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The impact of a 360° virtual tour on the reduction of psychological stress caused by COVID-19

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ABSTRACT

The continuous spread of the COVID-19 pandemic is causing people to feel anxiety and stress. This study constructs a four-layer research model to examine how a 360° virtual tour can reduce people's psychological stress through two types of presence (the sense of presence and telepresence) and affective-motivational states (enjoyment and involvement) in this extraordinary period of the COVID-19 pandemic. In order to test the moderating effect of involvement, partial least squares (PLS) analysis is employed to analyse valid data collected from 235 individuals. The results of this study indicate that telepresence has a higher impact in generating affective-motivational states than the sense of presence. Among the factors, enjoyment shows the highest effect on satisfaction with the 360° virtual tour experience and stress reduction; involvement moderates the effect of telepresence on satisfaction with the 360° virtual tour experience. This study also contributes to virtual reality research by distinguishing the concepts of 'sense of presence' and 'telepresence' as well as demonstrating the mechanisms whereby virtual reality technology influences people's psychological well-being. Timely recommendations are provided for people in order to reduce psychological stress during and after COVID-19 pandemic.

1. Introduction

In December 2019, a number of patients with pneumonia of an unknown aetiology emerged in Wuhan city, Hubei Province, China [1]. The World Health Organization (WHO) has called this pneumonia COVID-19. COVID-19 has spread rapidly throughout 200 countries, causing over 71.58 million confirmed cases and nearly 1,618,374 deaths as of December 16, 2020 [2]. The COVID-19 pandemic has caused not only the risk of death from the viral infection but also unbearable psychological stress to people throughout the world [3]. This intense stress is a root cause of many negative physical and psychological health outcomes [4]. These detrimental outcomes include anxiety, problems sleeping, depression, a decreased functioning of the immune system, and behavioural issues all of which intensified since the beginning of the pandemic [5,6]. Therefore, finding methods of guiding the general public to effectively and appropriately regulate their emotions during public health emergencies has become an urgent problem for people wishing to avoid losses caused by this crisis event [7].

There are various stress management and relaxation techniques to relieve psychological pressure. The attention restoration theory has stated that exploring nature can reduce stress [8]. Thus, the tourism experience can be a stress reliever [9]. As part of the tourism experience, a beautiful natural landscape and a peaceful ecological environment can effectively relieve tension and emotional exhaustion, reducing the level of stress and anxiety, and furthermore, restoring human function [10]. However, due to the continuous spread of COVID-19, the directive to 'stay home, stay safe' restricts people's movements outdoors. People cannot access natural attractions easily. However, researchers have found that virtual reality (VR) can provide a similar effect to the tourism experience and exposure to nature because it provides stimulation for a variety of human senses such as images and/or sounds to deceive the brain which is actually responding to virtual experience [11]. For example, Allison et al. [12] found that VR can provide exposure to nature for those living in isolated, confined environments to help them reduce stress and improve their mood. Indeed, as early as 2001, VR technology had been used to improve individuals' health [13]. VR is employed as a distraction tool in reducing patients' stress [14,15]. Hedblom et al. [16] compared the effects of visual stimuli and found that natural environments can lower stress levels within a minute of stressor offset. Therefore, in this extraordinary period of the COVID-19

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pandemic, a 360° virtual tour can be a solution resulting in stress reduction, but the question is how to build effective 360° virtual tour contents to decrease stress.

A 360° virtual tour is a virtual representation of an actual attraction, destination, or visitor experience using the three-dimensional world of an innovative technology that is designed as a prelude to visiting a destination or as a way of extending the previous experiences of consumers [17]. Recent studies have examined how 360° virtual tours can motivate tourists' intention to visit and help them with travel decision making [18,19]. On the other hand, some studies have identified the factors that influence satisfaction with the 360° virtual experience. Kim and Ko [20] in their research of sporting events, found that sports involvement and telepresence are factors of a flow experience of watching VR sports games. Involvement is the active and intensive processing of the mediated world [21]. Telepresence is the extent to which one feels present in the mediated environment [22]. Bogicevic et al. [23] in their study of a VR preview concluded that a positive sense of presence could spill over into the tourism experience. Tussyadiah et al. [24] had similar findings; namely that VR presence and VR enjoyment affect the post-VR experience. A 360° virtual tour leads users to perceive a sense of presence in a destination [25]. This sense of presence promotes the enjoyment of the VR experience [26]. Consolidating the results of the above VR studies, it is possible to conclude that the potential factors that may influence satisfaction with a 360° virtual tour experience include involvement, telepresence, sense of presence, and enjoyment.

This study aims to examine how 360° virtual tours can help to reduce people's psychological stress in during the COVID-19 pandemic. In order to achieve this objective, this study constructs a research model that evaluates the effects of two types of presence (sense of presence and telepresence) and affective-motivational states (enjoyment and involvement) on satisfaction with a 360° virtual tour experience and the perception of stress reduction. A survey was conducted in China in July 2020. This study contributes to VR research by distinguishing the roles of a sense of presence and telepresence in generating affective-motivational states and satisfaction in VR applications. It also contributes to cyber-psychological research by empirically proving the link of VR technology to people's psychological well-being. This study provides timely recommendations on how people can reduce psychological stress during periods of self-isolation and after the COVID-19 pandemic. This study highlights the importance of developing VR technology in order to improve public health.

2. Literature review

2.1. Research regarding 360° virtual tours

The potential of VR technology in tourism was recognised in the 1990s [27]. VR is a highly novel technology [28] and is widely defined as a communication medium that provides users with a computer-simulated 3D (360-degree) virtual context which enables users to become immersed, navigate, and interact in a fully digital environment [17,29,30]. As a result of VR becoming increasingly popular, VR technology in tourism has attracted great interest from both researchers and practitioners for decades [29]. Applications of VR include 3D VR and 360° video. Three-dimensional VR is crafted in the digital environment by artists like 3D game developers, and 360° video is filmed in the real places. In order to study tourism marketing, researchers commonly studied the effect of the 360° video rather than a 3D VR environment since 360° video demonstrates the real travel experience [31].

Twenty years ago, Williams and Hobson [32] had already stated that the tourism industry was about to enter the era of VR, and that it would have revolutionary effects on the promotion and selling of tourism products. Soon afterwards, the tourism industry adopted VR technology to represent interplanetary voyages, fantasy worlds, sporting events, and theme park experiences [33,34]. Nowadays, the use of VR technology in tourism is extensive, and include planning and management, sustainability and heritage preservation, marketing, accessibility, education, and entertainment [17]. Moreover, in the tourism industry, the use of VR technology is extended to the pre-visit phase, onsite/during the trip, and the post-visit stage [35,36].

Most existing research about VR in tourism has been about destination marketing [37]. Cheong [38] posited that using VR to compare different destinations helps consumers make informed decisions. Gibson and O'Rawe [39] pointed out that from a marketing perspective, VR technology offers the potential to build a sensory experience of a destination or attraction. VR technology can be used to reduce the barrier of distance between potential tourists and a destination [27]. Therefore, using VR as a promotional tool greatly increases the likelihood of visiting the destination in the future [39]. Meanwhile, VR provides opportunities for destination marketing organisations to communicate with targeted markets by offering a rich environment for potential visitors to explore tourism destinations [40]. Recently, Zeng et al. [41] have successfully conducted an experiment to show that VR can enhance marketing communication to persuade consumers to purchase tourism products and services.

On the other hand, researchers recently started to investigate the factors that influence experience of VR in tourism content. Huang et al. [42] revealed that skill, interactivity, and presence influence an engaging and pleasant experience in *Second Life*. Tussyadiah et al. [24] found that VR presence and VR enjoyment during VR experience have a positive effect on the post VR experience, and VR presence leads to enjoyment of the VR experience. Based on Technology Acceptance Model (TAM), Li and Chen [29] indicated that perceived enjoyment of VR mediates the effect of perceived ease of use and perceived usefulness of VR on travel intention. Bogicevic et al. [23] conducted an experiment in a VR hotel suite and found that elaboration (but not the quality of mental imagery) is positively associated with a sense of presence, and sense of presence is positively associated with the brand experience. Kim and Hall [17] studied consumer usage in VR tourism and found that people's flow state is likely to be well developed if they enjoy VR tourism content, and consequently the well-developed flow state improves their subjective well-being. Flow is an optimal experience that is most enjoyable in an activity, and flow state is a mental state in which a person is fully immersed in positive feelings of the activity [43]. These feelings include being cognitively efficient, motivated, and happy [44]. Later on, Kim et al. [19] posited that enjoyment, emotional involvement, and flow state are subconstructs of affective response; authentic experience is the stimulus that influences cognitive response and affective response; and that these two responses reflect an attachment to VR.

Other than serving as a tourism marketing tool, VR can also provide entertainment to people in the form of a 360° virtual tour. Ten years ago, Guttentag [45] suggested examining the factors that influence people's perceptions of a 360° virtual tour as a substitute tourism experience. Although some researchers have identified these factors in different research settings, few studies have been made that investigate other consequences of a 360° virtual tour experience, such as helping people reduce the perception of stress in their daily life.

2.2. Telepresence and presence

Presence is commonly referred to as telepresence, virtual presence, or mediated presence [46]. Some researchers in VR studies have argued that presence and telepresence are interchangeable [47]. However, some researchers argued that the sense of presence and telepresence are different [48].

The concept of presence was first discussed in the field of psychology by Short et al. [49] who identified a social presence in organisational communication. Kim and Biocca [50] defined presence as the person's perception of being at a specified or understood place, even when one was not physically situated there [51]. Most early studies on presence

related to media technologies such as television, movies, or games, and then the term of presence was gradually applied to the user experience of new technologies [52]. The concept of presence has been tested in different research contexts. For VR studies, Lee [46] defined presence as the 'psychological similarities between virtual and actual objects when people experience – perceive, manipulate, or interact with – virtual objects'. Therefore, presence is a mediated experience allowing the perception of a difference between real and virtual place [53]. Thus, the sense of presence refers to a user feeling of immersion and the experience in virtual environments provided by VR technologies.

Minsky [54] used telepresence to describe his artificial intelligence system. The concept of telepresence is a sense of 'being there' [54]. An extension of presence is Durlach and Mavor's [55] explanation that telepresence is a subjective sensation of being present in a remote or artificial environment but not in the surrounding physical environment. Telepresence is a technical term for describing the apparent participation in remote or virtual sites. In different applications, people can experience presence in a real place, a virtual place, and an imaginary place. For example, Tamborini et al. [56] found that playing a game creates a stronger sense of presence in an imaginary place. Thus, telepresence can be viewed as a measurement of a 'moment-to-moment' feeling of internal mental imagery of a place generated by the VR technology.

For research of VR, some researchers used the sense of presence [23] and some used telepresence [57]. In Bogicevic et al.'s [23] research, a participant stated 'while I was previewing the hotel suite, I felt I was in the world of Aevum Hotels' to measure the sense of presence. Whereas in Wei et al.'s [58] study, they used 'I felt like I was actually there in the VR environment'. Comparing these two studies, Bogicevic et al. [23] tested respondents' perception of being in a real hotel, where respondents subconsciously compared the hotel shown in VR with the real one. So, their study tested respondents' mediated experience between a real and a virtual place, thus testing the sense of presence. However, Wei et al. [58] measured respondents' perception of an imaginary environment, so their study tested the telepresence. Tussyadiah et al. [24] constructed VR presence as two dimensions (self-location and possible action) and used similar measurements as Wei et al. [58]. Most recently, Ye et al. [57] separated social presence and telepresence as two independent factors of purchasing online peer-to-peer (P2P) accommodation where social presence refers to awareness of the existence of other consumers. They used 'there is a sense of human contact in the P2P website' for measuring social presence and 'while I was surfing the P2P platform, I felt I was in a world it created' to measure the telepresence. However, the social presence specifically represents human personalness and is not the same as a sense of presence in a 360° virtual tour where there is no social communication.

Literature reveals that the sense of presence and telepresence are different and can both exist in users' perceptions. However, no studies were found which included these two types of presence. Comparing their effects on psychological states and flow experience is essential for designing the VR applications for different purposes such as training and health treatment. Therefore, this study attempts to compare their effects on the 360° virtual tour. In the study, a sense of presence is defined as a mediated experience of a virtual destination from a real tourist destination. The telepresence is defined as a subjective sensation of being present in a virtual tourist destination.

2.3. Enjoyment and involvement

Enjoyment is a psychological state that leads to performing an activity with positive states of feeling [59]. Involvement is a psychological state resulting from the attention to an activity [60]. Enjoyment and involvement are both positive affective-motivational states [61] which can be enhanced by the VR which can increase the prevalence of these states. Hruby et al. [62] argued that an increased sense of presence facilitates involvement with the visualized phenomena. Van Damme et al.'s [63] experimental study showed that a higher sense of presence in VR journalism leads to higher enjoyment and higher involvement. Zarzuela et al. [64] found that tourists exhibit involvement and enjoyment when using a VR game to learn a tourist destination. Therefore, two types of presence may be associated with the enjoyment and involvement of a virtual environment when a person is watching a 360° virtual tour.

H1a. A higher sense of presence perceived by people increases their level of enjoyment of the 360° virtual tour.

H2a. Higher telepresence perceived by people increases their level of enjoyment of the 360° virtual tour.

H1b. A higher sense of presence perceived by people increases their level of involvement in the 360° virtual tour.

H2b. Higher telepresence perceived by people increases their level of involvement in the 360° virtual tour.

2.4. Satisfaction with a 360° virtual tour experience

The above literature reveals that two types of presence and two affective-motivational states amplify participants' experience in different VR applications [20,23,24]. Lee et al. [65] found that enjoyment has a significant effect on the intention to use VR devices in the entertainment industry. Rahimizhian et al. [31] while studying the use of 360° virtual tours to promote tourist destinations found that perceived enjoyment is positively related to satisfaction with the 360° virtual tour experience. Li et al. [47] observed that consumers perceive telepresence, sense of presence, involvement, and enjoyment of virtual experiences when they are interacting with 3-D product simulation. Therefore, when people are watching a 360° virtual tour, these four factors may also influence their satisfaction with the 360° virtual tour experience. Furthermore, Kim and Ko [20] found that sports involvement also moderates the relationship between telepresence and flow experience in VR spectatorship. Flow experience is a satisfying experience [66]. Therefore, users who were highly involved in a 360° virtual tour, would focus more on being in the 360° virtual environment and would be more likely to be satisfied with the 360° virtual tour experience. Thus, people's involvement may also moderate the relationship between telepresence and their satisfaction with the 360° virtual tour experience. The following hypotheses are formulated.

H1c. A higher sense of presence perceived by people increases their level of satisfaction with the 360° virtual tour experience.

H2c. Higher telepresence perceived by people increases their level of satisfaction with the 360° virtual tour experience.

H3a. Higher enjoyment perceived by people increases their level of satisfaction with the 360° virtual tour experience.

H4a. Higher involvement perceived by people increases their level of satisfaction with the 360° virtual tour experience.

H5. Involvement moderates the effect of telepresence on satisfaction with the 360° virtual tour experience. At a high-level of telepresence, the high-involvement users would be more satisfied with the 360° virtual tour experience than the low-involvement users. At a low-level of telepresence, the low-involvement users would be more dissatisfied with the 360° virtual tour experience than the high-involvement users.

2.5. Perception of stress reduction

Psychological stress was defined as the negative emotional, behavioural, and biological response to a perceived threat [67]. Stress is one of 15 common life domains for the quality of life [68] and is one of four measures for well-being [69]. For managing stress, the psychologist Marwah [70] has suggested that when you take time out to do activities

which you enjoy, then you will not feel stressed. For example, people felt mentally better when they were enjoying a natural environment [71]. On the other hand, the psychologist Csikszentmihalyi [72] stated that when you are involved in flow activities, you lose track of time and become less self-conscious. Goldberg et al. [73] described this as 'losing yourself in the act'. Thus, VR technology has been used in different medical specialities and has received clinical validation [74]. For example, Diana et al. [75] confirmed that a nature-inspired VR simulation reduced stress and pain levels among cancer patients. Tarrant et al. [76] performed a similar experiment with a sample from the general population and found that a brief nature-based VR intervention had the effect of reducing potential anxiety. Thus, a 360° virtual tour as a flow activity, creating enjoyment, involvement, and satisfaction with the 360° virtual tour experience may reduce participants' stress caused by the COVID-19 pandemic.

H3b. Higher enjoyment of a 360° virtual tour by people reduces their stress from COVID-19.

H4b. Higher involvement in a 360° virtual tour by people reduces their stress from COVID-19.

H6. People's higher satisfaction with the experience of a 360° virtual tour reduces their stress from COVID-19.

3. Research method

3.1. Research model

Table 1 shows the conceptual development of the research model referred to in previous studies. The construction of the research model mainly follows the models of Tussyadiah et al. [24], Kim and Ko [20], and Kim and Hall [17] to link the concept of presence with affective-motivational status, a 360° virtual tour experience, and psychological well-being. Fig. 1 shows the four-layer theoretical framework of the study. Two types of presence influence people's affective-motivational states when they are experiencing a 360° virtual tour. Then, two types of presence and affective-motivational states affect people's experience of the 360° virtual tour. Finally, people's affective-motivational states and satisfaction with the 360° virtual tour experience help to reduce their stress from COVID-19.

Table 1
The conceptual development of the research model.

Hypothesis	This study	Previous study	Authors
H1a, H2a, H1b, H2b	Concept of presence → affective-motivational status	VR presence → VR enjoyment Presence → enjoyment Presence → involvement	Tussyadiah et al. [24] Van Damme et al. [63]
H1c, H2c	Concept of presence → 360° virtual tour experience	Presence → shopping experience VR presence→ overall satisfaction Sense of presence → tourism brand experience	Pizzi et al. [77] Wei et al. [58] Bogicevic et al. [23]
H3a, H4a	Affective-motivational status → 360° virtual tour experience	VR enjoyment → attitude change Perceived enjoyment → flow state Involvement → flow experience	Tussyadiah et al. [24] Kim and Hall [17] Kim and Ko [20]
H3b, H4b	Affective-motivational status → psychological well-being	Enjoying natural environment → subjective well-being	Kim et al. [71]
H5	Involvement moderates the relationship between telepresence and 360° virtual tour experience	Sport involvement moderates the relationship between telepresence and flow experience	Kim and Ko [20]
H6	360° virtual tour experience → psychological well-being	Flow state → subject well-being	Kim and Hall [17]

3.2. Measurements

The measurable items of sense of presence (five items) and enjoyment (five items) were adapted from Pizzi et al. [77] and Kim et al. [30], respectively. Telepresence (three items) and involvement (three items) were adapted from Kim and Ko [20]. The 360° virtual tour experience (three items) was adapted from Kim et al. [19,30]. To evaluate the perception of stress reduction, four symptoms of stress mentioned in a government health channel [78] (tension, upset, panic, and pressure) were used resulting in responses such as 'after experiencing the 360° virtual tour, I felt that the tension caused by the COVID-19 pandemic has decreased.' All the measurable items were evaluated by a 7-point Likert-type scale ranging from strongly disagree (1) to strongly agree (7), except the measurement of involvement was measured by Zaichkowsky's [79] scale, in which the dimensions of irrelevant/relevant, boring/interesting, and unimportant/important were ranked using 7-point semantic-type measures.

3.3. Questionnaire design and data collection

The original survey questionnaire was first developed in English and then translated into Chinese by professionals who are proficient in English and Chinese. A back-translation procedure was conducted with discrepancies then being remedied between the English and Chinese translations in order to confirm the precision of the translation [80]. Two scholars who know the study topic well were invited to evaluate the content validity of the survey questions. Then, the questionnaire was revised according to the comments from the scholars. A pilot test of the questionnaire was conducted with 20 Chinese people to ensure the clarity of the content. Several items of the questionnaire were reworded and modified based on comments and feedback. Finally, all the questions were confirmed to be easily comprehensible by the respondents.

The survey questionnaire used in this study consisted of four parts. The first part was an introduction to the 360° virtual tour, and then the respondents were asked to watch a short video of the 360° virtual tour so that the respondents could experience it. The second part consisted of questions measuring five constructs excluded the stress reduction of the research model. The third part recorded the respondents' demographic characteristics such as gender, age, marital status, education, income, occupation, and so on. The final part measured the perception of stress reduction as a result of using the 360° virtual tour. This setting helped to reduce the common method bias [81].

Since the COVID-19 pandemic has spread extensively in China, the participants of this study had endured the pandemic in China. The survey was performed from 1 to July 15, 2020. Respondents viewed a 3-min '360° VR Gondola Ride in Venice!' video [82] before answering the questions. Overall, 260 samples were collected face-to-face at shopping malls in Zhuhai, a southern city in China. Shopping malls provided a comfortable environment for respondents to view the 360° virtual tour video. Well-trained research assistants systematically collected one datum every 30 min at the entrances of the shopping malls. Twenty-five sets of samples were manually removed because questions were similarly rated. Finally, 235 valid samples of this study were obtained.

Table 2 shows the sample characteristics. There were 106 respondents (45.1%) who were male and 129 respondents (54.9%) who were female. The majority of the respondents' age groups were 18–25 (31.1%) and 26–35 (25.5%). Most of the respondents (76.6%) had no experience with 360° virtual tours prior to completing the survey.

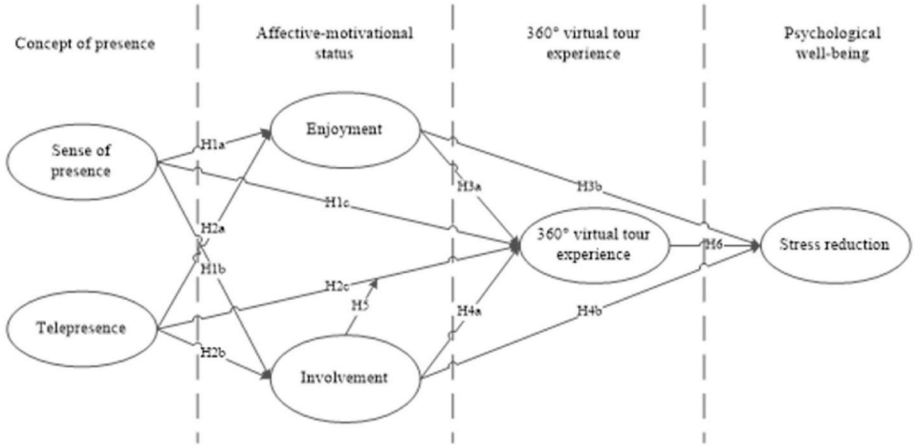

Fig. 1. Research model.

Table 2
Sample characteristics (n = 235).

		Frequency	Percentage
Gender	Male	106	45.1
	Female	129	54.9
Age	18–25	73	31.1
	26–35	60	25.5
	36–45	47	20.0
	46–55	20	8.5
	Over 55	35	14.9
Marital status	Single	101	43.0
	Married	134	57.0
Education (completed)	Below or secondary	40	17.0
	Diploma	52	22.1
	Bachelor	96	40.9
	Master or above	47	20.0
Monthly income (USD)	Under 300	31	13.2
	301–450	17	7.2
	451–770	51	21.7
	771–1200	45	19.1
	1201–2300	55	23.4
	2301 or more	36	15.3
Occupation	Professional	71	30.2
	Business owner	2	0.9
	Service worker	19	8.1
	Office worker	25	10.6
	Civil servant	8	3.4
	Home maker	6	2.6
	Retiree	15	6.4
	Self-employed	5	2.1
	Student	53	22.6
	Other	31	13.2
Experience with 360° virtual tour	First time	180	76.6
	<6 months	38	16.2
	6–12 months	5	2.1
	13–24 months	3	1.3
	>24 months	9	3.8

4. Findings

In order to examine the proposed study framework, statistical analyses were employed by using partial least squares structural equation modelling (PLS-SEM) with the programme SmartPLS version 3.0 for the following reasons [83]. PLS-SEM is one of the most popular and powerful statistical techniques. It requires minimal criteria for sample size and residual distributions in order to validate a model with bootstrap re-sampling method as the samples of this study [84]. Also, PLS-SEM can model the moderator's influence on the relationship between two constructs [85]. Therefore, PLS-SEM is suitable for this study as a method to analyse the conceptual model.

4.1. Reliability and validity of the constructs

Table 3 presents the values of mean, standard deviation, and PLS loading of each measurement item. All factor loadings exceed 0.8, which reach the recommended level [86]. The values of Cronbach's alpha for all the constructs are between 0.807 and 0.964. The values of Average Variance Extracted (AVE) and Construct Reliability (CR) for all the constructs exceed 0.7 and 0.8, respectively. The above results indicate that reasonable convergent validity is achieved.

Table 4 shows the results of the discriminant validity tests. The values of correlation are between 0.601 and 0.782 (less than 0.85), therefore, the constructs of the proposed model are relatively independent of one another. The square root of AVE for each construct is larger than its construct correlations [87]. Further, Heterotrait-Monotrait (HTMT) ratio of correlations is used to access the discriminant validity of the measurement model. The highest value of HTMT ratio is 0.886 (<0.900, the threshold) and it is concluded that discriminant validity has been established [88]. Table A1 in the Appendix shows cross-loadings of all the indicators and latent variables. It indicates that latent variables have been adequately reflected in their indicators. These results confirm the data reliability and validity of the discriminants [89].

4.2. Results of PLS-SEM analysis

There are 235 cases and 5000 samples which are used for bootstrapping to evaluate the proposed research model. As shown in Fig. 2, each of the endogenous variables has ample variance explained as the R squared for the satisfaction with a 360° virtual tour experience (70.8%) and stress reduction (58.5%), which can be described as 'substantial' [90]. The sense of presence perceived by people is significantly related to their level of enjoyment ($\beta = 0.221$, t-statistics = 2.256), involvement ($\beta = 0.250$, t-statistics = 3.224), and satisfaction with the 360° virtual tour experience ($\beta = 0.289$, t-statistics = 4.099), indicating that H1a, H1b, and H1c are supported. The telepresence perceived by people is significantly related to their level of enjoyment ($\beta = 0.528$, t-statistics = 5.411), involvement ($\beta = 0.466$, t-statistics = 6.028), and satisfaction with the 360° virtual tour experience ($\beta = 0.235$, t-statistics = 3.246), indicating that H2a, H2b, and H2c are supported. The path coefficients of enjoyment on satisfaction with the 360° virtual tour experience and on the perception of COVID-19 stress reduction are 0.268 (t-statistics = 4.345) and 0.474 (t-statistics = 5.904), respectively. The path coefficients of involvement on the 360° virtual tour experience and the perception of COVID-19 stress reduction are 0.164 (t-statistics = 2.626) and 0.158 (t-statistics = 2.093), respectively. The path coefficient from the satisfaction with the 360° virtual tour experience by people on the reduction of their stress from COVID-19 is 0.196 (t-statistics = 3.116). Therefore, H3a, H3b, H4a, H4b, and H6 are supported. The f^2 effect sizes

Table 3
Reliability and validity of the constructs.

Measurable Item		Mean	S.D.	Cronbach's alpha	PLS loadings	AVE	CR
SP	Sense of presence (adapted from Pizzi et al. [77])			0.924		0.768	0.943
SP1	During experiencing the 360° virtual tour, I felt the normal experience of being in a tourist destination.	4.442	1.420		0.875		
SP2	During experiencing the 360° virtual tour, the destination attraction was the reality for me.	4.674	1.344		0.906		
SP3	When I memorized the 360° virtual tour, the images of the destination attraction like the place I have visited.	4.545	1.394		0.901		
SP4	During experiencing the 360° virtual tour, I was strongest by the destination attraction or of being elsewhere.	4.814	1.274		0.842		
SP5	During experiencing the 360° virtual tour, I often thought to myself that I was actually in the destination attraction.	4.537	1.302		0.902		
EN	Enjoyment (adapted from Kim et al. [30])			0.948		0.828	0.960
EN1	Experiencing the 360° virtual tour was enjoyable for me.	4.736	1.102		0.912		
EN2	Experiencing the 360° virtual tour was exciting for me.	4.553	1.245		0.916		
EN3	Experiencing the 360° virtual tour was fun for me.	4.932	1.150		0.907		
EN4	Experiencing the 360° virtual tour was pleasurable for me.	4.868	1.147		0.936		
EN5	Experiencing the 360° virtual tour kept me happy.	4.847	1.096		0.900		
TP	Telepresence (adapted from Kim and Ko [20])			0.898		0.831	0.937
TP1	When I was experiencing the 360° virtual tour, I forgot about my physical location.	4.251	1.324		0.899		
TP2	When I was experiencing the 360° virtual tour, I felt I was in a tourist destination.	4.540	1.299		0.948		
TP3	When I was experiencing the 360° virtual tour, I felt my mind was inside a tourist destination.	4.698	1.173		0.900		
IN	Involvement (adapted from Kim and Ko [20])			0.807		0.721	0.886
IN1	To me the 360° virtual tour was irrelevant (1)/relevant (7)	4.413	1.183		0.855		
IN2	To me the 360° virtual tour was boring (1)/interesting (7)	4.860	1.040		0.835		
IN3	To me the 360° virtual tour was unimportant (1)/important (7)	4.153	1.085		0.884		
SA	Satisfaction with the 360° virtual tour experience (adapted from Kim et al. [19,30])			0.863		0.785	0.916
SA1	I was satisfied with the authentic experience from the 360° virtual tour.	5.030	1.081		0.878		
SA2	I was satisfied with the genuine experience from the 360° virtual tour.	4.872	1.126		0.898		
SA3	I was satisfied with the unique experience from the 360° virtual tour.	4.774	1.208		0.905		
SR	Stress reduction (four symptoms of stress acquired from betterheal.vic.gov.au [78])			0.964		0.902	0.973
SR1	After experiencing the 360° virtual tour, I felt that the tension caused by the COVID-19 epidemic has decreased.	4.694	1.261		0.940		
SR2	After experiencing the 360° virtual tour, I felt that the upset caused by the COVID-19 epidemic has decreased.	4.745	1.246		0.961		
SR3	After experiencing the 360° virtual tour, I felt that the panic caused by the COVID-19 epidemic has decreased.	4.719	1.247		0.959		
SR4	After experiencing the 360° virtual tour, I felt that the pressure caused by the COVID-19 epidemic has decreased.	4.766	1.255		0.954		

Table 4
Discriminant validity.

Construct	Fornell-Larcker Criterion						Heterotrait-Monotrait Ratio				
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)
(1) EN	*0.910*										
(2) IN	0.780	*0.849*					0.886				
(3) SA	0.739	0.697	*0.886*				0.816	0.831			
(4) SP	0.634	0.614	0.741	*0.877*			0.674	0.708	0.828		
(5) SR	0.742	0.664	0.656	0.601	*0.950*		0.775	0.748	0.719	0.636	
(6) TP	0.701	0.661	0.754	0.782	0.668	*0.912*	0.753	0.772	0.852	0.857	0.718

Note: EN = Enjoyment; IN=Involvement; SA= Satisfaction with the 360° virtual tour experience; SP=Sense of presence; SR=Stress reduction; TP = Telepresence.

are used to complement the hypothesis testing. Table 5 shows that the f^2 effect sizes of *telepresence on enjoyment*, *telepresence on involvement*, and *enjoyment on stress reduction* represent medium effects ($f^2 > 0.15$) [86]. Furthermore, the f^2 effect sizes of other endogenous variables are all over 0.02 (counted as small effects), so each exogenous construct has a substantial impact on its endogenous construct [86].

4.3. Collinearity detection

For detecting any collinearity issue, a variance inflation factor (VIF) is used to quantify how much the variance is inflated. Kock and Lynn [91] considered VIF values higher than 3.3 as indicative of collinearity. Table 5 shows that all VIF values are less than this cut of value (3.3). The highest VIF was 3.200 (between telepresence and satisfaction). Therefore, it is concluded that collinearity is not present in the research model.

4.4. Moderating effect

For the moderating effect, the interactive effect of involvement and telepresence on the satisfaction with the 360° virtual tour experience is significant ($\beta = -0.077$, t-statistics = 3.057). Fig. 3 shows the results of the simple slope analysis. The high-involvement line (the green one) is above the low-involvement line (the blue one). Audiences who were highly involved in the 360° virtual tour content get better satisfaction with this experience when they perceive the same level of telepresence, so hypothesis H5 is supported. However, the low-involvement line is below the high-involvement line, since the low-involvement line's slope is steeper, so the moderating effect is negative.

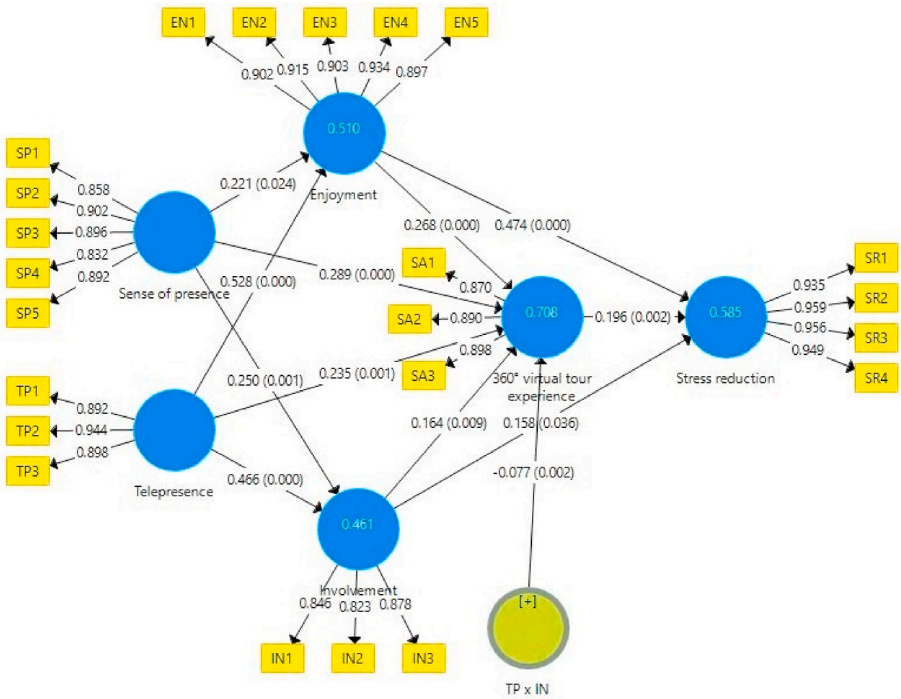

Fig. 2. Results of the PLS analysis.

Table 5
Results of PLS-SEM analysis.

	coefficient	p-value	f-square	VIF	Hypothesis	Result
Sense of presence ->Enjoyment	0.221	0.024	0.039	2.571	H1a	Accept
Sense of presence ->Involvement	0.250	0.001	0.045	2.571	H1b	Accept
Sense of presence ->Satisfaction	0.289	0.000	0.105	2.712	H1c	Accept
Telepresence ->Enjoyment	0.528	0.000	0.157	2.571	H2a	Accept
Telepresence ->Involvement	0.466	0.000	0.221	2.571	H2b	Accept
Telepresence ->Satisfaction	0.235	0.001	0.059	3.200	H2c	Accept
Enjoyment ->Satisfaction	0.268	0.000	0.081	3.045	H3a	Accept
Enjoyment ->Stress reduction	0.474	0.000	0.172	3.149	H3b	Accept
Involvement ->Satisfaction	0.164	0.009	0.033	2.798	H4a	Accept
Involvement ->Stress reduction	0.158	0.036	0.022	2.778	H4b	Accept
TP x IN -> Satisfaction	−0.077	0.002	0.026	1.013	H5	Accept
Satisfaction ->Stress reduction	0.196	0.002	0.039	2.402	H6	Accept

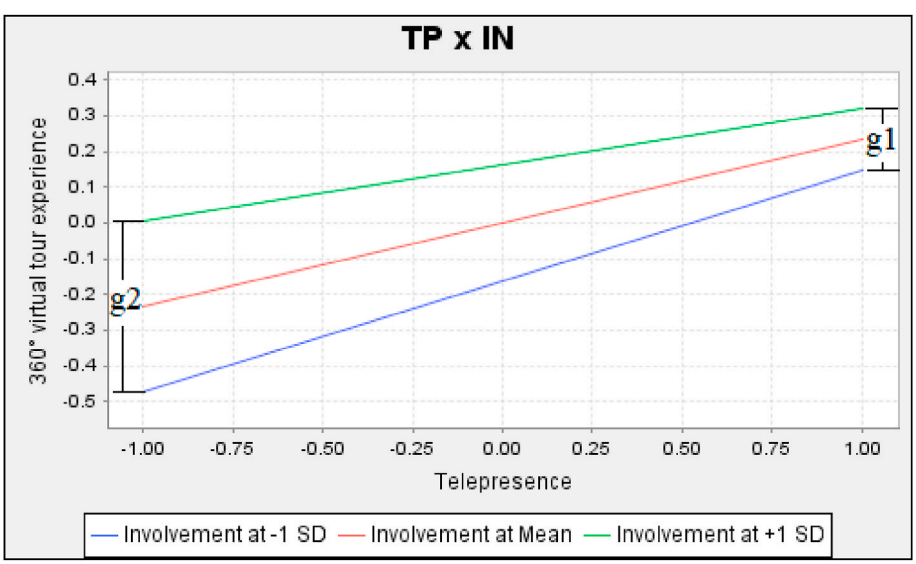

Fig. 3. Simple slope test.

5. Discussion and conclusion

5.1. Theoretical contributions

Literature reveals that the concept of presence can be distinguished from 'telepresence' as a 'sense of presence' although some people may confuse them. This study successfully shows the difference in the effects of a 'sense of presence' and 'telepresence' on formulating a 360° virtual tour experience. For a 360° virtual tour, telepresence is the sense of 'being in a virtual tourist destination', where people perceive it as equivalent to a real experience. Therefore, people will enjoy the experience more and be involved in it even it is not real, just like in Kim and Ko's [20] study of VR sports events. But for the sense of presence, the mediated experience generated by VR strongly links with the realism of the physical tourist destination. If participants have a feeling of 'being in a real place', they will be highly concentrated at the 'place'. This flow experience increases participants' enjoyment and involvement. Therefore, telepresence provides stronger effects on affective-motivational states and the 360° virtual tour experience. However, when studying how virtual technology influences people's travel intention to a real tourist destination, researchers could employ a sense of presence such as the one posited by Tussyadiah et al. [24]. On the other hand, for studying people's attitude and behaviour towards VR technology, researchers should consider telepresence. Of course, it is possible to include both types of presence in certain studies. This study is the first that includes both the sense of presence and telepresence in the 360° virtual tour experience in VR research. It contributes to VR research by clarifying the concepts of two types of presence in a virtual environment.

This study explains the effects of 'sense of presence' and 'telepresence' on satisfaction with a 360° virtual tour experience. The results of this study suggest the interesting finding that a sense of presence has the greatest direct effect on satisfaction with a 360° virtual tour experience (direct effect = 0.289). However, telepresence shows the greatest total effect on the satisfaction with the 360° virtual tour experience (total effect = 0.452). This implies that the destination attractions shown in 360° VR create a sense of presence that provides the first impression to make inferences on the satisfaction. This impression is directly created from the attributes of destination attractions, so it has the strongest direct effect on satisfying the 360° VR. Telepresence is a technical aspect of presence; high telepresence can be created by embedding rich 360° video [62]. In cases where the 360° VR interface utilises a better immersive experience of the VR display, people will feel themselves immersed in the virtual environment. This impression is created from the attributes of the virtual interface. Thus, high telepresence embedded with scenes of the real destination enhances people's full enjoyment and involvement in the 360° virtual tour, thus it has a higher indirect effect on satisfaction through affective-motivational states. Furthermore, highly involved audiences are more likely to have higher rates of satisfaction with the 360° virtual tour because they tend to evaluate their 360° virtual tour experience in a central route [20]. Despite the impact of two types of presence on user attitudes and behaviours identified in previous studies [77], no studies have distinguished their roles in generating satisfaction in VR research. Since satisfaction with a 360° virtual tour would affect people's intention to visit a tourist destination [19], this distinction contributes to tourism research by understanding the scenes and design elements of the 360° virtual tour in generating satisfaction for promoting tourist destinations.

The results of the moderating effect are consistent with Kim and Ko's [20] proposition that involvement negatively moderates the relationship between telepresence and VR experience. As shown in Fig. 3, the satisfaction gap (g1) between high involvement and low involvement for a high telepresence level is smaller than the satisfaction gap (g2) for a low telepresence level. It implies that when people perceive a low level of telepresence in the 360° video, low-involvement viewers will be more dissatisfied with this experience than the high-involvement viewers. However, when people perceive a high level of telepresence, both low-level and high-level involvement viewers have a high level of satisfaction with the 360° video. As in the above discussion, a low-telepresence interface discourages viewers' involvement, thus, low telepresence is the culprit of dissatisfaction.

This study explores the mechanism linking the concept of presence to psychological stress reduction through affective-motivational states and a 360° virtual tour experience. When audiences are exposed to a stimulus from the VR content, they have subjective responses to the sense of presence and telepresence of a virtual environment. These subjective responses lead audiences to enjoy and be involved in a 360° virtual tour. Audiences are involved in the journey and feel pleasant. The affective-motivational states (enjoyment and involvement) provide audiences with a sense of being away and escape from the pressures of COVID-19, thus people can feel that their stress is relieved as a result of their positive 360° virtual tour experience. Audiences who are highly involved experience these effects to a greater extent than those who are less involved. As shown in Table 6, telepresence provides a great total effect on stress reduction (total effect = 0.412) as well as enjoyment (total effect = 0.526). Thus, the 'moment-to-moment' feeling from VR content is a cause of reduced stress. Previous studies indicated that VR can divert a participant's attention away from stress [92]. However, this study provides an explanation for this stress reduction because a 360° virtual tour can generate affective-motivational states. This study contributes to technology research by explaining how technology can help people's psychological well-being.

5.2. Practical implications

When designing a 360° virtual tour, many developers focus on providing a sense of the 'real'. However, participants tend to have a sense of 'being there' rather than the sense of the 'real'. Just like the creators of Marvel movies, in order to attract audiences, the VR developers should put effort into creating a sense of 'being there'. People who have been to a tourist destination are looking for more than a 'real' sense of the tourist destination in their memory. They like 360° content because they want to discover an ideal place where they can have more than in the real place - for example, fast-moving clouds in the sky and a colourful rainbow in a tourist destination. Everyone knows these are post-processed effects, but they like to have the 360° virtual tour experience that they could never have accessed in the 'real' environment.

The affective-motivational states are responses to the 360° virtual tour content. So that participants can have more enjoyment and involvement, the design of 360° virtual tour experience should be more immersive so that participants can imagine themselves to be tourists. VR developers could co-design with participants to incorporate their interests and enhance the flow components of the 360° virtual tour content with audio, video, and even the smell of the natural places.

A 360° virtual tour helps people to reduce stress when they are staying at home during pandemic. It also provides a tourist experience for people who have mobility issues, for instance, older people who are not able to take a long-distance trip. Therefore, the government of

Table 6
Effects on satisfaction with the 360° virtual tour experience and stress reduction.

	Direct effect	Indirect effect	Total effect
Effects on satisfaction with the 360° virtual tour experience			
Sense of presence	0.289	0.100 (0.018)	0.389 (0.000)
Telepresence	0.235	0.218 (0.000)	0.452 (0.000)
Enjoyment	0.268		0.268 (0.000)
Involvement	0.164		0.164 (0.009)
Effects on stress reduction			
Sense of presence		0.221 (0.001)	0.221 (0.001)
Telepresence		0.412 (0.000)	0.412 (0.000)
Enjoyment	0.474	0.053 (0.013)	0.526 (0.000)
Involvement	0.158	0.032 (0.042)	0.190 (0.010)

territories where there are tourist destinations should support the development of 360° virtual tours not only to promote the image of the destinations but also to promote citizens' well-being.

5.3. Limitations

This study used only one 360° virtual tour context for the survey. Different people may have different interests in different 360° virtual tour contexts. Further studies are recommended to understand these differences and the effects on stress reduction. This study was conducted with a systematic sample in China in order to achieve timely results. Further studies could be done in other countries. Referring to the literature on VR technology, this study only examined two affective-motivational states. Researchers could try to test the effect of other affective-motivational states in their studies. Furthermore, measurements were borrowed from different sources. For some respondents, the contents for certain items may easily be confused for a sense of presence and telepresence. Further studies are recommended to develop more refined measurement scales for these two types of presence. Finally, this study considered involvement as an affective response to VR presence [30]. However, due to different research settings, researchers may question this causal relationship [21]. Further studies are recommended to clarify this reciprocal relationship.

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Appendix

Table A1
Cross loadings.

Indicator	Satisfaction	Enjoyment	Involvement	Sense of presence	Stress reduction	Telepresence
EN1	0.672	**0.902**	0.741	0.578	0.634	0.628
EN2	0.704	**0.915**	0.729	0.620	0.695	0.710
EN3	0.631	**0.903**	0.655	0.539	0.657	0.587
EN4	0.719	**0.934**	0.706	0.583	0.695	0.628
EN5	0.634	**0.897**	0.714	0.559	0.693	0.628
IN1	0.512	0.565	**0.846**	0.493	0.500	0.533
IN2	0.627	0.719	**0.823**	0.510	0.559	0.553
IN3	0.627	0.691	**0.878**	0.557	0.622	0.594
SA1	**0.870**	0.668	0.624	0.630	0.585	0.619
SA2	**0.890**	0.641	0.617	0.646	0.551	0.660
SA3	**0.898**	0.656	0.613	0.693	0.607	0.723
SP1	0.606	0.505	0.523	**0.858**	0.516	0.643
SP2	0.644	0.560	0.558	**0.902**	0.544	0.686
SP3	0.631	0.534	0.498	**0.896**	0.520	0.698
SP4	0.673	0.601	0.521	**0.832**	0.523	0.645
SP5	0.688	0.570	0.585	**0.892**	0.528	0.747
SR1	0.590	0.665	0.606	0.568	**0.935**	0.614
SR2	0.627	0.716	0.655	0.552	**0.959**	0.625
SR3	0.631	0.713	0.627	0.579	**0.956**	0.638
SR4	0.644	0.721	0.632	0.583	**0.949**	0.658
TP1	0.628	0.560	0.554	0.693	0.616	**0.892**
TP2	0.722	0.645	0.611	0.765	0.598	**0.944**
TP3	0.706	0.701	0.638	0.679	0.613	**0.898**

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