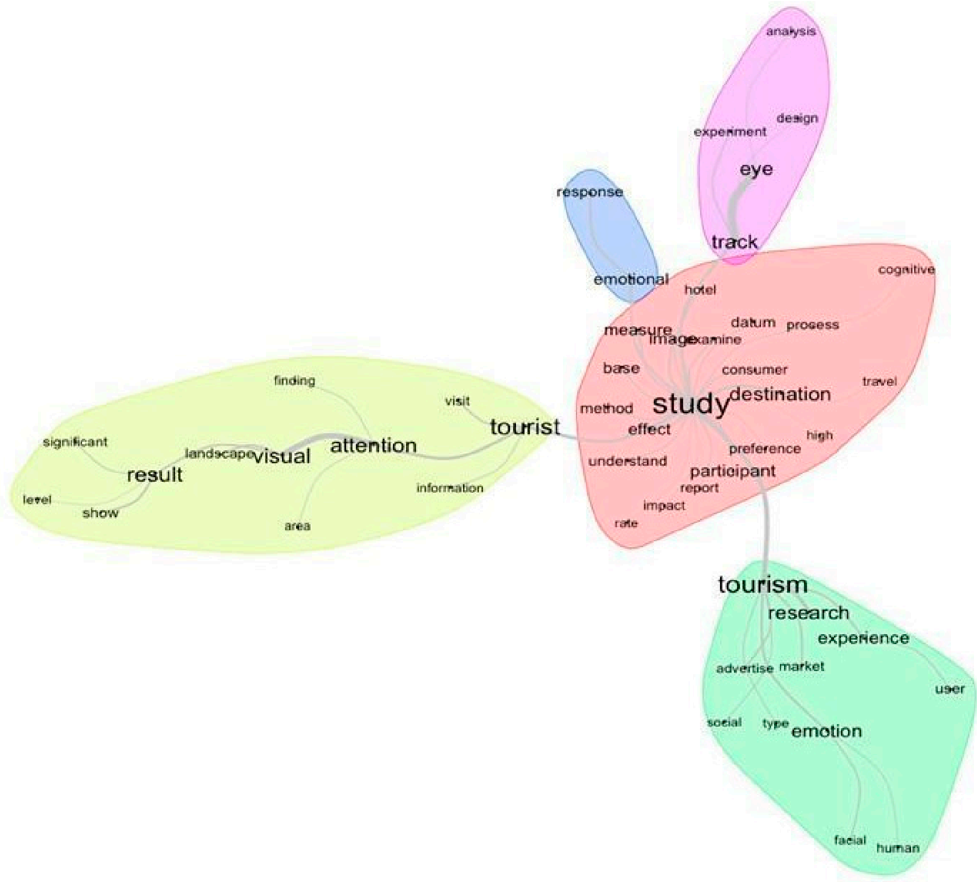

Figure 3. Similitude analysis.

Table 2. Scientific evidence by halos.

Halos (f = frequency)	Scientific Evidence
1.Study (f = 192)	In the search for neuroscientific methods applied in tourism research, a relevant finding word was destination (f = 134). Therefore, it is relevant to consider this textual corpus to shape the future of the destination in the perspective of smart tourism, achieving the main goal of this paper.
2. Tourism (f = 165)	It became evident that emotion (f = 113) as a new frontier of the research (f = 96) on touristic experience (f = 89) is the hot topic, as related by Moyle et al. (2019).
3. Tourist (f= 149)	The visual (131) attention (f = 126) in halo three, the significance of tourist's gaze was one of the most important aspects to shaping the future of tourism destinations from a neuroscientific methods perspectives.
4. Eye (f = 96) track (f = 93)	Eye tracking (f = 96) and track (f = 93) highlight issues related to experimentation, design and analysis. This technology can be mobile or fixed and, in certain cases, incorporates virtual reality and augmented reality possibilities. Therefore, the tourist gaze is validated as a significant facet of this textual corpus. The use of gaze-tracking technology should therefore be central to shaping the future of destinations in a smart tourism approach.
5. Emotional (f = 75) response (f = 64)	Another aspect of defining the future of smart tourism destinations includes studies that measure emotional responses (f = 75). If a smart destination offers a smart tourism experience, emotional responses become crucial in planning and managing its future.

According to Halo 1, the "tourism destination" as a theoretical category is observed in many studies that use neuroscientific methods. For instance, Zhao et al. (2022) used eye-tracking methods to analyze the effect of spatial and modality configurations on tourism destination advertisement attention. In this perspective, they also studied travel intentions. Shoval et al. (2018) created the emotional maps of Jerusalem city. They used tracking technologies (GPS) in real time to measure arousal at tourism destinations. Thus, to learn about emotional maps from neurosciences method perspectives is a significant advance to shape the future of destinations.

Tourism (Halo 2), as a contemporary phenomenon, has smart tourism a turning point. In this sense, Santamaria-Granados et al. (2021) mark a big step forward when their research uses wearable data to recommend tourist experiences based on emotion (Halo 2). On the other hand, Wang and Sparks (2016), by a triangulated approach (self-reports and observational ET data), highlight the role of visual attention. Thus, ET is a relevant technology tool in this way. New technology including the eyes as senses are important. For instance, Marchiori et al. (2018) focus on engaging VR experiences to promote tourism destinations (Halo 4). Here, there is a methodological crossroad between visual attention and emotional response (Halos 4 and 5). However, Marchiori et al. (2018) showed a transdisciplinary approach when they mixed: (1) biophysical data; (2) emotional responses; (3) HR data; (4) tourism destination; (5) VR, and (6) VR characteristics.

In short, the outputs (Figures 2 and 3) of software Iramuteq—from a qualitative and quantitative perspective—become undeniable in the role of the neuroscientific methods approaches to shaping the future of destinations if the goal is a smart tourism approach. Therefore, future lines of research should study the research networks (see Section 4.2). This exploration can enhance future research efforts by taking advantage of neuroscience methods and theories to address the challenges and drive advances in the ontology and epistemology of neurotourism, an emerging field of the 21st century.

4.2. The Research Networks Using Neuroscientific Methods in Smart Tourism

The research networks using the neuroscientific methods from 2000s to February 2024 applied to smart tourism run along a more expressive corridor, with a connection from Australia in two directions: (1) Australia to China and (2) Australia to France. There are two country collaboration links along this corridor: United Arab Emirates and Denmark and Spain and Portugal. As can be seen in Figure 4, another significant connection is made between researchers from China and the United States.

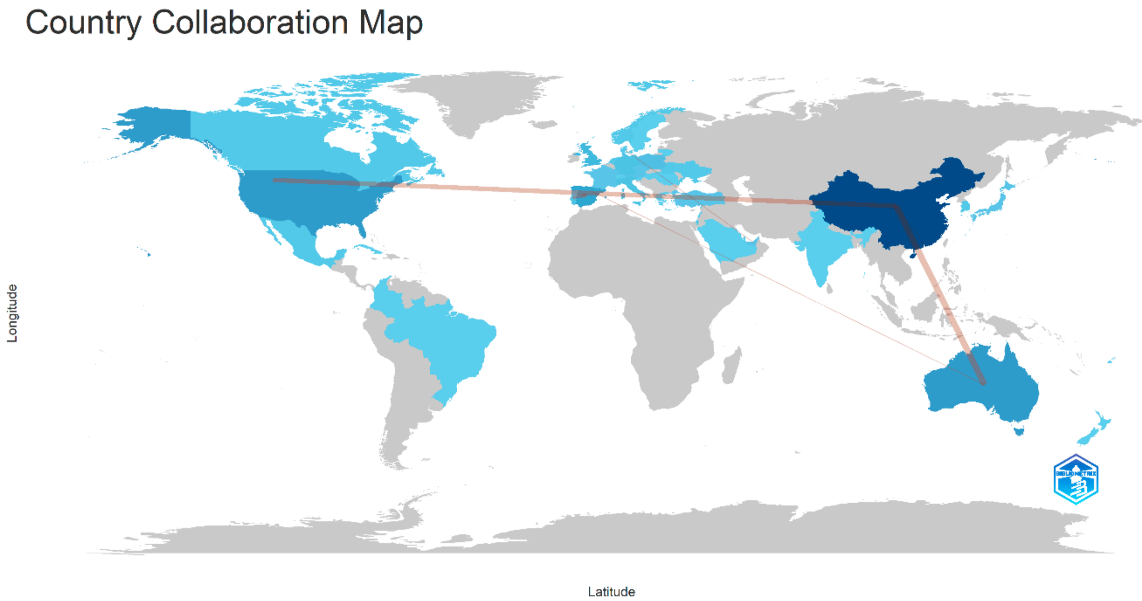

Figure 4. Neuroscientific methods in smart tourism research, a country collaboration map.

The collaboration network (see Figure 4) reveals the emergence of a new school, called neurotourism in the 21st century, formed mainly by actors and organizations from the Global North, evoking the need to include the Global South in the research scenario. The Global South and North are categories of analysis from development perspectives. For instance, the United Nations Development Programme—UNDP (2024, n.p.) highlights that the Global South "rests on the fact that all of the world's industrially developed countries (with the exception of Australia and New Zealand) lie to the north of its developing countries".

Thus, the results of the analysis of the authors' collaboration, as shown in Figure 5, reveal two clusters that stand out, two that are interconnected, and the rest are isolated clusters. The cluster with the highest representation (15 betweenness and closeness 0.142 on the connection) is "muños-leiva f" from the University of Granada's Department of Market Commercialisation (e.g., Hernández-Méndez and Muñoz-Leiva 2015; Muñoz-Leiva et al. 2019, 2021). Their research, conducted in collaboration with colleagues from Spain and Portugal, employs eye-tracking neuroscientific methods. In their first paper, Hernández-Méndez and Muñoz-Leiva (2015) explored online advertising through ET. Hernández-Méndez is from the University of Cadiz, Spain, specializing in marketing and communication. Muñoz-Leiva et al. (2019) investigates measuring advertising effectiveness on travel websites. The second author is a marketing professor at Laguna University, Spain, while the third is affiliated with the University of Cadiz, Spain, focusing on marketing and communication. Espigares-Jurado et al. (2020) analyzed visual attention on hotel websites' main images. The first author, also affiliated with Granada University's Department of Market Commercialisation, collaborated with five authors from the University of Algarve, Portugal, specializing in computing, tourism, and psychology. Muñoz-Leiva et al. (2021)'s paper examined the influence of banner position and user experience on topic recall. Four authors from Algarve University, Portugal, experts in tourism and psychology, collaborated with the final author from Granada University's business field. In García-Carrión et al. (2023), the research is focused on the effect of social-media message congruence with all authors from Granada University's marketing field. Finally, in García-Carrión et al. (2024), the research focused on destination social media content congruence with all authors from Granada University specializing in markets and marketing. So, this cluster includes psychology, business, marketing, computing and tourism experts who apply eye tracking to tourism studies, so we can say that this research has multidisciplinary and interdisciplinary integration in tourism. It is significant to shape the future destinations by smart tourism from the neuroscientific methods approach.

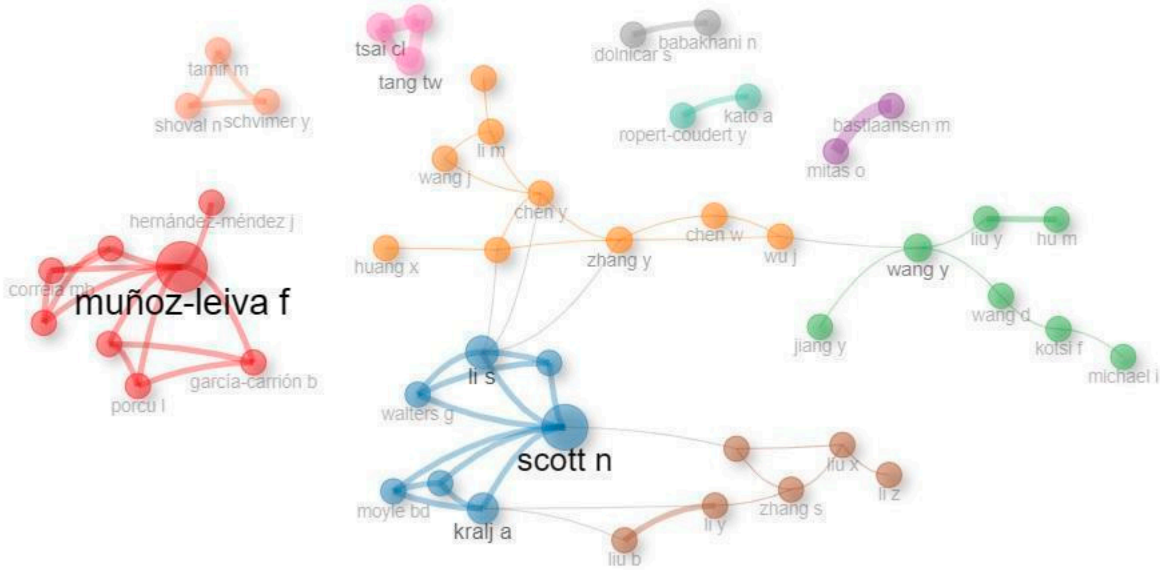

Figure 5. Neuroscientific methods in smart tourism research networks'.

The cluster "Scott N" presents 0.166 betweenness with various connections. Scott N., a philosophy researcher from the Griffith University, Australia, collaborates with multiple Australian universities, employing diverse neuroscientific and biometric methods in his research. In their study, Li et al. (2018) utilize skin conductance (SC) and facial electromyography to measure emotional reactions to tourism advertising. In this paper, Scott collaborates with authors from Queensland University, attracting researchers from the tourism and psychology domains. Kong et al. (2019) is a paper that evaluates attention and memory in the effectiveness of web advertising through ET. In this paper, Scott's co-authorship extends to Nanjing Normal University in China, as well as researchers specializing in geophysics and chemistry. With Hadinejad et al. (2019b) using FaceReader™ technology and Hadinejad et al. (2019a) using SC, the Scott's Griffith University team strengthen multidisciplinary cohesion. Thus, by bringing together researchers from Griffith University Australia and the University of the Sunshine Coast, Australia, Scott captures the scientific fields of philosophy, psychology, geophysics and chemistry for tourism.

The interconnection of clusters, originating in "Zhang Y" from Beijing Forestry University, China and "Wang Y" from Pekin University, China, brings virtual reality and engineering to the investigation of neuroscientific methods applied to tourism. This cluster also bridges the gap between China, the United Kingdom and Australia. However, the data provided by Scopus are not sufficient to characterize this interconnection and future lines of research could verify whether the pattern that occurred in previous clusters is maintained in this case.

A smaller but more compact cluster is the "Bastiaansen M" expert in experimental psychology, PhD in Cognitive Neuroscience and is the leader group of EEG and physiological correlates of emotions of Breda University of Applied Sciences, Netherlands. The cluster "Bastiaansen m" presents 0.166 betweenness with bilateral connections of 16 researchers; however, the outputs from Scopus regarding ORCID do not allow us to determine the scientific domains of these researchers. Regarding the papers published by this cluster, Bastiaansen et al. (2022b) present a study on emotion measurement in tourism destination marketing utilizing EEG technology. In a separate work, Bastiaansen et al. (2022a) employ SC and VR to investigate emotional engagement during a Roller-Coaster Ride. Additionally, Mitas et al. (2022) utilize SC and state-of-the-art computer vision techniques to explore the emotional dynamics of an exceptional experience. Following the collaboration between the authors, the findings of this research reveal that in the top 10 of the most relevant affiliations, as shown in Table 3, the ranking is led by Griffith University, Australia.

Table 3. Top 10 of the most relevant author affiliations.

Affiliation	Articles
Griffith University, Australia	9
Sun Yat-Sen University, China	7
Algarve University, Portugal	7
Granada University, Spain	6
Asia University, China	5
The Hong Kong Polytechnic University, China	5
Zayed University, Dubai, United Arab Emirates	5
Breda University of Applied Sciences, Netherlands	4
Shandong University, China	4
California University, USA	4

Lastly, the results of the research networks using neuroscientific methods in smart tourism reveal that there is a pattern in most studies of bringing different scientific domains into this area of research, and that this trend connects researchers from different countries according to their areas of expertise, which on the one hand is in line with Tasci's (2019) advocacy of integrating interdisciplinary into tourism for a more holistic understanding.

4.3. Neuroscientific Methods and Metrics Applied to Shaping the Future of Destination with a View to Smart Tourism

Beyond the details, the most important of these divergences and convergences is the fact the blurry zone among "neuroscientific methods", "immersive technologies" and "biometric technologies". What researchers call the "facial expressions" or "facial emotion" of biometric technologies is a relative technology (see Table 4). However, these technologies are based on neuroscientific methods such as facial coding (see Table 1). Thus, the top 10 were developed from two perspectives, according to the scientific literature consulted: (1) "neuroscientific methods" and (2) "immersive and biometric technologies". Finally, the construct that was the target of observation and measure by methods and/or technologies was added as (3) "construct". All perspectives are illustrated by the absolute frequency (f).

Table 4. Top 10 methods, technologies and constructs.

Top	Neuroscientific Methods	(f)	Immersive and Biometric Technologies	(f)	Constructs	(f)
1º	Eye Tracking	53	Virtual Reality	8	Attention	48
2º	Heart Rate	22	Facial Expressions	6	Preference	19
3º	Electroencephalography	10	Facereader™	3	Arousal	14
4º	Skin Conductance	8	Augmented Reality (ar)	1	Engagement	9
5º	Electrodermal Activity	4	Face Reader—Eye Movement	1	Valence	2
6º	FmRI	4	Facial Emotion	1	Attachment	1
7º	Facial Electromyography	2	Facial-Expression Recognition	1	Behavioral	1
8º	Blood Pressure	1	Mood and Facial Expressions	1	Emotion	1
9º	Brain Scanning	1	Online Survey	1	Emotions	1
10º	Corticosterone Levels	1	The-Art Computer Vision Techniques	1	Evaluation	1

Therefore, we highlight some lessons from the scientific literature to improve shaping the future of destinations in order to promote smart tourism. For instance, first of all, the "attention" refers to focusing on certain stimuli and has been applied mainly to studies on tourism advertising using eye tracking. However, it is often triangulated with preference (Hong et al. 2022). Thus, when we look at Table 4, the ET leads the ranking of studies with 53 studies applying this "neuroscientific method" (in some cases, together with other methods and technologies, often triangulated). Thus, if we review Table 1, when Cerf (2017, p. 66) explained "what can be studied" by use of ET, it is possible to note that: "Arousal, engagement, response time, attention, low-level features, recognition content-salient features". On the other hand, when we look for the "constructs" column, the scientific evidence confirms that the top ranking is "attention (f = 48)". Hence, with the role of ET as a "neuroscientific method" and "attention" as construct, both together is a step forward to understanding the gaze of tourists (see Urry and Larsen 2021) in the context of smart tourism perspectives in the 21st century.

Other lessons, in ontological and epistemological ways, are illustrated by the question of electrodermal activity (EDA) (n = 4) and skin conductance (SC) (n = 8) (see Table 4). They are often used synonymously to refer to the same physiological phenomenon. According to Li et al. (2022a), technically, they represent slightly different aspects of the same process—SC is used to measure electrical conductance through the application of a small electric current and EDA includes not only skin conductance, but also other related parameters such as skin resistance and skin potential. The same can be said for the results of using HR, which measures the frequency of heart contractions, and the use of heart rate variability (HRV), which reflects the dynamic fluctuations in the time intervals between heartbeats (Marchiori et al. 2018). In this study, it is not possible (the content analysis of data does not give this information) to ensure the accurate usage of terms. Therefore, subsequent research should conduct a comprehensive literature review to validate these findings, for instance.

The next lesson is on "preference" as a construct. It refers to liking or disliking and involves choices. It is often triangulated with arousal as in the study by Zoëga Ramsøy et al. (2019), which triangulates using eye tracking and electroencephalography (EEG). On the other hand, "engagement" refers to the state of being absorbed, concentrated and involved in an activity or experience and implies active participation. Examples of studies that measure engagement are the neuroscientific approach to hotel sustainability and ecological tourism by Fronda et al. (2021) and travel behavior by Penz et al. (2017) using eye tracking. In fact, the choice of neuroscientific methods triangulating immersive and biometric technologies depends on the objectives of each study and future lines of research should analyze which methods and techniques are most effective for assessing different emotional elements/constructs.

The last lesson is centered on the analysis of emotions as "constructs ", and the same problem of labels appears. For instance, when the question is emotion or emotions in plural. In theory, valence and arousal follow the stipulations of Russell's 1989 model defended by Dabas et al. (2018). In addition, Marci and Murray (2017) explained that "The basic emotion (to body) theory posits that there is a discrete set of biologically basic emotions (e.g.,: fear, sadness, anger, happiness) that are universal across individuals and cultures". Also, they explained "The psychological construction theory (to/from body) uses a multidimensional scaling approach to parse emotional responses into two orthogonal dimensions upon which emotions are constructed: arousal and valence" (pp. 152–53). Therefore, the advances in shaping the destination in a smart tourism way depend deeply on the emotions as a complex construct. As mentioned, according to Moyle et al. (2019), the new frontier of research of tourism is emotion. Thus, emotions as complex constructs plus the blurry zone between methodologies and technologies identified in Table 4 delivered a new paradigm. So, the researchers will be challenged by several border questions, and will probably take a disciplinary approach in the secondary plan. After all, the blurry zone between methodologies and technologies, in fact, is a transdisciplinary invitation to understanding destination tourism questions in order to achieve smart tourism in the 21st century.

4.4. Limitations, Theoretical and Practical Implications and Future Research Directions

In terms of limitations, this study followed the strategic craft query when searching for keywords in Scopus, so studies that do not include the keywords in this craft query are excluded. Future studies in this area could use another keyword search craft query to confirm or refute the results of this study.

In practical implications, this study provides both theoretical and practical implications concerning the role of neuroscientific methods in contributing to the advancement of smart tourism and influencing the future of destinations. The theoretical foundations of the results of this study identify neuroscientific methods, immersive and biometric technologies and the elements of emotions that act as a lever for smart tourism research and management. Furthermore, this study identifies the main authors and research networks applying neuroscience to tourism, facilitating the identification of specialists by type of technology, enabling the extension of future collaborative networks. This study brings methodological contributions by applying an innovative hybrid methodology mixing bibliometric techniques with content analysis in the area of neuroscientific methods applied to smart tourism.

In the context of neuromanagement, this study discusses and identifies the typology of neuroscientific methods applied to tourism, making it a useful tool for managers of tourism products and destinations. Neuroscientific tools can capture and record the cognitive and emotional process in real time during the tourist experience and this application helps the tourism manager to achieve better monitoring and programming. In this way, stakeholders can use the neurophysiological data to be added to the management information system. However, Pykett et al. (2020), from the field of neurourbanism, explained that:

> "City authorities increasingly favor new data-driven and technology-enabled approaches to governing smart cities, with the aim that governments will be enabled to pursue evidence-based urban well-being policies. Yet there are few signs that our cities are undergoing the transformative, structural changes necessary to promote well-being" (p. 1936).

Given the importance that tourism plays in countries' economies, this study reveals the growing application of neuroscientific methods to tourism research. The results of this study reveal a crucial political implication. Governments and regulatory bodies will need to develop policies and regulations governing the ethical use of neuroscientific techniques in tourism research, including guidelines for obtaining informed consent from participants, guaranteeing the privacy and confidentiality of data and addressing potential ethical concerns related to the manipulation of emotions or behavior. In this manner, Roskies (2002) demonstrated the significance of neuroethics in addressing both present and future challenges.

In terms of future research, this study proposes further investigation into the potential of interdisciplinary collaborations within smart tourism research networks, leveraging neuroscientific methodologies towards the development of tourist destinations leveraging smart tourism. Furthermore, recognizing the inconsistencies in terminology associated with neuroscientific methods, future research efforts should focus on elucidating the appropriate use of these terms.

5. Conclusions

As mentioned throughout this study, in the 21st century, a bridge between two realms, the human and the artificial, is prominent in order to advance along the path of smart tourism. In fact, neuroscience methods are one of the new frontiers of knowledge that can connect these domains. In this sense, this research has highlighted the most prominent topics for shaping the future of destinations from a smart tourism perspective. This study concludes that:

The application of the hypergeometric law through factor analysis of correspondences reveals a remarkable trend in studies employing neuroscientific methods in the field of tourism: the emergence of a transdisciplinary approach that transcends disciplinary boundaries. This approach is evident in the collaborative efforts of experts from various fields, including psychology, management, marketing, computing and tourism, who collectively use neuroscientific methods from ET, HR, EEG, SC, EDA, fMRI, FE and immersive technologies such as VR and facial expressions in their research. This research paradigm emphasizes the fusion of multidisciplinary and interdisciplinary methodologies in the field of tourism. This integration emphasizes the importance of using neuroscientific methods to drive smart tourism and shape the future trajectory of tourism destinations.

Although the term "neuroscience" was not evident in the similarity analysis, considering that the search focused on empirical studies and did not include this word, it is relevant to delve deeper into the theoretical dimension of neuroscience and how interdisciplinary knowledge can advance in ontology and epistemology beyond the use of neuroscientific methods in isolation.

This study identifies five key elements of behavior and cognition dimensions using neuroscientific methods and immersive technologies: attention, preference, arousal, involvement and valence (emotions). These elements are crucial to understanding emotional responses in smart tourism and the evolution of tourism destinations. Attention, which is mainly studied through ET, is often correlated with preference. Preference, which involves choices and liking or disliking, is often linked to arousal, as can be seen in recent studies using ET and EEG. Engagement, which indicates active participation in an experience, has been explored in various contexts, such as hotel sustainability and travel behavior, using neuroscientific approaches. However, the choice of neuroscientific methods, immersive technologies and biometrics, or the combination of them, depends on the specific objectives of each study.

It is therefore clear that the relationship between neurosciences and computing supports the new frontier for shaping the future of tourism destinations from the perspective of smart tourism. And it requires the strengthening of a new school of thought in the 21st century, which has been called neurotourism.

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