



A Review of Eye-tracking Technology Application in Tourism Research

Lin Ma*, Xiaohua Wang^a

School of Tourism & Research Institute of Human Geography, Xi'an International Studies University, Xi'an 710128, China

*Corresponding author: molly102@yeah.net

^awangxiaohua@xisu.edu.cn

Abstract. To avoid information overload, the human brain selects the information it notices, making selective attention a scarce resource. Most topics in tourism research have centred around tourist attention due to the focus on tourists. However, the measurement of attention has been carried out by questionnaires and interviews, which are subjective methods that may be influenced by factors such as social expectations and personal values to make the experiment fall into error. Since 80-90% of the information in the human brain originates from the visual system, measuring visual attention can reflect human attention. Eye-tracking technology based on that principle can measure human attention very well. This paper focuses on the following three topics: (1) Introduction of eye-tracking technology; (2) Summary of the research content in different tourism fields; (3) Conclusion of the shortcomings and future enhancement approaches. Based on those, this article makes several contributions. By analysing the application of eye-tracking technology in tourism research, the paper will provide new research methods and research ideas for later studies and help the development of the tourism discipline.

Keywords: review, tourism; eye-tracking technology; eye movement

1 Introduction

Selective attention reduces people's information burden and makes attention more precious. With the development of information technology, information dissemination has become convenient and efficient, as well as more crowded and overloaded, to avoid the negative impact of information overload on individuals, the human brain can select the information it is exposed to. The emergence of selective attention is inextricably linked to the evolution of human beings. Early human beings lived in a complex environment, where they needed to pay attention to natural disasters that might occur or had occurred, and also needed to obtain food by paying attention to prey, that is why they were more dependent on attention, especially visual attention. Today, the human brain and sensory system evolved the ability to pay selective attention to avoid visual information overload and to ensure that attention is focused on key things, which makes selective

© The Author(s) 2024

F. Cao et al. (eds.), *Proceedings of the 2023 5th International Conference on Economic Management and Cultural Industry (ICEMCI 2023)*, Advances in Economics, Business and Management Research 276,

https://doi.org/10.2991/978-94-6463-368-9_98

attention scarce in the age of information explosion. 80-90% of the information in the human brain originates from the visual system ^[1], so a variety of marketing tactics have been formulated and implemented for obtaining the audience's visual attention, and even a new word of eyeball economy appeared.

Studying the selective attention of tourists can advance the solution to the core problems of tourism and promote the development of the tourism discipline. Tourist attention is reflected everywhere in the studies of the tourist gaze, tourist perception, destination image, etc., but there is a lack of appropriate ways and means to study tourist attention, which has limited the research on tourist behaviour and validity testing. The common methods of questionnaire and interview can obtain tourist attention information for the study, to a certain extent. However, the information obtained is subjective, and the participants may provide information that does not correspond to the real situation due to their values, relationship with the researcher, social expectations, etc., which reduces the study's accuracy.

The emergence of eye-tracking technology provides a research method for tourist attention, this technology is used to study attention by its measurement of visual attention. The appearance of this technology has opened up a new world of visual perception research and can lead us into the mysterious world of visual perception and visual attention, so it has been widely used in various disciplines. The application prospect of eye-tracking technology in tourism is also very promising, but the current research is very little.

After combing the relevant literature, we find three main issues. First, the distribution field of papers is uneven as a result of 73.77% of related articles focusing on tourism marketing. Second, eye-tracking technology has limited interpretive power, even if it can obtain accurate results. Different mental processes may produce similar behavioural results in experiments, for example, changes in pupil size may be caused by difficulty in reading or by emotional responses, but eye-tracking technology cannot explain the cause of the behaviour. Third, the representation of experimental materials and participants in some papers requires further discussion.

To sum up, this paper mainly focuses on the following three topics: (1) Introduction of eye-tracking technology; (2) Summary of the research content in different tourism fields; (3) Conclusion of the shortcomings and future enhancement approaches. Based on those, this article makes several contributions. First, this paper introduces eye-tracking technology which is a new method to measure attention. Second, it provides references for later studies by analysing the distribution areas of previous studies and the research content of different fields. Third, it advances the development of the tourism discipline by providing suggestions for improvement.

2 Eye-Tracking Technology

2.1 About Eye-Tracking Technology

Most animals with a developed visual system control their vision through eye or head movement, which enables them to obtain a large amount of visual information, thus eye movement is the basis of the visual system. Eye movements can be tracked with great

speed and precision, and there are three types of eye movements: fixation, saccade, and smooth pursuit [2]. Fixation is a common movement of the eyeball for visual processing, the light (stimulus) of a specific part of the visual field gathers in the sensory fovea with a higher density of neurons during fixation. At that time, the visual acuity reaches the highest and the attention is more concentrated, and the stimulus received more cognitive processing. When the eyeballs flick, light (stimuli) is distributed to the parafovea around the eyeballs and the fovea of the surrounding sensory neurons, which areas have a low density of sensory neurons and can only provide perceptions of general shape, colour, and movement of objects. During the smooth pursuit, the eye moves from a fixation point to look for the next target, and the brain can quickly grasp the main points in the field of vision although it can't receive specific perceptual information [3].

Eye-tracking technology is based on hardware or software, for example, using eye cameras to lock the eyes or using software to locate the face and eyes in the image to track eye movement. In eye tracking, it is particularly important to study the area of interest (AOI), that is, the attention area. Many measurement indicators have been formed based on the measurement of the three main eye movements in the search for AOI. The commonly used measurement indicators are total fixation times, fixation duration, fixation times, fixation point sequence, time to first arrival at AOI, etc. (Table 1) [2].

Table 1. The main measurement indicators of eye movement

Metric	Description
the total number of fixations	the more fixations happen, the more unreasonable the layout of the display area may be. Besides, the relationship between the number of fixations and the task time should also be considered (e.g., the longer the task costs, the more fixations are required)
fixation duration	reflects the difficulty of extracting information, a longer duration means that a participant is harder to obtain information from the display area
the number of fixations	is a sign of the importance of the area, the more important the display area is, the more times it is watched
the fixation point sequence	the conversion of the fixation point can measure the rationality of the user interface layout
time to reach AOI for the first time	when searching for a specific target in the display area, the time to reach the target area for the first time is an important indicator of the rationality of the user interface layout

2.2 Advantages and Disadvantages of Eye-Tracking Technology

Eye tracking is a psychophysiological technique commonly used to measure attentional processes, it has both advantages and disadvantages compared with other traditional methods. Traditional methods of self-report, questionnaire methods, etc. rely on the participant's memory and recollection, which may lead to wrong conclusions due to the participant's unclear memory and forgetting. Besides, affected by social expectations, correct values, etc., participants may conceal their real consciousness and behaviour, making researchers get invalid data. In this case, eye-tracking technology can ensure the timeliness and accuracy of the data by recording the participant's visual trajectory, fixation, saccade, fixation times, fixation duration and other data records.

However, this technique also has disadvantages. First, the eye-tracking equipment requires the eyesight of the participants, which makes the design and implementation of eye-tracking experiments more time-consuming than traditional methods. Secondly, the quantity of equipment is usually limited due to the high cost, and a machine can only be used by one participant at a time in the eye-tracking experiment, thus eye-tracking experiment is more inefficient than others. Finally, eye-tracking software requires rigorous calibration procedures to ensure accurate data collection, or the information collected could be invalidated.

3 Application Research of Eye-Tracking Technology In Tourism

Search for pairs of keywords, tourism and eye-tracking, tourism and eye movement in the Web of Science database, and the period from January 1, 2012, to July 15, 2023, we got 61 papers after eliminating duplication and weak association. According to the data from journals and conferences in the Web of Science database, the first publication appeared in 2012, and the peak time of publication is in 2019 when the publication was 15, but the overall quantity is still small (Figure 1). Therefore, eye-tracking research in tourism needs more attention and effort.

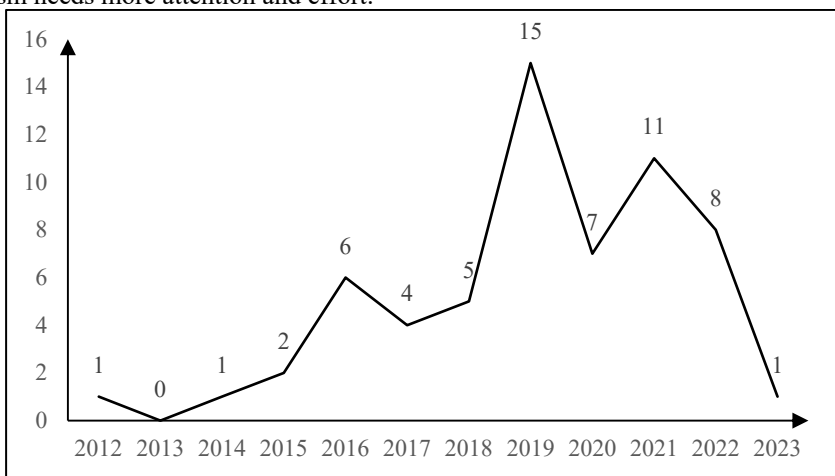


Fig. 1. Publications per year of the source paper

Through manual combing and keywords identified, the literature mainly covers five fields: tourism marketing, tourism landscape, environmental protection, experimental ethic, and literature review. As shown in Figure 2, we can see the existing research concentrated on tourism marketing.

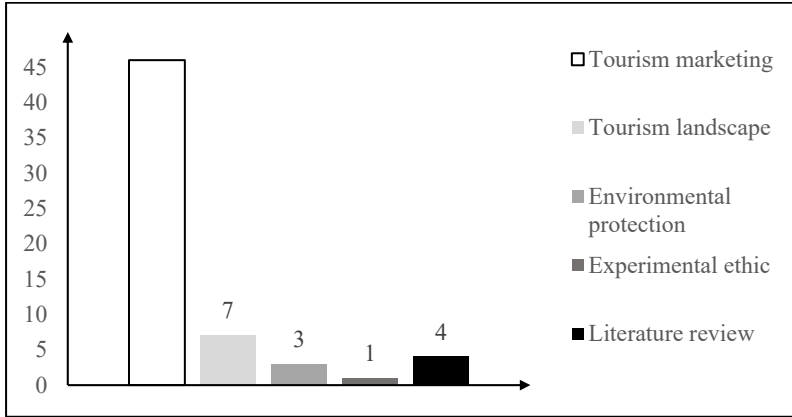


Fig. 2. Distribution of the number of documents of each type

3.1 Tourism Marketing

The design of tourism marketing materials usually requires theoretical support, and their effects need to be tested. In this case, eye-tracking technology is a good way to reflect the process and result of an individual's visual attention. Scholars tracked tourists' eye movement behaviour when they paid attention to objects such as brochures, food labels, pictures and landmarks [4-6], or studied the eye movements and behaviours of tourists under different tasks, cultural backgrounds, ages, and tour modes [7-11]. In a recent study, scholars compared the engagement level and emotional response of tourists in real and virtual tourism experiences, this study demonstrates the possibility of using eye-tracking technology for virtual tourism research [12].

3.2 Tourism Landscape

Landscape not only provides people with aesthetic enjoyment and a certain healing effect but also undertakes practical functions, so the planning and evaluation of landscape are of great significance. The evaluation methods of landscape were relatively subjective in the past, but it is becoming more accurate and objective with the application of eye-tracking. In previous research, scholars explored tourists' perception of the function and aesthetics of landscape, such as the visual perception of tourists of artificial architectural or natural elements [13-14]. Besides, scholars also evaluated the function of landscape, for example, they tested or evaluated the impact of landscape on tourist routes and wayfinding by eye-tracking technology [15-16].

3.3 Environmental Protection

To promote sustainable tourism, previous studies have focused on environmental protection. Babakhani et al. studied the awareness level of air passengers on carbon offsets, emphasized the importance of awareness for behaviour change, and proposed that other

information is needed to attract passengers' attention to carbon offsets. Subsequently, they studied consumers' visual attention to carbon labels on restaurant menus, and they believed that guiding consumers to choose more environmentally friendly menu items can reduce the negative environmental impact of tourism and hotels [17]. Penz et al. tracked the participants' perception of hotels with sustainable certification labels and suggested that displaying sustainable labels appropriately on tourism platforms can increase travellers' awareness of sustainability, thereby increasing sustainable tourism behaviour [18].

3.4 Experimental Ethic

Tham et al. discussed the ethic of invasive technology by using an approach of collaborative ethnography. In this research, three cross-cultural researchers shared and discussed their perspectives on three main questions, namely the meaning of ethic to researchers, the ethic in tourism and hotel research, and the proof ethic provided for moral responsibility [19].

4 Conclusion and Discussion

Based on the Web of Science database, this study collates tourism research using eye-tracking technology. Through the analysis of previous literature, we believe that the application of eye-tracking technology in tourism can be improved from three dimensions: research field, research method, and experimental design.

First, the research fields need to be expanded. According to the statistics we collected, 73.77% of related articles are centred around tourism marketing. There is a lack of exploration in other fields, especially in experimental ethic. Although the existing research has not exposed the problem of experimental ethics, there is still possible to cause physical, mental, and psychological harm to the subjects. Meanwhile, the current national institutions responsible for experimental ethics are relatively scattered, and the views on the institutionalization of academic ethics are not unified [19], so the ethical norms for the application of eye-tracking technology need to be further discussed.

Second, more research methods can be added to obtain more precise data. With the development of technology, many methods can be used with eye-tracking technology, such as functional magnetic resonance imaging, electroencephalogram, positron emission tomography, magnetoencephalography, and galvanic skin response. In experiments, different mental processes may produce similar behavioural results, and these techniques help to identify and distinguish the mental processes associated with specific behaviours, making the research more rigorous and in-depth [20].

The experimental design needs further consideration, especially in experimental materials and subjects. The data collection in an outdoor eye-tracking experiment may get into trouble, for example, an infrared camera does not work due to infrared reflection on the beach, that would make the experiment fails. That is why researchers prefer to experiment in an indoor environment, but the experimental materials they used in indoor experiments are possible to mislead the data. They often use pictures to replace

the real landscape and collect participants' eye-tracking data on the landscape while there is a controversy on whether tourists behave the same in real and virtual environments. Therefore, the scientificity of experiments which try to grasp landscape preference by replacing real environments with pictures needs to be thought twice^[21]. Besides, the majority of participants who participate in eye-tracking experiments are college students as a result of their accessibility, high quality and cooperation, but they cannot fully represent the tourist group, which makes the research conclusion lack universality and rigour.

5 Limitations and Prospects

As an emerging technology, eye tracking has a very small number of studies, and, as a result, related literature can only be analysed manually rather than using CITESPACE, VOSviewer and other software for commonality aggregation analysis.

Eye-tracking technology can help tourism disciplines form theories and paradigms from the experimental level, and promote the development of tourism disciplines. The application of eye-tracking technology is helpful to the exploration and establishment of theoretical knowledge, and we can find evidence in psychology, which has many intersections with the discipline of tourism. In psychology, a large number of experimental accumulations are often used to construct theoretical explanations, such as testing children's cognition of the psychological world through experiments. Therefore, tourism disciplines can also use eye-tracking technology to study tourists' cognition, perception and so on, and try to explain the mechanism behind it, to verify and establish theories and paradigms.

Acknowledgments

This work was supported by the Postgraduate Research Fund Project of Xi'an International Studies University (project number: 2021SS096).

References

1. Rainoldi, M., & Jooss, M. (Eds.). (2020) Eye tracking in tourism. Springer, Switzerland. <https://link.springer.com/book/10.1007/978-3-030-49709-5>.
2. Scott, N., Zhang, R., Le, D., & Moyle, B. (2019) A review of eye-tracking research in tourism. *Current Issues in Tourism*, 22(10), 1244-1261. <https://doi.org/10.1080/13683500.2017.1367367>.
3. Xu, X., Scott, N., & Gao, J. (2017) Cultural influences on viewing tourism advertising: An eye-tracking study comparing Chinese and Australian tourists. *Journal of Tourism & Services*, 8(14). <https://research-repository.griffith.edu.au/bitstream/handle/10072/413856/Xu250360-Published.pdf?sequence=2>.
4. Savelli, E., Gregory-Smith, D., Murmura, F., & Pencarelli, T. (2022) How to communicate typical-local foods to improve food tourism attractiveness. *Psychology & Marketing*, 39(7), 1350-1369. <https://doi.org/10.1002/mar.21668>.

5. Hong, W. C. H., Ngan, H. F. B., Yu, J., & Zhao, Y. (2022) An eye-tracking study of exoticism in intra-national destinations in the Greater Bay area of China. *Tourism Recreation Research*, 47(4), 414-427. <https://doi.org/10.1080/02508281.2020.1846431>.
6. Kong, S., Huang, Z., Scott, N., Zhang, Z. A., & Shen, Z. (2019) Web advertisement effectiveness evaluation: Attention and memory. *Journal of Vacation Marketing*, 25(1), 130-146. <https://doi.org/10.1177/1356766718757272>.
7. Lin, W., Li, M., Lin, J., & Lin, J. (2022) Self-decisions versus other-decisions in adventure tourism. *Journal of Travel & Tourism Marketing*, 39(1), 31-41. <https://doi.org/10.1080/10548408.2022.2044973>.
8. Huang, X., Chen, M., Wang, Y., Yi, J., Song, Z., & Ryan, C. (2022) Visitors' spatial-temporal behaviour and their learning experience: A comparative study. *Tourism Management Perspectives*, 42, 100951. <https://doi.org/10.1016/j.tmp.2022.100951>.
9. Lustigová, Z., Jarolímková, L., & Žufan, J. (2021) Evaluation of Tourist Decision-Making Process by Eye-Tracking Method–Focused on Methodology Gap and Cross-National Comparison. *Journal of Tourism and Services*, 12(22), 89-104. <https://www.jots.cz/index.php/JoTS/article/download/258/98>.
10. Coba, L., Rook, L., & Zanker, M. (2020) Choosing between hotels: impact of bimodal rating summary statistics and maximizing behavioural tendency. *Information Technology & Tourism*, 22, 167-186. <https://link.springer.com/article/10.1007/s40558-019-00156-z>.
11. García-Carrión, B., Del Barrio-García, S., Muñoz-Leiva, F., & Porcu, L. (2023) Effect of social-media message congruence and generational cohort on visual attention and information-processing in culinary tourism: An eye-tracking study. *Journal of Hospitality and Tourism Management*, 55, 78-90. <https://doi.org/10.1016/j.jhtm.2023.03.006>.
12. Xie, Z., Zhang, M., & Ma, Z. (2022) The impact of mental simulation on subsequent tourist experience–dual evidence from eye tracking and self-reported measurement. *Current Issues in Tourism*, 1-16. <https://doi.org/10.1080/13683500.2022.2106194>.
13. Guo, S., Sun, W., Chen, W., Zhang, J., & Liu, P. (2021) Impact of artificial elements on mountain landscape perception: An eye-tracking study. *Land*, 10(10), 1102. <https://www.mdpi.com/2073-445X/10/10/1102>.
14. Gao, Y., Zhang, T., Zhang, W., Meng, H., & Zhang, Z. (2020) Research on visual behavior characteristics and cognitive evaluation of different types of forest landscape spaces. *Urban Forestry & Urban Greening*, 54, 126788. <https://doi.org/10.1016/j.ufug.2020.126788>.
15. Fedotov, D., Matsuda, Y., Takahashi, Y., Arakawa, Y., Yasumoto, K., & Minker, W. (2018) Towards estimating emotions and satisfaction level of tourist based on eye gaze and head movement. In: 2018 IEEE International Conference on Smart Computing. Sicily. pp. 399-404. <https://ieeexplore.ieee.org/abstract/document/8421393>.
16. Sang, Å. O., Tveit, M. S., Pihel, J., & Hägerhäll, C. M. (2016) Identifying cues for monitoring stewardship in Swedish pasture landscapes. *Land Use Policy*, 53, 20-26. <https://doi.org/10.1016/j.landusepol.2015.09.020>.
17. Babakhani, N., Ritchie, B. W., & Dolnicar, S. (2019) Improving carbon offsetting appeals in online airplane ticket purchasing: Testing new messages, and using new test methods. *Journal of Sustainable Tourism*, 25(7), 955-969. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780203711668-6/improving-carbon-offsetting-appeals-online-airplane-ticket-purchasing-testing-new-messages-using-new-test-methods-nazila-babakhani-brent-ritchie-sara-dolnicar>.
18. Penz, E., Hofmann, E., & Hartl, B. (2017) Fostering sustainable travel behavior: Role of sustainability labels and goal-directed behavior regarding touristic services. *Sustainability*, 9(6), 1056. <https://doi.org/10.3390/su9061056>.

19. Tham, A., Schaffer, V., & Sinay, L. (2021) The ethics of experimental research employing intrusive technologies in tourism: A collaborative ethnography perspective. *Tourism and Hospitality Research*, 21(3), 303-316. <https://doi.org/10.1177/1467358421993893>.
20. Zhang, J., & Chen, M. L. (2022) Application of neuroscience methods in online consumer behavior research: a review based on online consumer behavior patterns. *Foreign Economics & Management*, 44(02), 84-101. <https://qks.shufe.edu.cn/J/WJGL/Article/Details/1adb8deb-c7a6-4706-aa54-133b0279774f>.
21. Yu, Z. Y., & Liu Y. (2020) Reflection and prospect on the application of eye tracking experimental method in tourism psychology research. *Tourism Tribune*, 35(12), 7-8. <https://doi.org/10.1016/j.tourman.2023.104750>.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

