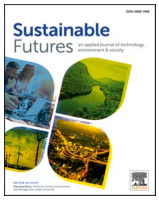
Sustainable Futures 10 (2025) 100811

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures



The effect of pre-trip virtual reality and on-site smart device use on accessible tourism experiences

Chung-Shing CHAN [a,*], Shing Yan WONG [b], Dora AGAPITO [c], Veleda TAM [b]

[a] Centre for Environmental Policy and Resource Management (CEPRM) Department of Geography and Resource Management, The Chinese University of Hong Kong, Room 244, Sino Building, Sha Tin, N.T., Hong Kong
[b] Department of Geography and Resource Management, The Chinese University of Hong Kong, Sha Tin, N.T., Hong Kong
[c] Research Centre for Tourism, Sustainability and Well-being (CinTurs) and Faculty of Economics, University of Algarve, Faro, Portugal

ARTICLE INFO

Keywords:
Virtual reality
Smart devices
Hearing loss
Travel barriers
Rural tourism experience
Accessible tourism

ABSTRACT

This study investigates the contribution of pre-visit virtual reality (VR) experiences and the use of smart devices (SDs) in enhancing accessible tourism for visitors with hearing loss at Yim Tin Tsai Island, a rural destination in Hong Kong. A total of 163 participants, including 78 individuals with varying degrees of hearing impairment and 85 persons without reported disabilities, participated in a self-guided visit. They were randomly assigned to four groups based on whether a VR experience was provided before the visit and whether SDs were used during the visit. Post-visit focus group discussions explored challenges faced, solutions proposed, and perceptions of VR and SD applications. The findings suggest that while VR and SDs offer practical and emotional benefits, visitors with hearing loss do not perceive them as particularly effective in overcoming barriers or significantly enhancing their experiences on the island. Recommendations proposed to improve tourism experiences of visitors with hearing loss include the provision of a multi-sensory environment and information supplementing the visit in VR experiences, as well as adopting a non-intrusive and intuitive approach in presenting information on smart devices.

Introduction

Technology has been playing an increasing role in shaping the travel experiences of visitors [1–4]. At the same time, the tourism industry has been placing a stronger emphasis on accessible tourism, which allows tourist destinations to be accessible to everyone regardless of disability and physical conditions [5]. In promoting accessible tourism, which entails opportunities for all, there is a potential to utilize various smart technologies, including virtual reality (VR) and smart devices (SDs), such as smartphones and wearable technology, to aid people with disabilities in enjoying their travel to destinations [6–8].

This research follows the growing field of accessibility, which is increasingly recognized as a critical aspect of sustainable cities and communities [9] and is aligned with the Sustainable Development Goals (SDGs) proposed by the United Nations. In this context, accessibility refers to how the experiences of visitors with certain disabilities can be facilitated and improved through the use of VR- and SD-related attributes, ultimately ensuring inclusive travel experiences for all and contributing to social sustainability [9,10] and heritage preservation [11]. An estimated 1.3 billion people worldwide, or 16 % of the world population, experience at least one form of disability [12]. Therefore, understanding the experience of visitors with hearing impairment represents an evidence-based contribution to addressing the requirements of visitors with sensory disabilities [13]. Such research is especially relevant to destinations where multi-sensory features and environments are prominent, such as the countryside, rural villages, and islands [14,15].

The diverse nature of rural destinations, characterized by low population density, landscapes dominated by agriculture and forestry, and traditional social structures and lifestyles [16], underscores the urgent need for tailored approaches to tourism development and accessibility. These destinations provide an abundance of nature-based stimuli as unique opportunities for facilitating well-being and health [14]. However, to ensure that these restorative benefits are available and accessible to all individuals, it is crucial to prioritize accessibility, especially for those with sensory impairments or physical disabilities [17,18]. By integrating smart technologies, rural destinations can bridge accessibility gaps, allowing visitors with sensory challenges to fully engage

* Corresponding author.
E-mail addresses: ccs_johnson@cuhk.edu.hk (C.-S. CHAN), matthewwong@cuhk.edu.hk (S.Y. WONG), dlagapito@ualg.pt (D. AGAPITO), veledatam@cuhk.edu.hk (V. TAM).

https://doi.org/10.1016/j.sftr.2025.100811
Received 3 April 2025; Received in revised form 30 April 2025; Accepted 7 June 2025
Available online 8 June 2025

with their restorative potential [19]. Such efforts not only improve inclusivity but also align with the principles of sustainable and responsible tourism, ensuring that the health and well-being benefits of nature-based tourism are equitably distributed across diverse user groups [20]. This approach supports the goal of creating barrier-free rural tourism that combines the restorative power of natural environments with the enabling potential of smart technologies [21].

Bridging the areas of accessible tourism and the application of technology in the creation of tourism experiences, this study aims to investigate how the use of VR and SDs, two prominent technologies with wide ranges of applications, improves the experiences of visitors with reported hearing impairment (HI) at Yim Tin Tsai (YTT), an insular rural tourism destination in Hong Kong. While VR is defined in a variety of manners in the academic literature, this paper follows the definition used in Guttentag [22] – "the use of a computer-generated 3D environment … that one can navigate and possibly interact with, resulting in real-time simulation of one or more of the user's five senses" (p. 638). Although past studies have looked into the constraints faced by visitors in the context of urban or heritage destinations or focusing on visitors with visual impairment or reduced mobility (e.g., [1,23,24]), the limited understanding of perceived constraints concerning visitors with HI in the countryside justifies the need for further exploration in this research field [14,25]. Focusing on multi-faceted barriers, this research explores how VR and smart devices enhance visitor experiences for individuals with hearing impairments in rural destinations. This study is a response to such a knowledge gap by addressing the following research questions:

(1) What barriers or difficulties do visitors with HI encounter, and what solutions are employed to improve the accessibility of rural tourism destinations?
(2) How and to what extent can a pre-trip, non-immersive VR experience, and on-site SD usage enhance visitors' experience at rural destinations?

Literature review

Barriers and constraints faced by visitors with disabilities and hearing impairment

The types of difficulties faced by people with disabilities during travel, including those for leisure purposes, have been well covered in academic literature. Smith [26] categorized barriers faced by leisure travelers with disabilities into three main types – *Intrinsic* (related to visitors' characteristics), *Environmental* (related to external social and physical conditions), and *Interactive* (barriers that are neither intrinsic nor environmental). McKercher and Darcy [27] expanded the understanding of travel barriers by proposing a four-tiered hierarchy model. In the model, ignorance has been identified as a significant issue faced by all visitors with disabilities due to misconceptions about their level of ability and lack of knowledge among the general public. Other constraints include negative attitudes, the trustworthiness of accessibility information, and industry ignorance, such as the inflexible nature of package tours [27].

Research focus has shifted to the significant variations in travel barriers and constraints among visitors with different types of disabilities [25,27,28], of which reduced mobility is the most discussed, followed by visual, hearing, and cognitive challenges [29,30]. While the difficulties faced by the former two groups may be obvious, the challenges the visitors with hearing loss encounter may need to be more apparent to the general population. Nonetheless, these visitors may require assistive technologies such as real-time captioning and text messaging [27]. Architectural solutions, which may help solve challenges experienced by those with reduced mobility, are usually irrelevant to visitors with HI [27]. In a study focusing on the accessibility of geoparks in Iberia, Henriques et al. [31] found that while facilities designed for those with physical constraints are relatively sufficient, little has been done to provide sensory and communication access facilities, which are more essential in enhancing tourism experiences for visitors with HI [32].

Specifically, the challenges experienced by visitors with HI are multifaceted, including aspects related to limited information about accessibility and information reliability [33,34]. There were also communication barriers and insufficient awareness and training across practitioners in the tourism industry [33,34], negative staff behaviors and discriminatory attitudes by service providers, group tours, and other visitors [35, 29]. Moreover, some structural and context-specific barriers might vary across different travel experiences, such as inadequate and limited visual guidance at different destination environments [27]. However, the existing literature focusing on HI travel experiences is limited, usually with minimal focus and low representation in small samples.

Effects of VR technology on visitors' experience

The Technology Acceptance Model (TAM) [36] is one of the most popular models employed to explain the extent of technology acknowledgment and has been used as a foundation for studies related to the use of VR and mobile devices in tourism [37,38]. In the model, one's acceptance level of technology is determined by two factors – perceived usefulness ("the degree to which a person believes that using a particular system would enhance his or her job performance") and perceived ease of use ("the degree to which a person believes that using a particular system would be free of effort") ([36], p. 320). Davis [36] also suggested that perceived ease of use may influence perceived usefulness rather than directly determining technology acceptance. Arguably, understanding the technology acceptance behavior of visitors with disabilities can, in turn, allow recognition of the effectiveness of such technologies in helping them travel. Past studies have examined the positive influences of VR and augmented reality (AR) on the consumer experience of 3D virtual tourism sites and cultural heritage tourism through the application of TAM [39,40]. Previous TAM-based studies mainly implemented a survey and quantitative approach to identify the relationships between factors of VR experience and positive outcomes of visitor attitudes, VR usage, and travel intention (e.g., [41–44]).

The stimuli-organism-response (SOR) framework is another theoretical foundation used in tourism VR studies [45,46]. The theoretical base of the SOR framework postulates that environmental stimuli (whether physical or virtual) affect an individual's internal cognitive and emotional states, which in turn drive their responses and behaviour [47]. The external environment, such as sensory, atmospheric, and ambience characteristics, can become stimulus factors affecting individuals [48]. Many empirical and quantitative studies applying the SOR framework identified the transformative potential of social, cultural, physical, and environmental stimuli for shaping visitors' attitudes, satisfaction, and behaviours through emotional and experiential factors of visitors [49–51].

Focusing on technology-related experiences, Yeh et al.'s [46] study applied SOR in the context of online tourism marketing and advertising, concluding that when compared with picture presentations, VR technology exhibits significantly better effects on visitors' responses, including attention, interest, desire, and action, with the relationship moderated by arousal level. Nieves-Pavón et al. [50] emphasized the transformative potential of smart technological solutions to improve visitor experiences in destination management and development. Yu et al. [52] similarly inferred that VR stimuli, as measured by informativeness, esthetics, and novelty, have a positive influence on presence – "the perceptual illusion of being in the real destination via a mediated virtual destination" (p. 3) – and emotional arousal [53].

The distinction between immersive and non-immersive VR experiences is key when reviewing literature that discusses the effects of VR on tourism experience [54]. Immersive VR usually requires the use of a head-mounted display, which allows users to view the panoramic image as if inside the environment, and the viewing angle is changed by tilting

one's head or moving one's body to face another direction [54,55]. Non-immersive VR typically involves viewing the panoramic image on a standard screen with users being aware of their actual environment, and more traditional methods, such as a mouse, keyboard, fingers for touchscreens or rotating the display, are used to change the viewing angle [55]. There is evidence that immersive VR is more effective in memory retention, teaching, and learning [56,55,57]. Although few studies compare the effects of immersive and non-immersive VR in the tourism field, findings suggest immersive VR induce more emotional responses physiologically among users and is more effective in destination promotion, with its users likelier to suggest the portrayed destination to others [58]. However, resource and technical constraints, such as the lack of 3D devices, often discourage the use of immersive VR by individuals.

VR experience has been suggested for the promotion of destinations, complement real experiences, and as a substitute for in situ visits of destinations vulnerable to degradation and overtourism [45], all of which can be easily personalized to meet visitors' diverse characteristics [59]. Wedel et al. [59] advocate that VR products for tourism marketing should be hedonic, experiential, and involve stimulation of multiple senses (primarily, vision, sound, and touch). However, it does not need to be too realistic as improving the accuracy in depicting the virtual environment might not have any apparent effect in enhancing users' state of presence [60].

VR effectively enhances the experience and satisfaction of leisure visitors in general. The study by Atzeni et al. [23], placed on the UNESCO site of Su Nuraxi in Italy, suggested that non-immersive VR experiences can convey objective authenticity, eliciting existential authenticity. Both objective and existential authenticity strongly influenced visitor satisfaction, attachment to VR, and visit intention [23]. The study concluded by recommending that virtual atmospherics should be enhanced in VR experiences to promote and market heritage destinations, in addition to their preservation [11]. Jung et al. [61] suggested that VR users exhibited a positive attitude towards the technology in the tourism context through an immersive VR experience of Lake District National Park in the United Kingdom (UK). The authors found that sound has prominently influenced the experience and was an essential element in allowing users to fully immerse themselves. Kim et al. [43] also highlighted the importance of authenticity on consumers' cognitive and affective responses to VR tourism experiences. Such responses are strong indirect predictors of attachment to VR and intention to visit the destination. The authors suggested that producers of VR tourism value authenticity when developing such content. Lee et al. [62] employed an immersive VR experience for a museum that is an industrial heritage site in the UK as their research subject and found absorption (education and entertainment experience) to be influential on immersion (escapism and esthetic experience), overall VR museum experience, and intention to visit the museum offline. A recent study found that a 360-degree VR experience prior to a visit to a destination demonstrated a significant positive effect of pleasure on visiting intention through inspiration and emotional states of pleasure and arousal [53,63].

While most VR tourism studies positively cast the application of VR, a handful of studies have raised some critical aspects of using the technology. The criticism includes high costs for VR users, gamification concerns, and a spatiotemporal disconnection between the virtual and real worlds by simplification of the latter in the former, which may consequently lead to the banalization of the educational, social, and cultural elements of heritage. Fan et al. [42] conducted a meta-analysis and found that simulation type and social interaction positively influenced on-site tourism experiences. However, prior visitation had a negative effect, and the type of experience did not significantly impact the outcome.

In the context of accessible tourism, VR has been suggested to be useful in expanding the potential tourist market by allowing people with disabilities to better experience destinations, possibly through a brain-stimulated environment [64]. Individuals can determine the accessibility of the real surroundings of the destination through exploration of the VR environment in a safe and controlled manner, boosting their motivation, intention, and confidence in visiting the destination itself, as well as emotional connection with the destination [65–67]. Nonetheless, empirical research examining the impacts of VR in promoting accessible tourism is sparse, with most relevant academic works remaining on the exploratory level [65]. Iftikhar et al. [37] proposed a conceptual model of VR tourism acceptance specifically for visitors with disabilities. While the empirical studies discussed earlier that focus on the effects of VR in improving outcomes of visitors' experience could be applied to all visitors, little discussion has been found on the role VR can perform in complementing the tourism experience of visitors with sensory disabilities, particularly hearing impairment.

Effects of SD usage on visitors' experience and accessibility

Research has identified diverse positive aspects of mobile usage and other SDs. Visitors can use their mobile devices to find directions, search for information, make reservations, and perform other essential travel-related tasks [68]. VR on SDs allows visitors to psychologically prepare for the visit [69]. On the other hand, the negative aspects of SD use (smart tourism) have rarely been discussed, with Gretzel et al. [70] stating that research in the area of smart tourism "has adopted a very optimistic and uncritical stance" (p. 184). Some caveats of increased use of SDs include privacy and security concerns, poor Internet connectivity, not experiencing destinations as they are, less interaction with people, and limited discovery [71].

Studies have found that SD use increases visitors' satisfaction levels. Kokkinou et al. [1] examined visitors' connected mobile device use at famous attractions in Amsterdam, Netherlands, concluding that such use has a positive association with travel experience and emotional responses, echoing the findings of Wang et al. [68]. Moreover, the researchers suggested mobile devices can fill in waiting times at attractions by allowing visitors to entertain themselves and potentially look up information relevant to the attractions. The study findings also align with Gillet et al.'s [72] work, which concluded that the frequency of taking photos (using smartphones), life satisfaction, the importance of photography, and positive emotions are positively associated. Pradhan et al.'s [69] study in South Korea revealed that perceived benefits of SDs have a more significant impact on usage intention than perceived risks, but older people tend to avoid the risk of using them. The study recommends that the hospitality industry develop applications that make services more accessible for visitors, integrating the concepts of AR, VR, and artificial intelligence. Meanwhile, Tan [73] suggested that smartphones only play a supplementary role in the tourism experience (e.g., searching for information and navigation) rather than being an integral part of the experience itself in the context of a nature-based destination in Taiwan.

Similar to the literature on VR tourism, studies linking smartphones and other smart technologies to tourism for visitors with disabilities are uncommon, and most remain on a reflection-based level, although mobile technologies have shown potential in contributing to a positive future of accessible tourism development [8,28]. For example, mobile applications for visitors with hearing impairment can incorporate visual communication options such as speech-to-text, subtitling and sign language videos to improve their accessibility to important information [8]. Provision of information with mobile technologies can be effective in eliminating knowledge constraints, which has been found to be one of the most significant barriers encountered by visitors with visual impairment [74]. D'Amico et al. [75] developed a case study of Amsterdam, Netherlands, and examined the smart measures adopted by the city to cater to the needs of visitors with disabilities at significant destinations, such as providing information for visitors with sensory disabilities on museum websites. Huang and Lau [76] experimented to determine how gamification on SDs can improve the tourism experience of visitors with visual impairment. Nevertheless, it is arguable that more

empirical research addressing the effects of SD use overall on the experience of visitors with disabilities is necessary [20,21].

Methodology

YTT, a rural outlying island in Sai Kung District, was chosen as the research subject of this study. With an area of 0.31 square kilometers and only accessible by ferry, the unique characteristics of the island are related to Catholicism, salt production, and Hakka culture [77,78]. At the same time, the area is also abundant in natural resources, including mangroves and local floral and faunal species, with much of the island remaining undeveloped. Becoming uninhabited in the 1990s, endeavors have been made recently to revitalize YTT, with the Salt and Light Preservation Center, a non-profit organization founded in 2011. The Center was tasked to conserve and promote the culture and ecological preservation of YTT [78,79,80]. The renovated St. Joseph's Chapel and revitalized salt pans won UNESCO cultural heritage conservation awards in 2005 and 2015, respectively, in commendation of the efforts made [78]. An arts festival showcasing large-scale artworks created by various artists around the island has been held annually since 2019 to attract more visitors [77].

A total of 163 adult participants have been recruited for this study, with roughly half of them (78) reporting having various degrees of HI and the other half (85) without indication of disabilities. In Hong Kong, 534,200 people, or 7.1 % of the total population, reported one or more types of disability in 2020, of whom 47,900 (0.6 % of the total population) were experiencing some degree of hearing loss [81]. The definition of the Hong Kong SAR Government for individuals with HI – "those who had perceived themselves as having 'a lot of long-term difficulty' in hearing or 'cannot hear at all' with one ear or both ears even when using a hearing aid if necessary at the time of enumeration" ([81], p. 20) is adopted for the purpose of this study. Participants with hearing loss were recruited in cooperation with the Hong Kong Society for the Deaf, and the reports of hearing loss followed the professional services provided by the Society [82]. In contrast, participants with no reported disabilities were recruited through various channels, including university campus emails and participant referrals. Non-probabilistic sampling through a purposive sample is deemed appropriate due to the unavailability of a sampling frame through the usual random sampling approach.

The research ethics of the research design and methods were approved by an institutional committee. All participants were invited to visit the island of YTT for a self-guided tour and compensated with a small cash allowance in addition to the cost of returning ferry tickets to YTT. 16 visits were conducted over 11 months, from June 2022 to April 2023. For each season, two visits consist entirely of participants with HI, and the other two are for general participants without reported disabilities. Participants from two of the visits – one each from the HI and general participant visits – were given a link to view a non-immersive VR tour of YTT around one week before the visit, which is an in-house production and accessible at https://ytt-vr.s3-ap-southeast-1.amazonaws.com/index.htm. The VR platform has an interactive function that the participants could use to adjust their angle of viewing each scene on the platform, and it should be noted that the platform is not a video-based tool. Participants from each visit were then further split up into two equal groups randomly, of which one of them was allowed to freely use their SDs during the visit, while the other was instructed not to use them. This results in a sample size of around 80 for each experimental condition (around 20 for each unique combination of experimental condition) (Tables 1 and 2), which is considered representative and sufficient to generate reliable statistics for analytical purposes, while simultaneously being manageable for the researchers.

All study participants completed a self-administered questionnaire to collect basic information on their demographic characteristics. Participants also completed a consent form to ensure that they understand and agree to the terms of the study. Semi-structured focus group discussions were conducted in Cantonese immediately after each visit, which were moderated by trained research staff and prompted with a few open-ended questions. Focus group discussions have been utilized in past research related to tourism for visitors with disabilities [83–85] and allow the collection of a relatively large amount of information in a short period [86]. The discussion questions are designed to gain an understanding of the difficulties or barriers participants have encountered during the visit, the solutions exercised by participants to cope with them, as well as their opinions and usage habits on the pre-trip VR experience and SD use during the visit, in response to the research questions (Table 3). Separate discussions were held for participants with and without SD usage during the visit, with 4–7 participants in each discussion, ensuring ample opportunity and a comfortable environment

Table 1
Participants' experimental conditions of each YTT visit.

	Season	Participant disability	Pre-trip VR administered?
1.	Summer	None reported	Yes
2.	(June – July 2022)		No
3.		HI	Yes
4.			No
5.	Fall	None reported	Yes
6.	(October 2022)		No
7.		HI	Yes
8.			No
9.	Winter	None reported	Yes
10.	(January – February		No
11.	2023)	HI	Yes
12.			No
13.	Spring	None reported	Yes
14.	(March – April 2023)		No
15.		HI	Yes
16.			No

Table 2
Number of participants in each experimental group.

General participants (No disabilities)	Participants with HI
85	78
Pre-trip VR administered	Pre-trip VR not administered
81	82
Use of SD allowed	Use of SD not allowed
82	81
General participants (No disabilities)	**Participants with HI**
Pre-trip VR administered and use of SD allowed	
21	20
Pre-trip VR not administered and use of SD allowed	
21	20
Pre-trip VR administered and use of SD not allowed	
21	19
Pre-trip VR not administered and use of SD not allowed	
22	19

Table 3
Focus group discussion questions.

Common to all focus groups	
• What types of challenges did you face during the visit? When and where? • How did you attempt to minimize or overcome the difficulties?	
Only for focus groups with pre-trip VR administered	Only for focus groups with pre-trip VR not administered
• Do you think the pre-trip VR platform is useful for your visit today? Is anything good or bad?	• If you could use an online VR platform of YTT before the visit, would you? Why or why not?
Only for focus groups with SD use allowed	Only for focus groups with SD use not allowed
• How did you use your SDs (e.g., smartphone, tablet, smart watch, etc.) during the visit? • How did the use of your SDs affect your visit? Is anything good or bad?	• Would you prefer using a SD (e.g., smartphone, tablet, smart watch, etc.) during your visit? Why or why not?

for them to raise their opinions and experiences [87]. A sign language translator was present to relay verbally any responses made by deaf participants using sign language and sign any verbal statements made by the moderator and other participants where necessary.

The discussions were audio-recorded, transcribed, translated to English, and coded using NVivo Release 1.0 through content analysis. Content analysis allows systematic examination of discussion content to identify patterns, themes, and meanings, with content categories being developed through a standardized set of rules such that data between different focus groups can be compared more methodically [88,89]. The codes are generally categorized into groups according to participants' responses to each discussion question, as outlined in Table 3, with the proportion of coding references within each group computed to provide an overall picture of all ideas and opinions expressed by the participants. Such figures conditioned by participants' experimental condition have also been worked out and analyzed using Z-score for two population proportions, which allows straightforward quantitative estimates of the significance of coding differences between the three pairs of groups – participants with HI vs. general participants, VR vs. non-VR users, and SD vs. non-SD users, so that an objective comparison between focus group discussions with contrasting experimental conditions can be made. Simultaneously, verbatim quotations have also been identified and presented as objective evidence to illustrate the most representative findings from the content analysis [90].

Participants' demographic profile

The focus group participants' demographic profile is presented in Table 4, in which the statistics suggest an excellent distribution and variance. 66.7 % of HI participants reported severe hearing loss (>70 dB HL for both ears), while 10.3 % were unsure of their degree of hearing loss.

The demographic profiles of participants with different experimental conditions have also been compared using Z-score. It can be observed that the group of participants with HI for the study is significantly older, has a lower education level, and contains substantially more retired and fewer employed individuals compared to the group of general participants. General participants and participants with hearing loss are considerably more likely to have never visited YTT and visited YTT once before, respectively. The demographic profiles of participants conditioned by VR and SD use are generally statistically consistent.

Results

Difficulties and barriers encountered during visit and solutions to overcome

The proportions of coding references within each coding group and the Z-scores comparing the coding patterns between opposing experimental groups are tabulated in Tables 5 and 6, respectively. The Z-scores for the "HI specific" and "Other" nodes are not reported, as "HI specific" includes challenges/solutions unique to participants with HI, and "Others" includes phrases that only sparsely appear in the data, thus making it impractical to compute Z-scores.

In response to research question 1, it can be observed from Table 5 that the most commonly mentioned challenges are related to wayfinding and infrastructure on YTT, i.e., environmental barriers according to Smith's [26] classification, accounting for around three-quarters of all references. Participants tended to mention occurrences of getting lost when navigating around YTT due to the lack of or unclear directional signage or trails and the confusing topography of YTT, with an uneven terrain and trails branching off in different directions at junctions. The most prominent infrastructure-related difficulties mentioned include the closure of attractions, notably the St. Joseph's Chapel and salt pans during the participants' visits, and the low walkability of trails and

Table 4
Summary of participant demographics.

Gender		Employment Status	
Male	34.4 %	Employed	60.1 %
Female	65.6 %	Unemployed	3.7 %
Age Group		Student	1.2 %
20–29	17.8 %	Retired	26.4 %
30–39	18.4 %	Homemaker	7.4 %
40–49	11.7 %	Others / Not stated	1.2 %
50–59	20.2 %	No. of prior visits to YTT	
60 or above	31.9 %	None	58.3 %
Education Level		1	23.3 %
Primary School or below	8.6 %	2–3	12.3 %
Middle School	16.0 %	4 or above	6.1 %
High School	24.5 %		
Diploma/Cert/Associate's	12.3 %		
Bachelor's	31.3 %		
Master's or above	7.4 %		

Table 5
Difficulties and barriers and solution coding group.

Coding Group	Nodes	Prominent phrases or node description	Proportion of coding references within the coding group
Challenges or barriers encountered	Infrastructure related	Attractions closed or under renovation, low walkability of trails or staircases, lack of catering capacity or options, too many visitors	45.5 %
	Wayfinding	Lack of or unclear directional signage or trails, confusing topography in YTT	29.8 %
	Weather	Hot weather, rainy weather	12.0 %
	Mask wearing	Difficult to read the lips and breathe in outdoor environments	4.0 %
	HI specific	Cannot see sign language, difficulties in hearing, no subtitles and sign language translation	3.7 %
	Insects or mosquitoes	Afraid of insects	2.3 %
	Others	Cannot use mobile phone functions, dog barking, identity issue on guided commentary in salt pans, lack of information on opening hours of attractions	2.7 %
Solutions to overcome difficulties	Intra-YTT movement related	Ask or follow other people, guesswork, more or clear directional signage, use (paper) map for wayfinding, add handrails or fences along steep trails or staircases	75.3 %
	Physical perception related	Remove mask, drink water or other liquids	12.4 %
	HI specific	Go to less windy places, rely on companions to talk with participants, use sign language	2.4 %
	Others	Make another visit to YTT, provide more information on attraction opening hours, use the Internet	10.0 %

Table 6
Z-score calculations for coding pattern comparison (difficulties and barriers and solutions).

Coding Group	Nodes/Prominent phrases or node description	Z-score (Disability)[1]	Z-score (VR)[2]	Z-score (SD)[3]
Challenges or barriers encountered	Infrastructure related	0.20	1.94	0.14
	Wayfinding	−0.25	−1.07	0.21
	Weather	1.43	−1.25	0.62
	Mask wearing	0.20	0.29	**−2.02**
	Insects or mosquitoes	1.30	−0.61	−0.12
Solutions to overcome difficulties	Intra-YTT movement related	−1.94	−1.33	1.87
	Ask or follow other people	−0.19	−0.70	**−1.98**
	Guesswork	0.79	−0.19	**−2.47**
	More or clear directional signage	−1.69	−0.70	0.95
	Use the (physical) map for wayfinding	−0.67	0.88	**2.01**
	Add handrails or fences along steep trails or staircases	**−2.43**	−0.84	1.45
	Others	0.72	−0.25	**2.20**
	Physical perception related	−0.12	−0.07	**−2.86**

* Z-scores in **bold** indicate they are statistically significant (two-tailed test, 5 % level)
Positive Z-score: Group 1 > Group 2; Negative Z-score: Group 1 < Group 2.
[1] Group 1: General participants; Group 2: HI participants.
[2] Group 1: VR users; Group 2: Non-VR users.
[3] Group 1: SD users; Group 2: Non-SD users.

staircases connecting different parts of the island due to them being too steep, slippery, poorly maintained or uneven.

Some of the challenges encountered are specific to participants with HI. These include the inability to see sign language translation of the guided commentary in the salt pans due to the narrow walkways, difficulties in hearing other people and atmospheric noises, and lack of subtitles and sign language translation for clips in the heritage exhibition center. While the participants' disabilities may affect their sensory experiences on YTT in some way, and the artificial attractions may not have fully considered the accessibility needs of visitors with HI, it should be noted that these challenges specific to HI constitute only a minor portion (3.7 %; 7.0 % excluding general participants) of all difficulties mentioned during focus group discussions, suggesting that they are considered insignificant by participants with hearing loss in affecting their experience.

There are no significant differences in difficulties encountered between individuals reporting HI and general participants, other than those specific to HI, as well as solutions to overcome them. The difference relies on the suggestion of adding handrails or fences along steep trails or staircases, which was mentioned significantly more often by the latter participants. Nonetheless, this finding may result from the fact that the participants with HI comprise more older adults who are usually less mobile. This suggests that the negative impacts of hearing disabilities on visitors' experiences in rural destinations where the environment is primarily natural are limited. The results also indicate that non-SD users solve intra-YTT movement-related challenges through direct interaction with the environment, such as guesswork and asking or following other people. Conversely, SD users use maps for wayfinding, including the web map on their SDs. Non-SD users may be more aware of their physical surroundings with their senses during their navigation process around the island.

VR usage

Tables 7 and 8 tabulate the proportions of coding references and Z-scores, which are adequate for answering research question 2. The

Table 7
VR usage coding group.

Coding Group	Nodes	Prominent phrases or node description	Proportion of coding references within the coding group
VR usage	**Cons of using VR / Pros or reasons for not using VR**	–	**64.3 %**
	Limitations of VR experience	Not offering a whole sensory experience, no sound in the VR experience, only offers a visual experience, lacks directional sense, is more realistic in an actual visit, the interface is not user-friendly, lacks experience with temperature and sense of actual distance, the scenery is not appealing	27.0 %
	Novelty	Curiosity and adventurous feeling, freshness, mysteriousness, no surprises	9.9 %
	Prefer in-person visit	–	5.3 %
	Prefer using a map	–	4.2 %
	Internet connectivity issues	–	3.4 %
	Repetition with the actual visit	–	3.0 %
	May inhibit desire or expectation for an actual visit	–	2.7 %
	Others	Inability to use VR, no need for preliminary understanding of YTT, not helpful as already familiar with YTT	8.7 %
	Pros of using VR / Reasons for using VR	–	**35.7 %**
	Allows preliminary understanding and planning of YTT visit	–	14.1 %
	Helpful in wayfinding	–	3.8 %
	Has supplementary information	–	3.8 %
	Can view the past	–	3.0 %
	Increase in interest or expectations	–	2.3 %
	Others	It can be used for teaching purposes, can view places inaccessible or missed in actual visit, and is suitable for people who cannot visit YTT in person	8.7 %

limitations of VR experiences, in particular, the inability of VR to offer sensory experiences other than vision, the lack of directional sense when navigating around the virtual environment, and the fact that the actual visit would be more realistic, are the most commonly mentioned negatives of VR usage. Together with a more user-friendly interface, the use of other sensory stimuli (e.g., sound effects for users who have less hearing difficulty) for a more realistic and holistic experience seems to be valued. These deficiencies are mentioned far more often by VR users than non-VR users.

> *"… when coming here, the purpose is to breathe the air in nature. If I am to watch* [sic] *VR, it completely takes away that feeling of being in nature, the air, the atmosphere, and the place."* (Participant with HI, non-VR,

Table 8
Z-score calculations for coding pattern comparison (VR usage).

Coding Group	Nodes/Prominent phrases or node description	Z-score (Disability)[1]	Z-score (VR)[2]	Z-score (SD)[3]
VR usage	**Cons of using VR / Pros or reasons for not using VR**	−0.49	0.88	−0.01
	Deficiencies of VR experience	−1.46	**3.32**	0.44
	It does not offer a whole sensory experience	0.53	−0.57	−0.79
	Lack of directional sense	0.24	**2.30**	0.35
	More realistic in an actual visit	−1.40	0.80	**2.94**
	Others	−1.91	**3.20**	−0.65
	Novelty	1.66	−1.22	−0.33
	Prefer in-person visit	−0.73	−1.93	−0.45
	I prefer using the map	**−2.13**	0.06	**−2.23**
	Internet connectivity issues	0.75	**2.16**	0.87
	Repetition with the actual visit	1.30	**−2.37**	**2.69**
	May inhibit desire or expectation for an actual visit	1.92	−0.58	0.08
	Pros of using VR / Reasons for using VR	0.49	−0.88	0.01
	Allows preliminary understanding and planning of YTT visit	1.69	−0.30	−1.20
	Helpful in wayfinding	1.62	−0.23	−0.09
	Has supplementary information	**−3.15**	**2.35**	0.56
	Can view the past	0.54	−0.93	0.50
	Increase in interest or expectations	−0.85	−1.01	1.27

and non-SD user stating the lack of a complete sensory experience offered in typical VR experiences)

One important aspect to be noted on how specific technology features could mitigate barriers for visitors could be, at least to some extent, by using an immersive VR system instead of a non-immersive one. The feeling of novelty when visiting YTT is another significant reason for not using VR, as the participants opined that if they had viewed the environment of YTT before the visit, the adventurous feeling, freshness, mysteriousness, and surprises would have been lost. As one participant (General participant, non-VR, and non-SD user) shared:

> *"If there were a VR experience, I would choose not to watch it, meaning I want to keep the mystery. This is because if I had watched (VR), I would know whether to turn left or right on the next trail and lose the joy of exploration."*

Meanwhile, the most common reason for using VR is its usefulness in preliminary understanding and planning of the visit.

There are a few other notable differences in the typical responses between participant groups with opposite experimental conditions. Participants with hearing loss and non-SD users prefer using a map (whether paper or web map) to VR for navigation compared with the opposing group. They tend to view VR experiences as not very useful in finding their way around the natural environment of YTT. Moreover, participants with HI and VR users tend to agree that VR is more valuable when it provides supplementary information that the physical visit cannot provide, such as short visual or audio explanations introducing the background of attractions and wildlife in YTT. Such information is absent from the VR platform used for the experiment in this study, which essentially only provides a 360-degree panoramic view of the visual environment at various locations around YTT. However, it can be found in some other (non-immersive) VR experiences. This is the case of the one used in Atzeni et al.'s [23] study for the "Su Nuraxi" site and Assiouras et al.'s [63] research for destinations in the United Kingdom.

SD usage

The proportions of coding references and Z-scores are presented in Tables 9 and 10, respectively. The data in these two tables are also applicable to research question 2. Smartphone is the SD most often referred to in the discussions. It can be observed that compared with the SD users, non-SD users have significantly more mentions of the negative aspects of SD usage in their sightseeing experience, including references to focusing on experiencing the actual environment, which is also the most commonly mentioned reason for not using SDs during the visit. This finding suggests that such participants have gotten used to their imposed experimental condition of not being able to use their SDs and even appreciated such inability. An analysis of the emotional responses and feelings expressed by participants has also been conducted, and it was found that non-SD users have significantly more positive mentions of the surrounding environment, including "comfortable," "relaxing," "beautiful place," and "nice scenery." Participants shared that not using smartphones during the visit to YTT could enhance their sensory experience and let them be more sensitive to the surroundings:

> *"I am not used to using smartphones. At the same time, when you do not have your phone, you will be very focused on the environment and especially hear what sounds are nearby, such as birds, crickets, waves, or the wind. So not using a phone can make the sensory experience more immersive."* (General participant, non-VR and non-SD user)

> *"Since we couldn't use our phones this time, I was able to focus on looking at every place and its related introduction, which is a good thing."* (Participant with HI, VR and non-SD user)

On the other spectrum of the coding group, taking photos or videos is distinctly the most commonly mentioned reason for using SDs, with no significant differences across all three pairings. This function of SD usage seems to be valued, together with searching for information and wayfinding that could mitigate some reported barriers by visitors with HI. Participants have often remarked on the beautiful and unique scenery and the natural environment on and surrounding YTT when discussing their actions in taking photos or videos. There is an association between

Table 9
SD usage coding group.

Coding Group	Nodes	Prominent phrases or node description	Proportion of coding references within the coding group
SD usage	**Cons of using SD / Pros or reasons for not using SD**	–	**33.1 %**
	Focus on experiencing the environment	Use of own eyes	14.5 %
	Know directions without using SD	–	4.5 %
	Lack of time	–	2.5 %
	Distraction	–	2.5 %
	Others	Induce conversations with other people, no need to search for information, poor mobile phone signal	9.1 %
	Pros of using SD / Reasons for using SD	–	**66.9 %**
	Take photos or videos	Take photos of scenery and the natural environment	40.5 %
	Search for information	Search for wildlife species and background information on attractions, scan QR codes	9.1 %
	Wayfinding	Use of web map	7.4 %
	Others	Make emergency calls, if necessary, receive or respond to text messages, use social media	9.9 %

Table 10
Z-score calculations for coding pattern comparison (SD usage).

Coding Group	Nodes/Prominent phrases or node description	Z-score (Disability)[1]	Z-score (VR)[2]	Z-score (SD)[3]
SD usage	**Cons of using SD / Pros or reasons for not using SD**	0.28	−1.29	**−2.84**
	Focus on experiencing the environment	−0.34	0.51	**−2.17**
	Know directions without using SD	1.46	−0.56	−1.24
	Lack of time	−1.72	**−2.23**	−0.60
	Distraction	−0.06	−0.56	−0.60
	Pros of using SD / Reasons for using SD	−0.28	1.29	**2.84**
	Take photos or videos	1.25	1.65	0.38
	Search for information	0.33	0.08	0.90
	Wayfinding	−1.09	0.48	1.39

positive visual stimulation from the natural environment at rural destinations and photography.

No significant differences are recognized in actual usage and reasons for using or not using SDs between visitors with hearing loss and general participants. While SDs and smartphone applications designed explicitly for participants with HI have not been provided in this study, the results suggest that the former do not perceive SDs as tools particularly helpful in solving accessibility problems they may encounter during the visit.

Discussion

Differences in challenges and barriers encountered by participants with HI when compared to general participants are minor, corroborating the findings of Chan et al. [13]. Compared with general participants, although participants with hearing loss significantly prefer the provision of supplementary information in VR experiences, they are generally indifferent to VR and SD use, suggesting the effects of smart technology in enhancing the visit experience of the latter participants are limited in the context of a visit to a rural destination. In addition, rural destinations are richer in multi-sensory nature-based elements [14,91,92]. Therefore, the effects of technology may be diluted in these environments.

Considering TAM model, the findings suggest that, in general, participants did not rate VR highly in terms of perceived ease of use, as the difficulty in navigating around the virtual environment, as well as the inability to use VR and other limitations in the VR experience, were frequently mentioned by participants. The current results contrast with previous findings that support the effective use of antecedents of the TAM model in predicting users' intention to adopt virtual technologies and positively impact the tendency to visit the actual site [41]. This, together with the perception that VR could not offer non-visual sensory experiences, leads to a low level of perceived usefulness and the technology not entirely accepted in the context of rural tourism experience. Referring back to the SOR framework, since authentic experience had significant impacts on cognitive and affective responses to VR tourism [43], the current study also found such comments from participants with hearing loss about the declined attractiveness and novelty of the site after viewing the VR platform (Table 7). The current research does not reflect some previous findings on how VR experience may lead to a higher level of visitation through the heightened feeling of being and a positive attitude [44]. While all participants perceived SDs to be helpful to some extent by enhancing their travel experiences, the similarities in responses concerning SD use indicate that participants with HI do not regard the usefulness of SD to be over and above that of general participants.

Implications for the design of the VR experience

As highlighted in the focus group discussions, the content of the VR experience, which can be designed for smartphone use such that visitors can refer to it on the actual site, can be enhanced to offer information (e.g., information on the background of cultural heritage attractions, flora and fauna species, and the natural environment) not provided in the actual visit. Stories of residents living in YTT and other such rural destinations can also be included and portrayed to increase users' engagement with the VR experience and allow them to enjoy it and the actual visit with pleasure [9,62,93,94]. As such, regarding the four realms of experience economy proposed by Pine II and Gilmore [95] - entertainment, education, esthetic, and escapism - the absorptive experiences of VR in terms of its ability to educate and entertain potential visitors can be enhanced, which in turn positively influences immersion and the overall VR experience [62].

The lack of a complete sensory experience is another negative aspect of the VR experience often mentioned in discussions. VR tourism experiences should strive to include senses other than vision. VR developers can direct efforts in including sound in the experience, especially that of nature and preferably stereophonic [22,61]. Although including one extra sense still cannot fully replicate the sensory experience in an actual visit, it would help create an experience perceived as more immersive and authentic. While Wedel et al. [59] referred to the reproduction of haptics in VR systems, such as temperature and sense of force and weight, progress on the simulation of touch, as well as smell and taste in VR experiences, has not been significant in enhancing visitor experiences at destinations [22,96]. The high cost of including such features creates a hurdle in their applicability and popularization in VR experiences for tourism purposes, a current limitation that needs to be addressed.

When compared with non-immersive VR experiences, immersive experiences could improve users' directional sense and emotional stimulation. Immersive VR users may find viewing a panoramic image of the destination simpler if they are unfamiliar with computing device controls. Since individuals would be unaware of their actual surroundings, they may find it relatively effortless to immerse themselves in the virtual environment, thereby being emotionally stimulated more easily. Future studies shall help validate this case.

The role of SDs in transforming rural tourism experiences

To provide more accessible information to visitors, guided tours or commentaries of attractions, mainly artificial attractions such as salt pans and the heritage exhibition center, can be provided in textual, audio, or sign language format on an SD application, which can be a mobile VR platform, so that they can better follow their content [8]. This approach can ensure that visitors with various degrees of HI, as well as different types of disability, can access information relevant to destinations as quickly and seamlessly as possible and respond to the emerging themes of providing supplementary information on VR platforms and searching for information on SDs in the focus group discussions.

It is also noted that there is a stress on SD use for taking photos, regardless of the experimental group. This is mainly due to the positive visual stimulation from the natural environment of YTT. This can be seen as in line with past studies that found a linkage between photography as a tourist activity and positive emotional response or stimulation from tourists [1,72] and the motif of photography in travel is led by nature [94]. To further enhance the tourism experience at YTT and other similar rural destinations, relevant authorities can consider devising attractive photo spots to invite visitors and instil vivid visual memories into them, as mentioned by one of the focus group participants [1].

Many of the study participants, particularly non-SD users, stated that not using SDs has helped them to focus on experiencing the real-world environment. Smartphone applications should, therefore, facilitate visitors' immersion into and not require constant distraction from the environment [94,97]. Smartphones, after all, are regarded by visitors to rural destinations mainly as a functional tool to supplement their travel,

for example, making logistical arrangements such as planning their travel itineraries [73]. To minimize hindrance to visitors' in-person experience of the rural environment, any additional information on natural spots provided in smartphone applications should be provided only upon the users' request since digital-free experiences can be more memorable [97]. Moreover, such information should be presented intuitively to allow faster acquisition, and the application itself should be easy to use and install, such that its perceived ease of use can be improved [94,98,99]. Cellular networks and wireless connectivity in rural attractions should also be strengthened where possible to enhance the SD usage experience and its ease of use, as the importance of Internet accessibility has been emphasized in both the literature and focus group discussions [2,69,99,100].

Conclusion

This study has discussed the possible effects of VR and SD use on the experience of visitors with hearing loss in the context of a rural destination in Hong Kong. After analyzing the focus group discussions, several significant points have been concluded. Wayfinding and infrastructure-related challenges constitute the majority of obstacles encountered by both general and participants with HI, with only a small portion of perceived barriers raised by the latter being directly related to hearing. VR users and participants with HI agree that VR experiences are more useful when supplementary information is not provided during the actual visit. Limitations of the VR experience, particularly the lack of a comprehensive sensory experience and directional sense [32], the loss of feeling of novelty, and Internet connectivity issues, are the leading themes regarding the cons of VR and reasons for not using it. While taking photos or videos is often mentioned as a positive of using SDs across participants of all experimental conditions, non-SD users more often pointed out the ability to focus on experiencing the actual environment as an advantage of not using SDs during the visit. Given the limitations of the technological tools employed in this study, broader implications in developing accessible tourism have been discussed. These include employing immersive VR platforms that engage users' multiple senses, provision of supplementary information in VR experiences and SD applications in accessible formats with intuitive presentations to promote inclusive tourism and facilitate visitors' immersion into the destination environment, as well as identifying photo spots for visitors to record their visual memories with their SDs.

VR and SD contributions to accessible rural destinations

The use of VR and SDs contributes to innovative spatial planning as they reduce structural obstacles for visitors with hearing impairment, apart from physical mobility or disability [101]. Extended from Tao et al. [102], the environmental features that could either enhance visitor experiences (e.g., sensory stimuli, storytelling, etc.) or reduce the structure and intrapersonal barriers (e.g., mobile apps for orientation and communications, etc.) must be developed through a process of visitor-oriented co-creation to capture the feedback and experiences of visitors with disabilities [7]. Although visitors with physical disabilities predominantly refer to structural constraints, interpersonal constraints are increasingly relevant within all "visible" and "invisible" groups of disabilities and other challenges.

The future tourism industry should prioritize sustainable infrastructure that ensures inclusive access, particularly for visitors with disabilities and vulnerable groups [103], especially since some are relatively "invisible" [28]. Emerging technologies transforming travel experiences, such as mobile technology and virtual, augmented, or mixed reality [104], can drive smart tourism by enabling interactive environments and diversified visitor needs [105,106]. These opportunities, as evident in the current study, can provide more disability-friendly and accessible rural environments that ultimately help to develop more sustainable rural destinations [16,107] and, in so doing, contribute to the advancement of research on accessible tourism.

Research limitations and areas for further research

There are some limitations in this study that should be taken note of. First, there is a considerable difference in the demographic profiles in the used sample between general and participants with HI. It may, therefore, be challenging to ascertain whether attributes related to the touristic experience that are chosen for scrutinization in this study are solely related to the participant's reported disability or are influenced by other demographic characteristics as well, such as age and education level. As a purposive sample is used for the data collection process, it may also be possible that there are other underlying correlations among demographic variables, such as between a person's likelihood of HI and age. Second, using focus group discussions as a data collection method also has its caveats, as there may be non-responses from participants to some of the questions, or they may merely agree to responses made by other participants, thus giving limited information on the varying views among individual members of the focus group [87]. Third, only data from one site in the rural area of Hong Kong have been collected in this study, restricting the generalization of the findings to other geographical contexts. Future research may, therefore, comparatively analyze the differences in the needs of visitors with HI in rural and urban destinations. Another direction for future studies is to compare the effects of immersive and non-immersive VR experiences in transforming tourism experiences and examine whether using the former would be more effective than the latter used in this study. Lastly, comparing the experiences of visitors with hearing loss with varied prior experiences with technology and their levels of hearing impairment is a valuable area for further study, combined with surveys and quantitative analysis.

CRediT authorship contribution statement

Chung-Shing CHAN: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Shing Yan WONG:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis, Data curation. **Dora AGAPITO:** Writing – review & editing, Validation, Conceptualization. **Veleda TAM:** Project administration, Investigation, Data curation.

Declaration of competing interest

The authors declare no conflicts of interest related to this study. This research was conducted independently, and no financial, personal, or professional relationships influenced the design, data collection, analysis, or reporting of the findings. All funding sources have been fully disclosed, and the authors confirm the integrity and objectivity of the research presented.

Acknowledgement

This research project (Project Number: 14605121) is funded by the General Research Fund (GRF) administered by the Research Grants Council (RGC) of the Government of the Hong Kong Special Administrative Region. The researcher Dora Agapito is also financed by FCT - Foundation for Science and Technology (Portugal) through project UID/04020: Research Centre for Tourism, Sustainability and Well-being.

Data availability

Data will be made available on request.

References

[1] A. Kokkinou, E. Tremiliti, M.V. Iwaarden, O. Mitas, S. Straatman, Are you traveling alone or with your device? The impact of connected mobile device usage on the travel experience, J. Hosp. Tour. Insights 5 (1) (2022) 45–61.

[2] P. Liberato, E. Alen, D. Liberato, Smart tourism destination triggers consumer experience: the case of Porto, Eur. J. Manag. Bus. Econ. 27 (1) (2018) 6–25.

[3] Y. Mountije, D. Agapito, C. Ramos, Reshaping the future of tourism & hospitality industry through blockchain technology: a systematic literature review. Information Technology & Tourism, 2025, https://doi.org/10.1007/s40558-024-00306-y.

[4] B. Neuhofer, D. Buhalis, A. Ladkin, A typology of technology-enhanced tourism experiences, Int. J. Tour. Res. 16 (4) (2014) 340–350.

[5] World Tourism Organization; Fundación ONCE and Normalización Española, How to Apply ISO Standard 21902: Accessible tourism For All – Recommendations for Tour operators, Travel Agencies and Travel Agents, UN Tourism/Fundación ONCE/UNE, Madrid, Spain, 2024, https://doi.org/10.18111/9789284425860.

[6] F. Ercan, Accessible tourism experiences in smart destinations: the case of Breda (Netherlands). Planning and Managing the Experience Economy in Tourism, IGI Global, 2022, pp. 274–300.

[7] J.J. Nigg, M. Peters, The evolution of ICTs in accessible tourism: a stakeholder collaboration analysis, J. Hosp. Tour. Manag. 52 (2022) 287–294.

[8] F.R. Ribeiro, A. Silva, J.C. Metrôlho, A.P. Silva, F.S. Barbosa, A new framework for accessible tourism mobile application development, Int. J. Mob. Comput. Multimed. Commun. 9 (2) (2018) 31–46.

[9] J. Soulard, E. Lundin, S.S. Zou, Exploring inclusivity perceptions among residents: insights from rural tourism destinations, J. Sustain. Tour. 32 (12) (2024) 2580–2602.

[10] D. Buhalis, X.Y. Leung, D. Fan, S. Darcy, G. Chen, F. Xu, G. Wei-Han Tan, R. Nunkoo, A. Farmaki, Editorial: tourism 2030 and the contribution to the sustainable development goals: the tourism review viewpoint, Tour. Rev. 78 (2) (2023) 293–313.

[11] L. Lombardo, M. Saeli, T. Campisi, Smart technological tools for rising damp on monumental buildings for cultural heritage conservation: a proposal for smart villages implementation in the Madonie mountains (Sicily), Sustain. Futures 6 (2023) 100116.

[12] World Health Organization, Disability, March 7, World Health Organization, 2023, https://www.who.int/news-room/fact-sheets/detail/disability-and-health.

[13] C.S. Chan, K.F. Shek, D. Agapito, The sensory experience of visitors with hearing impairment in Hong Kong Wetland Park based on spatial sensory mapping and self-reported textual analysis, Landsc. Urban Plan. 226 (2022) 104491.

[14] D. Agapito, J. Mendes, P. Pinto, H. de Almeida, The sensory dimension of consumerexperiences in rural tourist destinations, Tourismos 11 (4) (2016) 43–63, https://doi.org/10.26215/tourismos.v11i4.493.

[15] E. Kastenholz, C. Eusébio, M.J. Carneiro, Segmenting the rural tourist market by sustainable travel behaviour: insights from village visitors in Portugal, J. Destin. Mark. Manag. 10 (2018) 132–142.

[16] C.-S. Chan, S.Y. Wong, V. Tam, D. Agapito, Sensory experience of visitors with hearing impairment on a rural island destination, Tour. Geogr. (2025), https://doi.org/10.1080/14616688.2025.2462785.

[17] Y. Qi, Q. Chen, F. Lin, Q. Liu, X. Zhang, J. Guo, L. Qiu, T. Gao, Comparative study on birdsong and its multi-sensory combinational effects on physio-psychological restoration, J Env. Psychol. 83 (2022) 101879, https://doi.org/10.1016/j.jenvp.2022.101879.

[18] M. Qiu, X. Jin, N. Scott, Sensescapes and attention restoration in nature-based tourism: evidence from China and Australia, Tour. Manag. Perspect. 39 (2021) 100855, https://doi.org/10.1016/j.tmp.2021.100855.

[19] D. Buhalis, T. Harwood, V. Bogicevic, G. Viglia, S. Beldona, C. Hofacker, Technological disruptions in services: lessons from tourism and hospitality, J. Serv. Manag. 30 (4) (2019) 484–506, https://doi.org/10.1108/JOSM-12-2018-0398.

[20] I. Arbidane, A. Puzule, D. Znotina, R. Narkuniene, J. Daubariene, Accessibility and smart tourism: tourism for all and reducing inequalities: a tourism agenda 2030, Worldw. Hosp. Tour. Themes 15 (5) (2023) 497–506, https://doi.org/10.1108/WHATT-06-2023-0078.

[21] F. Ali, L. Cain, T.S. Legendre, L. Wu, The intersection of technology, accessible tourism, and tourists with intellectual disabilities: proposing a novel conceptual framework, J. Hosp. Tour. Res. 47 (4) (2022) NP76–NP90, https://doi.org/10.1177/10963480221142499.

[22] D.A. Guttentag, Virtual reality: applications and implications for tourism, Tour. Manag. 31 (5) (2010) 637–651.

[23] M. Atzeni, G. Del Chiappa, J. Mei Pung, Enhancing visit intention in heritage tourism: the role of object-based and existential authenticity in non-immersive virtual reality heritage experiences, Int. J. Tour. Res. 24 (2) (2022) 240–255.

[24] A. Lauría, The Florence Experience": a multimedia and multisensory guidebook for cultural towns inspired by Universal Design approach, Work 53 (4) (2016) 709–727.

[25] E. Figueiredo, C. Eusébio, E. Kastenholz, How *diverse* are tourists with disabilities? A pilot study on accessible leisure tourism experiences in Portugal, Int. J. Tour. Res. 14 (6) (2012) 531–550.

[26] R.W. Smith, Leisure of disabled tourists: barriers to participation, Ann. Tour. Res. 14 (3) (1987) 376–389.

[27] B. McKercher, S. Darcy, *Re*-conceptualizing barriers to travel by people with disabilities, Tour. Manag. Perspect. 26 (2018) 59–66.

[28] R.C. Portales, Removing "invisible" barriers: opening paths towards the future of accessible tourism, J. Tour. Futures 1 (3) (2015) 269–284.

[29] C.-H. Ho, H.-H. Peng, Travel motivation for Taiwanese hearing-impaired backpackers, Asia Pac. J. Tour. Res. 22 (4) (2017) 449–464.

[30] P. Teixeira, L. Teixeira, C. Eusébio, S. Silva, A. Teixeira, The impact of ICTs on accessible tourism: evidence based on a systematic literature review. ICT Tools and Applications for Accessible Tourism, IGI Global, 2021, pp. 1–25.

[31] M.H. Henriques, M.L. Canales, A. García-Frank, M. Gomez-Heras, Accessible geoparks in Iberia: a challenge to promote geotourism and education for sustainable development, Geoheritage 11 (2019) 471–484.

[32] G. Qiao, S. Hou, Q. Chen, G. Xiang, B. Prideaux, Role of body in travel: wheelchair users' experience from a multi-sensory perspective, J. Travel Res. (2024), https://doi.org/10.1177/00472875241249391.

[33] I. Freeman, N. Selmi, French versus Canadian tourism: response to the disabled, J. Travel Res. 49 (4) (2009) 471–485.

[34] J.J. Nigg, A. Plaikner, M. Peters, M. Haid, Leisure constraints towards accessible tourism: self-characteristics of people with disability along tourism value chains, Curr. Issues Tour. (2024), https://doi.org/10.1080/13683500.2024.2394965.

[35] O. Chikuta, E. du Plessis, M. Saayman, Accessibility expectations of tourists with disabilities in national parks, Tour. Plan. Dev. 16 (1) (2019) 75–92.

[36] F.D. Davis, Perceived usefulness, perceived ease of use, and user acceptance of information technology, MIS Q. (1989) 319–340.

[37] R. Iftikhar, M.S. Khan, K. Pasanchay, Virtual reality tourism and technology acceptance: a disability perspective, Leis. Stud. 42 (6) (2023) 849–865.

[38] D.Y. Kim, J. Park, A.M. Morrison, A model of traveller acceptance of mobile technology, Int. J. Tour. Res. 10 (5) (2008) 393–407.

[39] M.C. tom Dieck, T.H. Jung, Value of augmented reality at cultural heritage sites: a stakeholder approach, J. Destin. Mark. Manag. 6 (2) (2017) 110–117.

[40] Y.C. Huang, K.F. Backman, S.J. Backman, L.L. Chang, Exploring the implications of virtual reality technology in tourism marketing: an integrated research framework, Int. J. Tour. Res. 18 (2) (2016) 116–128.

[41] O. El-Said, H. Aziz, Virtual tours a means to an end: an analysis of Virtual tours' Role in tourism recovery Post COVID-19, J. Travel Res. 61 (3) (2022) 528–548.

[42] X. Fan, X. Jiang, N. Deng, Immersive technology: a meta-analysis of augmented/virtual reality applications and their impact on tourism experience, Tour. Manag. 91 (2022) 104534.

[43] M.J. Kim, C.K. Lee, T. Jung, Exploring consumer behavior in virtual reality tourism using an extended stimulus-organism-response model, J. Travel Res. 59 (1) (2020) 69–89.

[44] I.P. Tussyadiah, D. Wang, T.H. Jung, M.C. tom Dieck, Virtual reality, presence, and attitude change: empirical evidence from tourism, Tour. Manag. 66 (2018) 140–154.

[45] S.M.C. Loureiro, J. Guerreiro, F. Ali, 20 years of research on virtual reality and augmented reality in tourism context: a text-mining approach, Tour. Manag. 77 (2020) 104028.

[46] C.H. Yeh, Y.S. Wang, H.T. Li, S.Y. Lin, The effect of information presentation modes on tourists' responses in internet marketing: the moderating role of emotions, J. Travel Tour. Mark. 34 (8) (2017) 1018–1032.

[47] A. Mehrabian, J.A. Russell, An Approach to Environmental Psychology, MIT Press, 1974.

[48] K.G. Kucukergin, F.N. Kucukergin, B.B. Dedeoglu, An overview of the destination physical servicescape with SOR paradigm: the importance of prestige sensitivity, Asia Pac. J. Tour. Res. 25 (5) (2020) 473–488.

[49] G. Chen, K.K.F. So, X. Hu, M. Poomchaisuwan, Travel for affection: a stimulus-organism response model of honeymoon tourism experiences, J. Hosp. Tour. Res. 46 (6) (2022) 1187–1219.

[50] S. Nieves-Pavón, N. López-Mosquera, H. Jiménez-Naranjo, The factors influencing STD through SOR theory, J. Retail. Consum. Serv. 75 (2023) 103533.

[51] A. Şahin, A. Kılıçlar, The effect of tourists' gastronomic experience on emotional and cognitive evaluation: an application of S-O-R paradigm, J. Hosp. Tour. Insights 6 (2) (2023) 595–612.

[52] H. Yu, H. Oh, K.C. Wang, Virtual reality and perceptions of destination presence, Int. J. Contemp. Hosp. Manag. (2024), https://doi.org/10.1108/ijchm-05-2023-0744.

[53] M. Di Dalmazi, M. Mandolfo, J. Guixeres, M.A. Raya, L. Lamberti, How immersive technologies impact behavioral responses in destination marketing: the role of physiological arousal, presence, and age, Int. J. Contemp. Hosp. Manag. 36 (11) (2024) 3628–3650.

[54] J. Beck, M. Rainoldi, R. Egger, Virtual reality in tourism: a state-of-the-art review, Tour. Rev. 74 (3) (2019) 586–612.

[55] A.J. Omlor, L.S. Schwärzel, M. Bewarder, M. Casper, E. Damm, G. Danziger, et al., Comparison of immersive and non-immersive virtual reality videos as substitute for in-hospital teaching during coronavirus lockdown: a survey with graduate medical students in Germany, Med. Educ. Online 27 (1) (2022) 2101417.

[56] K. Mahmoud, I. Harris, H. Yassin, T.J. Hurkxkens, O.K. Matar, N. Bhatia, I. Kalkanis, Does immersive VR increase learning gain when compared to a non-immersive VR learning experience?, in: International Conference on Human-Computer Interaction Springer International Publishing, Cham, 2020, pp. 480–498.

[57] S. Ventura, E. Brivio, G. Riva, R.M. Baños, Immersive versus non-immersive experience: exploring the feasibility of memory assessment through 360° technology, Front Psychol. 10 (2019) 2509.

[58] J. Beck, R. Egger, Emotionalize me: self-reporting and arousal measurements in virtual tourism environments, in: Information and Communication Technologies in Tourism 2018: Proceedings of the International Conference in Jönköping, Sweden, January 24-26, 2018, Springer International Publishing, 2018, pp. 3–15.

[59] M. Wedel, E. Bigné, J. Zhang, Virtual and augmented reality: advancing research in consumer marketing, Int. J. Res. Mark. 37 (3) (2020) 443–465.
[60] M.J. Schuemie, P. Van Der Straaten, M. Krijn, C.A Van Der Mast, Research on presence in virtual reality: a survey, Cyberpsychology Behav. 4 (2) (2001) 183–201.
[61] T. Jung, M.C. tom Dieck, N. Moorhouse, D. tom Dieck, Tourists' experience of Virtual reality applications, in: 2017 IEEE International Conference on Consumer Electronics (ICCE), IEEE, 2017, pp. 208–210.
[62] H. Lee, T.H. Jung, M.C. tom Dieck, N. Chung, Experiencing immersive virtual reality in museums, Inf. Manag. 57 (5) (2020) 103229.
[63] I. Assiouras, A. Giannopoulos, E. Mavragani, D. Buhalis, Virtual reality facilitated travel inspiration: the role of pleasure and arousal, Curr. Issues Tour. (2024), https://doi.org/10.1080/13683500.2024.2406412.
[64] F. Lotte, J. Faller, C. Guger, Y. Renard, G. Pfurtscheller, A. Lécuyer, R. Leeb, Combining BCI with virtual reality: towards new applications and improved BCI. Towards Practical Brain-Computer Interfaces: Bridging the Gap from Research to Real-World Applications, Springer, 2013, pp. 197–220.
[65] M.A. Ozdemir, Virtual reality (VR) and augmented reality (AR) technologies for accessibility and marketing in the tourism industry. ICT Tools and Applications for Accessible Tourism, IGI Global, 2021, pp. 277–301.
[66] U. Stankov, M.D. Vujičić, P. Orero, U. Gretzel, Accessibility of tourism 4.0—Designing more meaningful and inclusive tourist experiences, Univers. Access Inf. Soc. 23 (2024) 1503–1506.
[67] D. Ye, D. Cho, F. Liu, Y. Xu, Z. Jia, J. Chen, Investigating the impact of virtual tourism on travel intention during the post-COVID-19 era: evidence from China, Univers. Access Inf. Soc. 23 (2024) 1507–1523.
[68] D. Wang, S. Park, D.R. Fesenmaier, The role of smartphones in mediating the touristic experience, J. Travel Res. 51 (4) (2012) 371–387.
[69] M.K. Pradhan, J. Oh, H. Lee, Understanding travelers' behavior for sustainable smart tourism: a technology readiness perspective, Sustainability 10 (11) (2018) 4259.
[70] U. Gretzel, M. Sigala, Z. Xiang, C. Koo, Smart tourism: foundations and developments, Electron. Mark. 25 (2015) 179–188.
[71] O. Popoola, M. Rodrigues, J. Marchang, A. Shenfield, A. Ikpehai, J. Popoola, A critical literature review of security and privacy in smart home healthcare schemes adopting IoT & blockchain: problems, challenges and solutions, Blockchain: Res. Appl. 5 (2) (2024) 100178.
[72] S. Gillet, P. Schmitz, O. Mitas, The snap-happy tourist: the effects of photographing behavior on tourists' happiness, J. Hosp. Tour. Res. 40 (1) (2016) 37–57.
[73] W.K. Tan, The relationship between smartphone usage, tourist experience and trip satisfaction in the context of a nature-based destination, Telemat. Inform. 34 (2) (2017) 614–627.
[74] K.L. Lam, C.S. Chan, M. Peters, Understanding technological contributions to accessible tourism from the perspective of destination design for visually impaired visitors in Hong Kong, J. Destin. Mark. Manag. 17 (2020) 100434.
[75] A. D'Amico, V. Marozzo, V. Schifilliti, How to improve universal accessibility of smart tourism destinations: the case of Amsterdam City. Tourism and Disability: An Economic and Managerial Perspective, Springer International Publishing, Cham, 2022, pp. 89–102.
[76] L. Huang, N. Lau, Enhancing the smart tourism experience for people with visual impairments by gamified application approach through needs analysis in Hong Kong, Sustain 12 (15) (2020) 6213.
[77] Sai Kung Hoi Arts Festival, Yim Tin Tsai, Sai Kung Hoi Arts Festival, 2023. https://skhartsfestival.hk/en/island/yim-tin-tsai/.
[78] E. Yau, Abandoned Hong Kong island gets new life as heritage site and ecotourism destination, South China Morning Post (2016). https://www.scmp.com/lifestyle/travel-leisure/article/1908076/abandoned-island-sai-kung-comes-back-life-heritage-site-and.
[79] X. Su, Yim Tin Tsai Village in Hong Kong: a model for effective conservation. South China Morning Post, 2018. https://www.scmp.com/photos/hong-kong/2161879/yim-tin-tsai-village-hong-kong-model-effective-conservation.
[80] K. Whitehead, Yim Tin Tsai: Hong Kong's little salt pan. Hong Kong Tourism Board, 2023. https://www.discoverhongkong.com/eng/explore/great-outdoor/hong-kong-little-salt-pan-yim-tin-tsai.html.
[81] Census and Statistics Department, Social data collected via the General Household Survey. *Special Topics Report - Report No. 63 - Persons with Disabilities and Chronic Diseases*, 2021. https://www.censtatd.gov.hk/en/data/stat_report/product/B1130121/att/B11301632021XXXXB0100.pdf.
[82] Hong Kong Society for the Deaf, Audiological Service, 2024. https://www.deaf.org.hk/ch/med_aud_hearing.php.
[83] T.L. Packer, B. McKercher, M.K. Yau, Understanding the complex interplay between tourism, disability and environmental contexts, Disabil. Rehabil. 29 (4) (2007) 281–292.
[84] N.M. Ray, M.E. Ryder, Ebilities" tourism: an exploratory discussion of the travel needs and motivations of the mobility-disabled, Tour. Manag. 24 (1) (2003) 57–72.
[85] M.K.S. Yau, B. McKercher, T.L. Packer, Traveling with a disability: more than an access issue, Ann. Tour. Res. 31 (4) (2004) 946–960.
[86] S. Vaughn, J.S. Schumm, J.M. Sinagub, Focus Group Interviews in Education and Psychology, Sage, 1996.
[87] A.J. Onwuegbuzie, W.B. Dickinson, N.L. Leech, A.G. Zoran, A qualitative framework for collecting and analyzing data in focus group research, Int. J. Qual. Methods 8 (3) (2009) 1–21.
[88] R. Camprubí, L. Coromina, Content analysis in tourism research, Tour. Manag. Perspect. 18 (2016) 134–140.
[89] S. Stepchenkova, A.P. Kirilenko, A.M. Morrison, Facilitating content analysis in tourism research, J. Travel Res. 47 (4) (2009) 454–469.
[90] A. Corden, R. Sainsbury, Using Verbatim Quotations in Reporting Qualitative Social research: researchers' Views, The University of York, York, 2006.
[91] D. Agapito, J. Mendes, P. Valle, The rural village as an open door to nature-based tourism in Portugal: the Aldeia da Pedralva case. *Tourism*, Int. Interdiscip. J. 60 (3) (2012) 325–388.
[92] M. Qiu, X. Jin, N. Scott, Sensescapes and attention restoration in nature-based tourism: evidence from China and Australia, Tour. Manag. Perspect. 39 (2021) 100855, https://doi.org/10.1016/j.tmp.2021.100855.
[93] T. Jung, M.C. tom Dieck, H. Lee, N. Chung, Effects of virtual reality and augmented reality on visitor experiences in museum, in: Information and Communication Technologies in Tourism 2016: Proceedings of the International Conference in Bilbao, Spain, February 2-5, 2016, Springer International Publishing, 2016, pp. 621–635.
[94] A. Slavec, N. Sajinčič, V. Starman, Use of smartphone cameras and other applications while traveling to sustain outdoor cultural heritage, Sustain. 13 (13) (2021) 7312.
[95] B.J. Pine II, J.H Gilmore, Welcome to the Experience Economy, 76, Harvard Business Review Press, Cambridge, MA, USA, 1998, pp. 97–105.
[96] D. Guttentag. Virtual reality and the end of tourism? A Substitution Acceptance model. *Handbook of E-Tourism*, 2020, pp. 1–19.
[97] E. Sthapit, C. Ji, P. Yang, K. Woosnam, Memorable digital-free tourism experiences: antecedents and outcomes, J. Vacat. Mark. (2024), https://doi.org/10.1177/13567667241282022.
[98] E. Baker, J.A. Bakar, A. Zulkifli, A conceptual model of mobile augmented reality for hearing impaired museum visitors' engagement, Int. J. Interact. Mob. Technol. 14 (17) (2020) 79–96.
[99] D.I. Han, T. Jung, Identifying tourist requirements for mobile AR tourism applications in urban heritage tourism. Augmented Reality and Virtual Reality: Empowering Human, Place and Business, Springer International Publishing, 2018, pp. 3–20.
[100] M.J. Carneiro, L. Teixeira, C. Eusébio, E. Kastenholz, A.A. Moura, Use of the internet to plan tourism trips by people with special needs. ICT Tools and Applications for Accessible Tourism, IGI Global, 2021, pp. 74–95.
[101] R. Pagán, Time allocation in tourism for people with disabilities, Annals Tourism Res. 39 (3) (2012) 1514–1537, https://doi.org/10.1016/j.annals.2012.04.005.
[102] C. Tao, S. Huang, J. Wang, G. Qiao, Accessible tourism: tourists with physical disability - segmentation based on perceived travel barriers, Tour. Rev. (2024), https://doi.org/10.1108/tr-07-2023-0459.
[103] S. Darcy, B. Mckercher, S. Schweinsberg, From tourism and disability to accessible tourism: a perspective article, Tourism Rev. 75 (2020) 140–144.
[104] W.K.S. Leung, M.K. Chang, M.L. Cheung, S. Shi, VR tourism experiences and tourist behavior intention in COVID-19: An experience economy and mood management perspective, Inform. Technol. People 36 (3) (2023) 1095–1125, https://doi.org/10.1108/ITP-06-2021-0423.
[105] D. Buhalis, Technology in tourism-from information communication technologies to eTourism and smart tourism towards ambient intelligence tourism: a perspective article, Tourism Rev. 75 (1) (2020) 267–272, https://doi.org/10.1108/TR-06-2019-0258.
[106] R. Sharpley, Rural tourism and the challenge of tourism diversification: The case of Cyprus, Tourism Manage. 23 (3) (2002) 233–244, https://doi.org/10.1016/S0261-5177(01)00078-4.
[107] S. Shafiee, A.R. Ghatari, A. Hasanzadeh, S. Jahanyan, Developing a model for sustainable smart tourism destinations: a systematic review, Tour. Manag. Perspect. 31 (2019) 287–300.

(Corresponding and first author) CHAN, Chung-Shing is an Assistant Professor in the Department of Geography and Resource Management at The Chinese University of Hong Kong (CUHK). His research interests cover place branding, sustainable tourism development, and accessible and multi-sensory tourism. He is a core member of the teaching team for the Master of Social Science in Sustainable Tourism Programme at CUHK, with teaching interests including sustainable tourism, urban tourism, and ecotourism.

(Co-author) WONG, Shing Yan is a researcher in the Department of Geography and Resource Management at The Chinese University of Hong Kong and holds a Master's degree in Urban and Regional Planning from the University of Sheffield. His main research interests include tourism development, transport planning, and urban and rural revitalization.

(Co-author) AGAPITO, Dora holds a PhD in Tourism with a specialization in Management. She is currently an Assistant Professor at the Faculty of Economics, University of Algarve, and an integrated researcher at the Research Centre for Tourism, Sustainability and Well-being (CinTurs), where she is coordinator of the research area of Tourism and Hospitality Management. Her research interests include sensory experiences, consumer behaviour, experience design, destination marketing management, and well-being in tourism.

(Co-author) TAM, Veleda is a researcher holding a Master's degree in Tourism Management from the Erasmus Mundus European Master in Tourism Management (2020). Her research interests include sustainable-responsible tourism and community-based tourism.