When online reviews meet virtual reality: Effects on consumer hotel booking

Abstract

This study examines the direct and interaction effects of online reviews (quality and quantity) and virtual reality on consumer hotel booking. Data were collected from two 2 x 2 experimental studies. The results show a direct effect of both online review and virtual reality's application on behavioral intention, and the influence of online reviews on behavioral intention was weakened when virtual reality was applied. Moreover, online reviews and virtual reality had a significant combined effect on behavioral intention, with greater strength than that of online reviews alone. The findings provide insights for travel and tourism managers to enhance marketing communication effects by proper use of virtual reality to complement online reviews.

Keywords: Online review; virtual reality; dual coding theory; sensory information; textual information.

1. Introduction

Virtual reality has increasingly been used in tourism to engage consumers and to market and sell tourism services and products (Bogicevic et al., 2019; Li & Chen, 2019; Tussyadiah et al., 2018; Wei, Qi, & Zhang, 2019). The adoption of virtual reality started to spread to the travel and hospitality sector, including leading brands such as Carlson Rezidor, Hilton, Airbnb, Holiday Inn Express and Vacasa (Ting, 2016). Since the breakthrough year of virtual reality destination marketing campaigns in 2017, the application of virtual reality is thus expected to increasingly transform tourist experience and bring changes to the marketing strategy of experience goods in the tourism and hospitality industry (Graham, 2016). According to Statista (2018), the global market for virtual environments (augmented and virtual reality) is expected to grow from $16.8 billion in 2019 to $160 billion in 2023. It is therefore important to have a better understanding of how virtual reality influences consumer decision making.

Studies have demonstrated that the sense of presence and immersion provided by virtual reality could have a positive effect on consumer experience and enjoyment (De Gauquier et al., 2018). Virtual reality can facilitate users in obtaining dynamic visual, sensory information before they make a purchase decision (Lee & Chung, 2008). The inclusion of visual information could significantly enhance online reviews' usefulness and enjoyment (Lin, Lu, & Wu, 2012), leading to greater product interest and purchase intention (Yang et al., 2017). Despite the growing influence of virtual reality, most travelers still rely on online reviews for travel information, which are largely in textual format. Online reviews and virtual reality represent two types of information: verbal and non-verbal. Previous studies have addressed the effects of both online verbal and non-verbal information on consumer behavior in a variety of sectors

including tourism and hospitality (Lin et al., 2012; Yang et al., 2017). Research in virtual reality in tourism has also provided a greater understanding of the adoption of virtual reality technology and the effect of the use of virtual reality on consumer experiences, engagement, and attitude change (Beck, Rainoldi, & Egger, 2019; Cooper & MacNeil, 2008; Yung & Khoo-Lattimore, 2019). Several studies have begun to examine the design of immersive content and its effect on mental imagery, consumer perception (Beck et al., 2019; Bogicevic et al., 2019) and behavioral intention (Li & Chen, 2019; Marasco et al., 2018; Tussyadiah et al., 2018; Wei et al., 2019). However, there is a lack of research that examines the joint, interaction effect of virtual reality and online reviews on consumer decision making.

This study aims to fill the above gap in the literature by exploring the interactive effect of virtual reality and online reviews (review quality and quantity) on consumer hotel booking. Specifically, we conduct two experiments to examine: a) whether the information presented by virtual reality directly influences consumers' hotel booking decisions; and b) whether and how virtual reality interacts with online reviews in influencing consumers' hotel booking decisions.

This study offers three major contributions to the tourism literature. First, it provides evidence to support the direct effects of both virtual reality and online reviews on consumer behavioral intention. Second, it shows that the presence of virtual reality significantly reduces the effects of online reviews. Third, this research enriches our understanding of how virtual reality and online reviews interact in influencing behavioral intention. Practically, although tourism and hospitality industries have increased their investment in the development of virtual reality applications, low adoption from consumers and perceived high failure rate remains a significant challenge (tom Dieck et al., 2018; Wei et al., 2019). The study provides

practical implications for the proper use of virtual reality to compliment online reviews in hospitality and tourism marketing.

2. Literature review

2.1. Virtual reality in tourism and hospitality research

Virtual reality is a computer-generated environment that simulates the real-life scenarios, in which the user can interact with various objects and feels a sense of presence (Deng, Unnava, & Lee, 2019; Serrano, Baños, & Botella, 2016; Van Kerrebroeck, Brengman, & Willems, 2017). Virtual reality differs from other visual contents such as two-dimensional pictures or 360 degree-images, as it possesses more interactive and vivid multi-sensory information (Van Kerrebroeck et al., 2017). Interactivity and vividness are the two defining features of virtual reality (Steuer, 1992). Interactivity refers to the virtual environment's response to the user's maneuver "as if" in the actual reality, while vividness refers to the virtual reality's capability of providing information to users' senses, including both the breadth and depth of the sensory experience (Steuer, 1992). The sense of presence is a subjective feeling, which is enabled by the degree of immersion through the application of different technologies (Slater & Sanchez-Vives, 2016). Beck et al. (2019) recently conducted a review of virtual reality research in tourism based on the degree of immersion as full-, semi-, and non-immersion. In non-immersive and semi-immersive technological systems (e.g. those use computer screens or projectors), users have some degree of contact with the physical world, while in fully immersive systems (e.g. those use head-mounted devices, HMDs), users are completely isolated from the physical world. The current study focuses on the fully immersive system of virtual reality.

Application of virtual reality in travel and tourism has been increasingly popular (Beck et al., 2019; Deng et al., 2019), and the growth of research into the fully immersive system of virtual reality in tourism is exponential in recent years (see Table 1 for some examples). The stream of research has mainly focused on examining the role of virtual reality in enhancing consumer experiences (e.g. Beck et al., 2019; Errichiello et al., 2019; Flavián, Ibáñez-Sánchez, & Orús, 2019; Jung et al., 2018; Marchiori, Niforatos, & Preto, 2017; Rainoldi et al., 2018; Tussyadiah et al., 2018; Wei et al., 2019). Findings generally confirm that virtual reality enables a high level of mental imagery elaboration and sense of presence (Bogicevic et al., 2019; Jung et al., 2016; Tussyadiah, 2016; Wei et al., 2019), which could increase travel or visit intention (Disztinger, Schlögl, & Groth, 2017; Griffin et al., 2017; Kim, Lee, & Jung, 2019; Li & Chen, 2019; Tussyadiah et al., 2018). Full immersive virtual reality elicits better immediate effect than traditional hotel video commercials but not delayed effect (Leung, Lyu, & Bai, 2019). Overall, the extant studies primarily emphasize the effects of virtual reality in comparison with traditional communication formats. There has been little research on the interaction effects when both traditional and virtual reality are used by consumers.

Table 1. Empirical research on the application of virtual reality in tourism and hospitality (2016-2019)

Study	Research context	Key findings
Tussyadiah (2016)	Virtual destinations	Congruence between images held and stimuli presented in virtual reality influences spatial presence in virtual reality. A certain level of presence is necessary to support the persuasive power of virtual reality.
Jung et al. (2016)	Application of mixed augmented reality and virtual reality in museum	Social presence in mixed augmented reality and virtual reality has a positive effect on visitor's experiences.
Jung et al. (2018)	Application of virtual reality and other technologies at cultural heritage places	Usability, requirements, involvement, experience realism, and impression constitute the virtual reality experience. Positive attitude towards the use of virtual tourism increases immersed experience, which leads to greater visit intention.
Tussyadiah, Wang, and Jia (2017)	Virtual destinations	Attention in virtual reality experience increases perceived presence.
Marchiori et al. (2017),	Virtual destination	The characteristic of proposing an unusual horizon perceptive in virtual has the potential to lead to strong memories.
Griffin et al. (2017)	Virtual destination	When a destination is promoted through virtual reality rather than static photos or videos, consumer intention to share their experience and to recommend the destination is greater.
Disztinger et al. (2017)	Google street view for holiday destinations	Perceived immersion, interest, perceived enjoyment and perceived usefulness have a significant effect on the intention to use virtual reality for travel planning.
Beck and Egger (2018)	Destination virtual reality marketing video	Relevant virtual reality content positively influences emotions and decision-making.
Rainoldi et al. (2018)	Destination virtual reality marketing video	Compared to a traditional brochure, virtual reality enables a greater degree of interactivity that generates a stronger sense of “being there”.
Tussyadiah et al. (2018)	Virtual reality city tours and tourism destination.	The feeling of being present increases the enjoyment of virtual reality experience and liking of the destination, and the positive attitude change leads to a higher level of visit intention.
tom Dieck et al. (2018);	Virtual national park experience	The usability, hedonic benefits, emotional benefits, social benefits and attitude influence behavioral intention.
Kim et al. (2019)	Virtual reality tourism in general	Attachment to virtual reality, cognitive and affective response influence visit intention.
Flavián et al. (2019)	Tourism (city, nature, adventure	The embodiment of virtual reality influences tourist engagement and behavior intention via immersion and

	sports, sun and beach)	sensory stimulation.
Leung et al. (2019)	Hotel virtual reality commercial	Compared with traditional ad formats, virtual reality ads elicit better immediate advertising effects in terms of ad recognition, ad attitude, brand attitude, and purchase intention.
Israel, Zerres, and Tscheulin (2019)	Hotel virtual reality application	Perceived usefulness significant affect the attitudes and intention of using virtual reality, while perceived ease of use has no such effect.
Kim and Hall (2019)	Tourism-related virtual reality activities	Perceived enjoyment influences flow states and social well-being, which in turn influence continue usage of virtual reality tourism activities.
Deng et al. (2019)	Museum visit and leisure travel	The similarity of virtual reality to the real-world experience reduces consumer visit intention, but not recommendation.
Bogicevic et al. (2019)	Virtual reality hotel visit	Virtual reality preview enhances mental imagery and presence than both static images and 360° tours. Elaboration of mental imagery and sense of presence are positively associated.
Wei et al. (2019)	Virtual reality roller coaster at a theme park	The feeling of control, participation, effectiveness, curiosity, vividness, temporal association and enjoyment increase the users' sense of presence. The sense of VR presence increase visit intention.
Li and Chen (2019)	Virtual reality tourism experience	Perceived enjoyment of virtual reality mediates the effects of tourists' perceived ease of use and the usefulness of VR on travel intention.
Errichiello et al. (2019)	Virtual reality museum	The function of virtual reality application was identified as a sense of involvement, technology added value, escapism, personal innovativeness, technology intention and experience sharing.

2.2. The effect of online reviews

Online reviews are an important source of information for consumers when making a purchase decision (Tan et al., 2018). Because of the experiential and intangible nature of tourism products (Tan et al., 2018; Ye, Law, & Gu, 2009), online reviews are particularly helpful in reducing traveler perceived risk. A considerable body of research also shows that various attributes of online reviews, including valence, quantity, ratings, sources of reviewers, and perceived usefulness of online review affect consumers' evaluation of tourism products (Casaló et al., 2015; Sparks, Perkins, & Buckley, 2013). Overall, it is known that online reviews ultimately can have a significant effect on sales, although the effectiveness of online reviews on sales may differ across platforms, product characteristics, and attributes of reviews (Rosario et al., 2016).

An online review in our study refers to the information generated by online consumers concerning their personal experiences and evaluations of a product (Zhang et al., 2010). Review quality and review quantity are two important attributes that have been frequently used to evaluate online reviews' effectiveness. Review quality refers to information characteristics, such as understandability, informativeness, and product relevance (Ghose & Ipeirotis, 2011). High-quality online reviews are readily comprehensible, product-relevant, sufficient, and objective (Zhang et al., 2010). In contrast, low-quality online reviews are vacuous and limited informative, contain little product-related information, and are inundated with subjective feelings (Ghose, Ipeirotis, & Li, 2012). High-quality reviews provide sufficient and multi-aspect cues about products and thus better solve the problems of uncertainty and information insufficiency for consumers (Bickart & Schindler, 2001). Therefore, it can be expected that the quality of reviews will positively affect consumers' behavioral

intentions (assuming that the overall valence of reviews is positive rather than negative, similarly hereinafter). Hence:

H1: Review quality positively affects behavioral intention.

The quantity of reviews also provides important information for consumer decision making (Blal & Sturman, 2014). Consumers are more likely to be attracted by a hotel with a large number of reviews, as the higher quantity in reviews implies higher popularity and greater awareness of this hotel (Duan, Gu, & Whinston, 2008). Recent studies show that a large number of online reviews can produce the bandwagon effect among consumers, which makes them more likely to evaluate the product according to the conformity or groupthink (Maslowska, Malthouse, & Viswanathan, 2017). Furthermore, a large number of reviews can help consumers obtain more information about product details (Park, Lee, & Han, 2007). A recent meta-analysis further confirms that the quantity of online reviews has a stronger impact on sales than the valence of online reviews (Rosario et al., 2016). Thus consumers exposed to a large number of hotel reviews will have a more favorable attitude towards the hotel, leading to greater behavioral intention (Park et al., 2007).

H2: Review quantity positively affects behavioral intention.

2.3. The application of virtual reality

Virtual reality can replicate the experience of real vision by offering a monocular vision for each eye, which provides depth perception known as "*stereoscopic vision*" (Vince, 2004). As such, virtual reality can facilitate the sense of presence and experience the hotel in advance (Bogicevic et al., 2019). Virtual reality is a type of non-verbal information, and people can perceive, code, and store the information simultaneously (Holbrook & Moore, 1981; Paivio, 1990), with a relatively less cognitive effort that readily comes to one's mind (Pieters & Wedel, 2004). The

experiential aspects of virtual reality provide a fun, pleasant feeling, which leads to behavioral intentions. For instance, Tussyadiah et al. (2018) show that a virtual reality experience of a destination can enhance users' enjoyment, which positively influences attitudes and visit intentions. Li and Chen (2019) further confirm that the enjoyment derived from virtual reality experience leads to visit intention. Examining users' virtual reality experience of a theme park, Wei et al. (2019) found that the experiential aspects of virtual reality have a positive effect on the sense of presence, which enhances user satisfaction and visit intentions. Therefore, it can be argued that the application of virtual reality in hotel online booking platforms can increase consumer behavioral intention. Thus, we posit that:

H3: The application of virtual reality is more likely to increase behavioral intention than without the application of virtual reality.

2.4. The interaction of virtual reality and online reviews

Online reviews and virtual reality represents two different types of information. Online reviews are usually in textual form, some in combination with images or videos. In contrast, the information in virtual reality is visual and sensory. Dual coding theory suggests that people have two separate mental systems in processing different types of information: one handles verbal messages and the other non-verbal such as visual images (Paivio, 1990). It is believed that the left hemisphere of the human brain is specialized for processing verbal information, while the right hemisphere is specialized for processing non-verbal information (Geschwind, 1979). The two mental systems thus function differently: verbal information is often received, converted to mental representations, and stored in memory sequentially, while for non-verbal information, these activities were taken place simultaneously (Holbrook & Moore, 1981; Paivio, 1990). Processing text information often is rather

slow and laborious, and has a high demand on cognitive resources, while processing non-verbal information is fairly intuitive, with relative less demand on cognitive resources (Pieters & Wedel, 2004) and easier to form mental imagery (Bogicevic et al., 2019). Consistent with dual-coding theory, virtual reality allows consumers to "be there" to verify the information presented in online reviews, thus improve their decision confidence. Consumers need not devote too much energy and cognitive resources to read through online reviews to obtain objective and product-relevant information (Pieters & Wedel, 2004; Xu, Chen, & Santhanam, 2015; Yang et al., 2017).

Fully immersive virtual reality can increase users' direct attention to the content (Leung et al., 2019). According to the perceptual load theory, such direct attention has a positive impact on the viewers' performance of memory-related tasks (Lavie, 1995, 2010; Leung et al., 2019). Perceptual load theory argues that when the perceptual load of a targeted task is high, no spare capacity is available for unattended items, resulting in low-level processing of unattended stimulus (Lavie, 1995). When a consumer uses a virtual reality facility available in the online hotel booking platform, exploring the virtual hotel environment becomes the targeted task, and online reviews and other information become lower-level processing cue. Therefore, we can expect that the application of virtual reality will weaken the effects of online reviews (review quality & quantity) on consumer behavioral intention. Thus,

H4: The application of virtual reality and online review quality will interact. For the non-virtual reality condition, high-quality online reviews will result in high levels of behavioral intention, compared to low-quality online reviews. Such difference is not expected in the virtual reality condition.

H5: The application of virtual reality and online review quantity will interact. For the non-virtual reality condition, high quantity of online reviews will result in high levels of behavioral intention, compared to low quantity online reviews. Such difference is not expected in the virtual reality condition.

According to dual coding theory, the presentation with multiple types of information offers flexibility for processing, and individuals do not have to rely on text information only, thus free up cognitive resources and facilitate information integration, resulting in deep processing (Van Merriënboer, Kirschner, & Kester, 2003). A combination of verbal and non-verbal information thus can enhance memory, either because of the deep processing or because both the mental systems are at work in coding and integrating the information in multiple formats (Brunyé, Taylor, & Rapp, 2008). Therefore, it is expected when both online reviews and virtual reality are used, their effect on behavioral intention will be stronger than that of online reviews alone. Thus we posit that:

H6: The level of behavioral intention is higher in the condition of online reviews combined with virtual reality than in the condition of online reviews only.

Figure 1 depicts the conceptual framework that consists of the above hypotheses. We run two experimental studies to test the hypotheses. In Study 1, we focus on review quality. In Study 2, focus on review quantity.

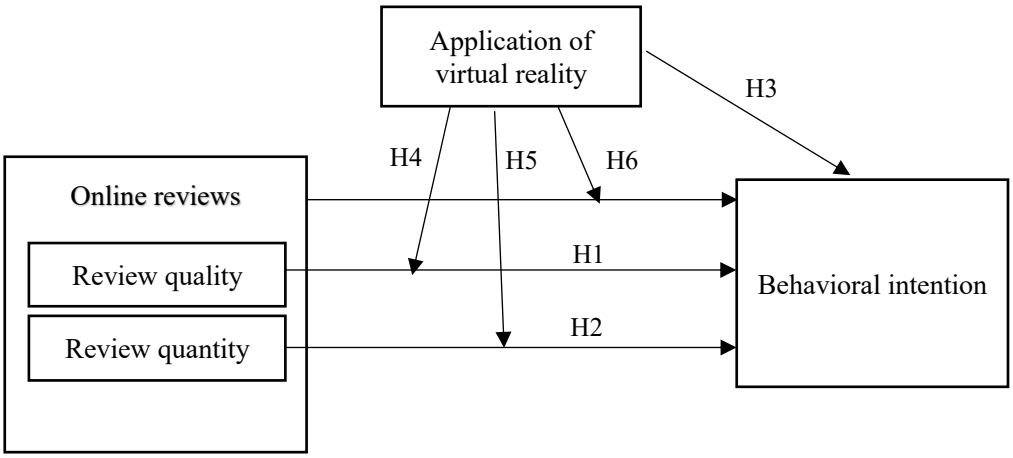

Figure 1. Conceptual framework

3. Study 1: Review quality and virtual reality

3.1. Methods

In this study, we conducted an experiment with a 2 (review quality: high or low) × 2 (virtual reality application: yes or no) between-subject design to investigate the interactive effect of review quality and application of virtual reality on behavioral intention (i.e., H1, H3, & H4)

3.1.1. Experimental stimuli and manipulations

A hotel-themed virtual reality app was downloaded from a 360-degree virtual reality platform (http://www.expoon.com/23391/) in which the virtual reality content of the hotel was created by using a real-world spherical panoramic 360-degree images. The 360-degree virtual reality is used because it is particularly applicable for the provision of realistic views and walk-throughs of outdoor scenes or accommodation establishments, which fit the purpose of this study (Cooper & MacNeil, 2008; Marasco et al., 2018; Slater & Sanchez-Vives, 2016). A Chinese

traditional solar-term themed hotel was chosen for the study, because this is one of the most popular types of hotel among Chinese consumers aged between 20-30 (China Industry and Planning Company, 2018), and is also in line with the characteristic of young students' pursuit of personal identity (Pan et al., 2017). Both the hotel's brand name and location were fictitious.

The participants can watch the 360-degree virtual reality content through head-mounted displays (HMDs) headset connected with a smartphone. The virtual reality headset can capture and analyze the users' head movement, directions, and eye movement. The virtual environment is changed accordingly to stimulate real-life-like experiences. Unlike watching a video as an observer in 2D, the virtual reality participants are able to be immersed into a 360-degree virtual environment (Beck et al., 2019; Bogicevic et al., 2019; Deng et al., 2019; Kandaurova & Lee, 2019; Van Kerrebroeck et al., 2017). Users can interact with the video through eye motion with the hotspot (a small cross " + ") in an intended direction when they were looking around in the virtual environment. For example, after a user looks around the surrounding environment of the front of the hotel, they can look at the hotel door where there is a hotspot " + ", the door opens, and the user then entering into the lounge area.

Before the experiment, we conducted a pre-test with 244 participants to measure the sense of presence, immersion and perceived usefulness of the virtual reality we used. The measurement of three variables was adapted from previous, well-established scales (Table 2). The overall mean value of all variables was significantly higher than the neutral scale point, thus the sense of presence, immersion and perceived usefulness of the virtual reality designed can be confirmed.

Table 2. Pre-test for the realistic nature of the virtual reality designed

Variables	Items	Cronbach'α	Mean value
Sense of presence (Barfield & Danas, 1996)	1. I had a sense of being in the scenes displayed in the virtual reality. 2. Overall, the scenes displayed in the virtual reality were very realistic to me. 3. I had a strong sense of presence in the virtual environment. 4. I think it was very real when I moved within the virtual environment.	0.797	3.49 (SD=.536)
Immersion (Trevino & Webster, 1992)	1. When interacting with virtual reality, I concentrated my attention on the virtual environment of the hotel. 2. I had a sense of control over my interaction with virtual reality. 3. I almost lost my consciousness of the real world when I interacted with the virtual reality.	0.691	3.31 (SD=.652)
Perceived usefulness (Purnawirawan, De Pelsmacker, & Dens, 2012)	1. I think the information provided by virtual reality is useful. 2. The information provided by virtual reality helps me form my attitude towards this hotel. 3. The information provided by virtual reality helps me decide on whether to book this hotel.	0.732	4.2 (SD=.441)

To provide a realistic and familiar online hotel booking and reviewing environment, the interface of a hotel booking website was designed to mimic the basic layout and core features of *Ctrip* which is one of the most popular online travel agency websites in China. Each simulated website included a fictitious name the same as the virtual reality platform and logo of the online review website, and the basic information and photos of a fictitious hotel. The hotel was given an unfamiliar name to avoid any potential effects of brand familiarity on participants' perceptions of the reviews. Two simulated websites were designed and each contained the same amount of reviews. Each review contained manipulated consumer identification, the content of the review and the date it was posted. The length of the reviews was fixed at two lines.

The valence of the online review was a control variable in the experiment design. In this study, the overall valence was manipulated to be positive, but neutral and

negative reviews were also added to the simulated websites to improve the believability of the websites (Ladhari & Michaud, 2015; Sparks & Browning, 2011). In addition, the balance of positive and negative reviews can be a factor considered by consumers. The overall valence of reviews would be considered positive when the ratio of positive to negative evaluation is close to or surpasses 3.1:1 (East, Hammond, & Lomax, 2008). Accordingly, participants were asked to browse the website with 12 reviews (9 positive, 1 neutral, & 2 negative).

The manipulation of review quality was consistent with previous studies (Ghose et al., 2012; Park et al., 2007; Zhang et al., 2010). Objectivity, informativeness, understandability, sufficiency, and linguistic correctness were chosen as the criteria for review quality. Reviews with high quality were understandable, product-relevant, relatively objective without linguistic errors, and have sufficient reasons to support reviewers' evaluations (e.g., "The room of this hotel is very big with nearly 30 square meters. The design of French sash and glass door of bathroom make it more capacious and bright. Very nice."). Low-quality reviews were more subjective and emotional, with no information except expressions of feelings and product-irrelevant information (e.g., "I like it so much and can't wait to share the picture of it with my friends, all of them will envy me!"), or some with simple interjections (e.g., "Aha!", "How wonderful!"). In addition, the manipulated reviews in each simulated website were with the same framing (i.e., the positivity/negativity setup of most recent reviews). Since the current virtual reality technology cannot provide details about the hotel service, the content of each review was about the core features of the hotel without any service-centric wording to maintain information consistency between virtual reality and online reviews. Before the experiment, a series of pre-tests and the pilot tests were conducted to clarify specific wording and to assess the external validity of

this study and the strength of manipulation.

3.1.2. Sample and procedure

An invitation letter was distributed at the end of several marketing lectures at a large university in Southeastern China participated in this study. Students who had online hotel booking experiences were invited to participate in the experiments. The rationale for using undergraduate student sample is the type of hotel are more popular among the young generation. In addition, both industry reports and previous research indicate that consumers at the age group of 18-34 were most interested in using virtual reality devices (Leung et al., 2019). The data were collected from early September 2018 and last for four months. A total of 224 undergraduate students participated in the experiments. A small bag of snacks was given at the end of experiments as incentives.

The participants were randomly assigned to one of the four conditions in a 2 (review quality: high or low) x 2 (virtual reality application: yes or no) experimental hotel websites. Each condition had the same number of participants (n=56), with the age range between 18 to 25. Among the participants, 62.1% of them were female. There was no gender effect on the hotel booking decision (M_{male} = 3.579, M_{female} = 3.625, p = .599), and there was no effect of booking experience (measured by a question: "I'm familiar with the online hotel booking process"; 1 = strongly disagree to 5 = strongly agree) on hotel booking decision. Independent Samples Test showed that the mean score of valence (M = 3.76, SD = .519) was significantly higher than the neutral scale point, t (223) = 21.901, p = .000, which was consistent with the design for valence in this study (Cronbach's α = .687). The overall valence of the designed reviews was effectively perceived by participants, which indicated that the valence was successfully controlled in the experiment.

When the experiment formally began, participants were asked to read the instructions, under a designed scenario in which they imagined searching for a hotel for a one-week holiday in an unknown location without any previous visiting experience, and their budget can cover the cost. After reading the scenario, each group of participants was asked to browse the corresponding fictitious websites. Each experiment session had one participant at a time because of the capacity of the lab and limited headset. In the non-visual reality groups, participants browsed this real-life-like website, which contains either high or low-quality online reviews. After browsing the website and read the reviews, participants were asked to complete a questionnaire that asks their evaluation of the online reviews and their behavioral intentions toward booking the hotel.

In the virtual reality groups, participants were also asked to browse the same real-life-like website. After browning the website and read the reviews, the subjects were asked to evaluate the level of quality of the reviews. Once they complete the evaluation, participants were then required to use a virtual reality device, a head-mounted display connected with a smartphone, to observe the simulated virtual reality scenes of the fictitious hotel. After the virtual reality tour, the subjects were asked to complete the questionnaire that asks about their behavioral intentions toward booking the hotel.

Each experiment session was conducted by one research coordinator, who provided a brief introduction of the study procedure and potential risk, and for the virtual reality group, how to wear the virtual reality devices and how to shift the virtual scenes via adjusting visual hotspot. Participants were briefed if at any time they feel any motion sickness, cybersickness, and other uncomfortable symptoms during the process, they can stop the experiment. Participants' navigation and

exploration in the virtual environment were entirely initiated and controlled by the participants themselves. The hotel virtual environment tour took about five minutes for each participant.

3.1.3. Construct measures

All the construct measures based on previous studies and were translated from English to Chinese using the translation-back translation procedure (Brislin, 1980). They were measured using 5-point Likert scales (1 = strongly disagree to 5 = strongly agree). Behavioral intention was measured with 3 items adapted from Sparks and Browning (2011) and Park and Kim (2008) (e.g., "I am willing to book a room at this hotel immediately", "It is very likely that I would book a room at this hotel", and "I would suggest booking this hotel"). Cronbach's α was .763.

3.1.4. Variables for manipulation and believability check

The manipulation check for the perceived quality of online reviews was conducted to ensure there was a significant difference between groups with high or low-quality reviews. This variable was measured by a 6-items scale adapted from Park et al. (2007) and Ghose et al. (2012). (e.g., "Each review has sufficient reasons supporting the opinions", "Each online review is objective", "Each online review is understandable", "Each online review has clear meanings", "Each online review is relevant to the hotel product", "In general, the quality of online reviews is high"). The Cronbach's α was .788.

The overall valence was measured by 2 items adapted from Sparks and Browning (2011) (e.g., "Overall, I feel that the reviews are more positive than negative" and "Most of the reviews recommend booking a room at the hotel"). The Cronbach's α was .687. Believability questions were also based on 3 items from Sparks and

Browning (2011), including “I think the hotel review website is realistic”, “I feel I can imagine myself using a website like this to search for hotels”, and “I’m able to imagine using this website to evaluate this hotel”. Cronbach’s α was .614.

3.2. Results

3.2.1. Manipulation and believability check

We checked whether our manipulations were effective using between-subjects ANOVA. Consistent with our manipulations, the participants who read the high quality online reviews reported higher score on quality than those who read the low quality ones, $M_{high\_quality}$ = 3.83 (SD = .428), $M_{low\_quality}$ = 3.12 (SD = .430), F (1, 222) = 153.883, p = .000. Additionally, we also checked whether there was a confounding effect of virtual reality on online review quality. Results showed that $M_{virtual\ reality}$ = 3.44 (SD = .644), $M_{Non\_virtual\ reality}$ = 3.50 (SD = .454), F (1, 222) = .638, p = .425, but this was the result in the case of violating Test of Homogeneity of Variances. Then the Independent Samples Test was used, and the unequal variances t-test showed that t (199.496) = .799, p = .425, indicating there was no confounding effect.

The believability check suggested website design was believable. Independent Samples Test showed that the mean score of believability (M = 3.79, SD = .484) was significantly higher than the neutral scale point, t (223) = 24.354, p = .000. Moreover, there was no difference in believability between high and low quality simulated conditions, F (1, 222) = .171, p = .680.

3.2.2. Hypothesis test

We first conducted One-way ANOVA analysis for the non-virtual reality group, the results confirmed the positive effect of online review quality on behavioral intention: $M_{high\_quality}$ = 3.75 (SD = .514), $M_{low\_quality}$ = 3.38 (SD = .433), F (1, 110) =

11.420, eta squared = .014, p = .001. Thus H1 was supported.

The results of between-subjects univariance analysis revealed the significant effect of virtual reality (F [1, 220] = 15.383, p = .000; eta squared = .065) supporting H3 and significant interaction effect (F [1, 220] = 3.992, p = .047, eta squared = .014.) on behavioral intention, supporting H4. Specifically, the effect of review quality receded into insignificance (F [1, 220] = 3.154, p = .077, Figure 2). Therefore, the impact of online review quality on behavioral intention faded when the virtual reality technique was applied.

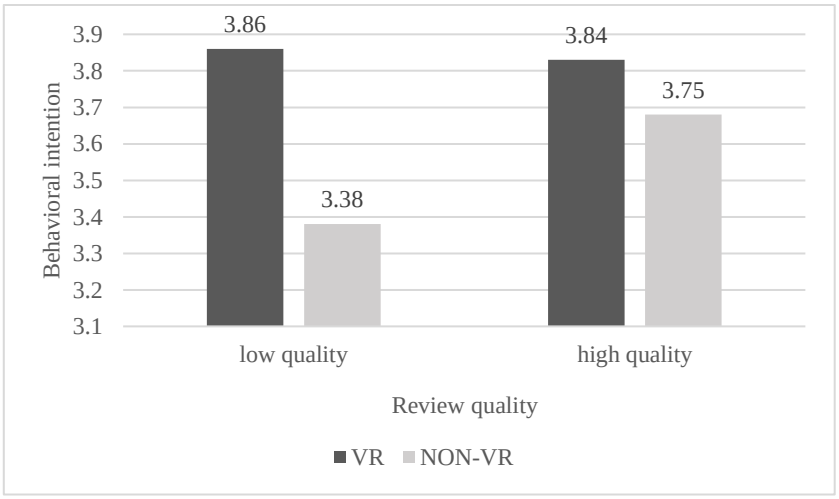

Figure 2. The interaction of online review quality and virtual reality

Several Independent Samples Tests were conducted to test the level of the behavioral intention of the group of participants who used virtual reality after reading online reviews and the group of reading online reviews only. The results showed that the mean score of purchase intention of the former group was significantly higher than the online reviews only group ($M_{VR+online\_reviews}$= 3.848, $M_{online\_reviews}$= 3.565, t= 3.473, p<0.05). Thus H6 was supported. Further examination shows the joint effect of online review and virtual reality was significant only when the review quality was low, t (110) = 24.354, p = .010, but when review quality was high, the joint effect was

insignificant (t= 0.794, p= 0.163).

This study confirms the positive effects of online reviews quality and virtual reality application on consumers' purchase intention (H1 & H3), and virtual reality performs a significant moderation role, such that the use of virtual reality weakens the effect of review quality on behavioral intention (H4); the joint effect of online reviews and virtual reality is stronger than online review alone (H6). The next study focuses on review quantity.

4. Study 2: Review quantity and virtual reality

4.1. Method

In this study, we conducted a 2 (review quantity: large or small) × 2 (virtual reality application: yes or no) experiment to investigate the interaction effect of review quantity and application of virtual reality on behavioral intention (i.e., H2, H3, & H5)

4.1.1. Experimental stimuli and manipulations

The website design and other features remained the same as in Study 1 except the number and content of manipulated reviews. We referred to previous literature to determine the appropriate amount of reviews for each group (i.e., large quantity group & small quantity group). Previous literature indicates that the difference of review quantity can be significantly identified, when the review amount of large quantity group and small quantity group was presented as a ratio of 6:1 (Park et al., 2007; Tsao et al., 2015). Given that consumers who were exposed to too many reviews may result in information overload (Kwon et al., 2015), we assigned 36 reviews and 6 reviews to the large quantity group and small quantity group, respectively.

Same as in Study 1, to ensure the manipulation of positive overall valence, we

assigned 36 reviews (24 positive, 6 negative & 6 moderate) to the large quantity group, and 6 reviews (4 positive, 1 negative & 1 moderate) to the small quantity group. All the manipulated reviews were of the same quality and with the same framing in each simulated website. The content of each review was about the core features of the hotel without any service-centric wording to maintain information consistency between virtual reality and online reviews.

4.1.2. Sample and procedure

Similar to the design of Study 1, we used a sample of undergraduate students from a large university in Southeastern China. The same recruitment process and criteria were used. Participants were randomly assigned to four conditions with an equal number of participants for each condition. The specific procedure of the experiment was the same as Study 1. Among the participants (N = 264), 66.7% of them were female, and 78.4% of them have had a hotel booking online experiences. There was no gender and booking experience effect on behavioral intention (M_{male} = 3.627, M_{female} = 3.713, p = .384). The Independent Samples Test showed that the mean score of valance (M = 3.83, SD = .543) was significantly higher than the neutral scale point, t (263) = 24.719, p = .000, consistent with the design for valance (Cronbach's α = .668). Independent Samples Test showed that mean score of quality (M = 3.77, SD = .396) was significantly higher than the neutral scale point, t (263) = 31.759, *p* = .000, consistent with the design for quality.

4.1.3. Design and measures

The measures of behavioral intention (Cronbach's α = .755), overall valence (Cronbach's α = .668), perceived quality of reviews (Cronbach's α =.669) and believability check of Study 2 were as same as Study 1 by using 5-point scale (1 =

strongly disagree, 5 = strongly agree). Perceived quantity of reviews was measured by 3 items (e.g., “The quantity of online review is enough for me to make booking decision,” “I do not need to read more online reviews after reading this much,” and “I can make booking decision without reading all of these online reviews”). The Cronbach’s α was .775.

4.2. Results

4.2.1. Manipulation and believability check

We examined whether our manipulations were effective by conducting between-subjects ANOVA. Consistent with our manipulations, the participants who read the large-quantity online reviews reported higher score on quantity than those who read the small-quantity ones. $M_{large\_quantity}$ = 3.62 (SD = .558), $M_{small\_quantity}$ = 2.60 (SD = .575), F (1, 262) = 213.967, p = .000. Besides, we also checked whether there was confounding effect of virtual reality on online review quantity. Results showed that $M_{virtual\ reality}$ = 3.05 (SD = .781), $M_{Non\_virtual\ reality}$ = 3.16 (SD = .742), F (1, 262) = 1.405, p = .237, indicating there was no confounding effect.

The results of the believability check (Cronbach's α = .615) suggested that the level of believability of the website design was satisfactory. Specifically, Independent Samples Test showed that mean score of believability (M = 3.83, SD = .452) was significantly higher than the neutral scale point, t (263) = 29.675, p = .000. Moreover, there was no difference in believability between large- and small-quantity simulated conditions, F (1, 262) = .033, p = .856.

4.2.2. Hypothesis test

We conducted an One-way ANOVA analysis for the non-virtual reality group, and the results confirmed the positive effect of online review quantity on behavioral

intention. Specifically, $M_{large\_quantity}$ = 3.59 (SD = .356), $M_{small\_quantity}$ = 3.19 (SD = .342), F (1, 130) = 43.170, eta squared = .010, *p* = .000. Thus H2 was supported.

The results between-subjects univariance analysis revealed the significant effect of virtual reality (F [1, 260] = 49.571, *p* = .000, eta squared = .160), supporting H3 and significant interaction effect (F [1, 260] = 19.702, *p* = .000, eta squared = .070.) on behavioral intention, supporting H5. Specifically, the effect of review quantity receded into insignificance (F [1, 260] = 2.583, *p* = .109, Figure 3). Therefore, the impact of online review quantity on behavioral intention had faded when virtual reality was applied.

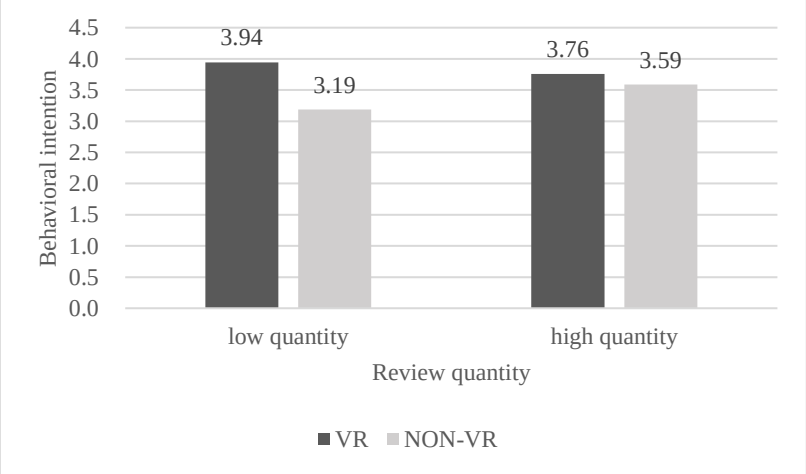

Figure 3. The interaction online review quantity and virtual reality

Several Independent Samples Tests were conducted to test the level of the behavioral intention of the group of participants who used virtual reality after reading online reviews and the group of reading online reviews only. The results showed that the mean score of purchase intention of online reviews plus the virtual reality group was significantly higher than online reviews only group ($M_{VR+online\_reviews}$=3.851, $M_{online\_reviews}$= 3.386, t=6.783, p<.01). The results showed that the mean score of purchase intention for joint online review and virtual reality group was significantly

higher than that for online review-only group, regardless whether the review quantity was low: t (130) = 8.874, p = .002, or high: t (130) = 1.706, p = .000. Thus H6 can be supported.

This study shows that there is a positive influence of online review quantity on consumers' behavioral intention when the virtual reality application was absent (H2), and confirms the direct effect of virtual reality application on consumers' behavioral intention again (H3). Furthermore, virtual reality application weakens the effect of review quantity on purchase intention (H5). Finally, the study further confirms the combined effect of online reviews and virtual reality is greater than that of online reviews alone (H6).

5. Discussion and conclusion

Virtual reality has been quickly adopted among the tourism and hospitality industries as an important marketing tool to persuade consumers to purchase their products and services. When booking a hotel room, potential travelers usually read online reviews to facilitate purchase decision making. The success of virtual reality applications thus depends on how consumers use both types of information – online reviews and full immerse virtual reality images. Through two experimental studies, we show that virtual reality and online reviews interact to influence behavioral intention. The findings from our study results offer important theoretical contributions to tourism research and practical managerial implications for tourism managers.

5.1. Theoretical implications

This research offers three major contributions to the literature. First, the findings of this research indicate that there is a direct effect of virtual reality applications on

behavioral intention along with online reviews. This result of virtual reality's direct effect is consistent with the findings from previous studies of virtual reality in tourism such as Tussyadiah et al. (2018), Li and Chen (2019) and Wei et al. (2019) that the use of virtual reality increases travelers' purchase intentions. Virtual reality provides a direct experiential process of the product information that triggers a positive attitude and purchase intention (Cowan & Ketron, 2019; Deng et al., 2019).

Second, our research shows that the application of virtual reality weakens the effects on online reviews (quality and quantity) on behavioral intention. Virtual reality provides visual and sensory information that is not possible for textual and stationary imagery information. The finding adds evidence to support previous findings of dual coding studies that visual images were more powerful than textual and stationary imagery information in predicting purchase intension (Stenberg, 2006; Xu et al., 2015). However, our study further extends such effect to the virtual reality's effect on hotel booking decisions.

Third, this research enriches our understanding of the joint effects of online reviews and virtual reality in influencing behavioral intentions. The results reveal that the two types of information have a joint effect on behavioral intention than online reviews alone. The result is consistent with the prediction derived from dual coding theory (Paivio, 1990), and previous studies that suggest the combination of textual and visual information has greater effect than either texts or pictures alone (Brunyé et al., 2008; Huang, 2018; Kim & Lennon, 2008; Ma et al., 2018). Moreover, the results are consistent with the study by San José-Cabezudo, Gutiérrez-Arranz, and Gutiérrez-Cillán (2009) in context of website design, but in contrast to an earlier study of website design by Kim and Lennon (2008) that suggests travelers tend to use the textual element than a visual one. The research further reveals a new finding that the

joint effect of online review and virtual reality is significant only when the review quality was low, and when review quality is high, the joint effect was insignificant. Nevertheless, the joint effect is significant regardless of the quantity of online reviews.

5.2. Practical implications

This research provides practical implications for hoteliers and online travel agencies. Managers should allocate resources in the design of virtual reality content from customers' perspective, such as high quality and visually stimulating imagery that generate richer experience and encourage exploration, and hence greater enjoyment for the visitors. Travel retailers may install virtual reality in stores as a simulation tool to create a virtual experience of the destination and hotel properties, which helps potential consumers to make travel and booking decisions, reducing their reliance on textual information.

Managers of travel and hospitality websites are encouraged to explore the use of virtual reality elements to provide more diverse information sources for potential consumers alongside online reviews. Virtual reality can be a very useful tool for destination marketers and travel agents to convert both online or store visitors into customers. Managers are encouraged to use virtual reality to complement online reviews, particularly when the review quality is low. As this study shows, the joint effect of online review and virtual reality is significant when review quality is low but regardless of the review quantity. However, when the review quality is high, consumers may not need to use the virtual reality facility for making hotel booking decisions.

5.3. Limitations and future research

There are several limitations to this study, and future research is suggested. First, this study does not include visual information formats such as 2D photos, 360-degree photos, or videos to compare their effects with that of fully immersive virtual reality. Future research could investigate the differential effects of various visual contents. Second, this study is limited to the of textual element of online reviews and does not address the design element of virtual reality, future research could generate insightful findings by examining the effects of the various design elements of virtual reality, in conjunction with the various design elements of the tourism service website and other formats of user-generated contents. Third, due to the inability of current virtual reality technology in our lab to simulate the service interaction in the virtual environment, the manipulated online reviews in the current study did not contain service-related content and only focused on feature-centric content. The absence of service-centric reviews may reduce perceived realism towards simulated websites and then behavioral intention. Future studies could keep up with the development of virtual reality technologies and investigate their influence on consumer behavior. Finally, this research uses behavioral intention as the dependent variable and recruited students as the study samples for a specific type of hotel booking, which may restrict the generalizability of the study findings. Future research could investigate the actual purchase behavior with the ordinary consumer participants by conducting real-world experiments and explore the psychological process of a consumer using virtual reality for making a purchase decision.

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