



With or without you? Interaction and immersion in a virtual reality experience

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ABSTRACT

This collaborative research between a team of digital technology developers and academic researchers investigates how social interaction affects visitors' experience during a virtual reality (VR) underwater seascape exploration. Prior research in immersive VR focused more on individual perceptions of immersion, interactive features and enjoyment. Analysis of focus-group discussions revealed three categories of immersion, interaction with the virtual environment (VE) and social interaction salient to satisfaction with the experience. Moderated mediation analysis of survey results from a full-scale trial ($N = 234$) show that the three variables had a significant role in experience satisfaction and loyalty intentions. Specifically, immersion mediates person-VE interaction effects on satisfaction and loyalty. The results contrast with previous findings from online gaming contexts, showing that social interactions decrease the impact of immersion on satisfaction and loyalty. We call for caution in the positioning and communication of VR experiences and for further research in other settings.

1. Virtual experience in leisure and tourism

Technology has transformed the tourism and leisure sectors over the past twenty years in so many ways (Navío-Marco, Ruiz-Gómez, & Sevilla-Sevilla, 2018), notably since the arrival of the eTourism era (Buhalis & Law, 2008) with its revolutionised distribution system and marketplace, altering barriers to entry and improving production efficiency.

Among the contributions that technology is making to these sectors, Virtual Reality (VR) is creating immense opportunities for the leisure and tourism industries throughout the pre-visit phase, during the trip and at the post-visit stage (Marasco & Balbi, 2018; Tussyadiah, Wang, Jung, & tom Dieck, 2018).

VR uses computerised and behavioral interfaces to simulate the behaviour of 3D entities such as people, places and objects in a virtual environment (VE). These entities interact with each other in real time, engaging one or more of the users' five senses (Fuchs & Moreau, 2006; Guttentag, 2010). Its forms are numerous in the experiential sectors, and include VR attractions (Viking City, Waterford), enhancing historical collections (British Museum) and theme parks (Europa Park), virtual visits to museums through the internet (The Louvre Virtual Tour), entertainment in hotels (Samsung VR gear in some Marriott hotels) and virtual videos of destinations (Australia Virtual Tour).

Virtual experiences are valuable additions to the experience economy itself, allowing for existing attractions to be enhanced (Bonetti, Warnaby, & Quinn, 2018; Moorhouse, tom Dieck, & Jung, 2018), new experiences to be staged (Williams & Hobson, 1995) and offering many advantages both from the perspective of consumers and the tourism industry. Tourists themselves can enjoy a very engaging virtual experience (Gibson & O'Rawe, 2018), the possibility of full immersion (Jung et al., 2018) and gamification (Xu, Buhalis, & Weber, 2017), increased accessibility to new and more personalised experience (Williams & Hobson, 1995) and co-creating their experiences with the tourism provider (Jung & tom Dieck, 2017).

At the same time, the tourism industry benefits in several ways. Firstly, from the marketing viewpoint, Virtual Reality contributes to destination image formation (Hyun & O'Keefe, 2012) and incites consumers to communicate on related brands (Guttentag, 2010). It also generates new and increased revenue (Radde, 2017), for example through creating a competitive advantage (Jung & tom Dieck, 2017) and can be used for heritage preservation and planning as well as for training service staff (Guttentag, 2010).

For all these reasons, there is no doubt that virtual reality applications will continue to have an impact in society in general and in the leisure and tourism industries in particular. It is therefore important that researchers gain a greater understanding of consumer experience

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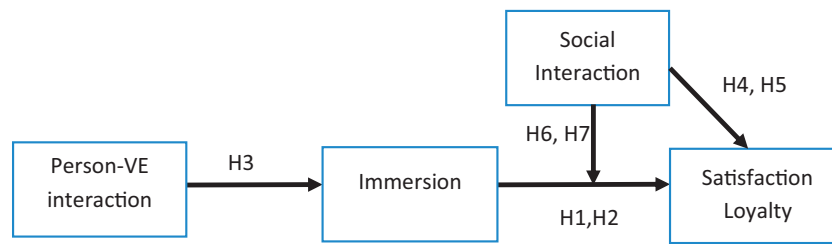


Fig. 1. Proposed model.

in virtual settings (Guttentag, 2010), as well as how that experience affects important marketing outcomes such as satisfaction and loyalty.

This paper therefore investigates these issues in a collaborative study involving an academic institution and a digital technology development institute who created a new VR experience for deployment in tourist centres worldwide. This particular VR technology provided the novel element of enabling interaction between participants within the virtual world, a previously untested feature.

The consumer experience literature has long suggested that two dimensions of consumer experience, namely active/passive ‘participation’, and ‘connection’ ranging from absorption to immersion are key to defining the nature of customer experience (Pine & Gilmore, 1999). The two concepts of participation and connection in the traditional experience literature find an echo in recent research into online, gaming or virtual experiences. Several studies find that immersion (Carù & Cova, 2006; Jennett et al., 2008; Raptis, Fidas, & Avouris, 2018; Shin, 2018) as subjectively experienced, interaction with other participants and interaction with the virtual environment (Cairns, Cox, Day, Martin, & Perryman, 2013; Grinberg, Careaga, Mehl, & O’Connor, 2014) are important to user experience in non-physical settings. However, the interrelations between these three variables, namely immersion, social (person-person) interaction and person-VE interaction are not yet clear. Moreover, their effects on outcomes of interest to the marketing sector, such as customer satisfaction and loyalty remain unknown.

One of the contributions of this paper, therefore, is to show that the immersion, social interaction and person-VE interaction in a VR setting are significant predictors of customer satisfaction and loyalty.

A second contribution of this work lies in its investigation of the moderating effects of social interaction on the immersion-satisfaction and immersion-loyalty relationships in non-physical settings, in particular a virtual underwater tourist experience.

The limited number of studies in this direction are in disagreement as to whether social interaction interferes with or enhances the effects of immersion. On the one hand, social exchanges may distract or interrupt the feeling of being immersed in another world, by reminding the participant that the “real” world (as represented by other participants) is present (Ermi & Mayra, 2005; Sweetser & Wyeth, 2005). On the other hand, participants may become more immersed in the experience because their common goals and mutual involvement lead them to enter the experience more profoundly (Cairns et al., 2013; Grinberg et al., 2014).

The contradictory findings described above arose from considering multiplayer online gaming, a socially interactive context, while the current study focuses on interaction and immersion in an underwater exploration of a VE. Our results show that person-environment interactions and increase participant immersion, but that social interaction diminishes the positive effect of immersion on satisfaction and loyalty. We discuss the possible reasons for, and the managerial implications of these findings.

2. Theoretical background and hypothesis development

2.1. Satisfaction and loyalty in VR experiences

Customer satisfaction and loyalty are the foundation of long-term corporate profits and success in any business sector (Oliver, 1999; Rust & Chung, 2006). Early work proposed a service quality-satisfaction link with a consequent effect on recommendation and repurchase intentions and behavior (Parasuraman & Grewal, 2000; Parasuraman, Zeithaml, & Berry, 1988). This conceptualization rapidly progressed to incorporate the notion that the service as subjectively experienced by the customer, rather than objectively measured from the provider viewpoint, was a better predictor of satisfaction and loyalty (Babin, Darden, & Griffin, 1994; Oliver, 2014). Within this stream of literature came the idea that there were multiple aspects of an experience, particularly in tourism, that could lead to exceptional experience value resulting in enhanced satisfaction (Arnould & Price, 1993). These aspects included a sense of harmony with the environment, exploration, escape and interactions with other participants (see also Fig. 1).

Where VR is concerned, the themes evoked in Arnould and Price’s study find direct parallels in research in Virtual Environments (VE’s). The aspects of exploration and using skills to interact with the environment exist in virtual worlds through the aesthetic and sensorial design of the VE, and by including interactive features enabling the user to explore and control the environment (Sutcliffe, 2016). The sense of harmony, escape and being in another world find resonance in the concept of immersion, where the participant feels as though s/he is “really there”, forgets the outside world and loses his/her sense of time (Carù & Cova, 2006; Jennett et al., 2008; Shin, 2018). We emphasize here that this paper concerns itself *only with subjectively experienced immersion*, and does not refer to technological definitions of immersive types of environment based on a taxonomy of mixed reality systems (Milgram & Kishino, 1994; Sutcliffe, 2016).

Finally, interaction with other individuals participating in the virtual space, although somewhat understudied, could also be a contributor to a good experience. Evidence from other technological domains such as augmented reality (Jung, tom Dieck, Lee, & Chung, 2016; Tusseyadiah et al., 2018; Yovcheva, Buhalis, & Gatzidis, 2013) or the study of video games, where social interaction is important for player experience (Cairns et al., 2013; Vella, 2016). If we extend these ideas to the VR immersive experience, we can speculate that social interaction may have a positive effect on satisfaction during a VR experience.

The role of these three experiential determinants of satisfaction and loyalty, namely person-VE interaction, immersion and social interaction are therefore worth exploring more thoroughly in the particular context of a virtual reality tourist experience.

2.2. The role of interaction and immersion in the consumer experience

Holbrook and Hirschman’s (1982) article kick-started the notion of customer experience, placing feelings, fantasies and fun at the centre of a new vision of consumption. Early research into consumer experience rapidly developed the idea that typology and the degree of immersion/absorption and passivity/activity mattered in the subjective consumer

experience (Pine & Gilmore, 1998). The interactions among participants in the experience (Edgell, Hetherington, & Warde, 1996), namely customer, provider and experience environment also played an important role. Belk brought these ideas together in his argument that experiences are in fact focused in three ways, around “things, surroundings and other people” (1988, p.147).

Recent work has started transposing these notions into virtual spaces. In a virtual experience, consumers interact with virtual objects (“things”) (Nagy & Koles, 2014; Raptis et al., 2018; Vicdan & Ulusoy, 2008), become immersed in the virtual environment (“surroundings”) (Gutiérrez, Vexo, & Thalmann, 2008; Raptis et al., 2018), and interact socially either with an avatar or a ‘real’ person (“other people”) (Jung & tom Dieck, 2017; Mennecke, Triplett, Hassall, Conde, & Heer, 2011). Drawing on these ideas, this paper looks into the effects of the subjective experience of the virtual surroundings, in terms of immersion, person-environment interaction, and inter-participant social interactions on customer satisfaction and loyalty.

2.2.1. Immersion

Immersion as subjectively experienced is a multifaceted construct. It means being “in” a real or virtual experience (Pine & Gilmore, 1999). It involves physical and mental participation (Carù & Cova, 2006) and implies getting away from everyday experience, playing a different role or taking on a new identity (Pine & Gilmore, 1999). Hansen and Mossberg (2013) define immersion as “a form of spatio-temporal belonging in the world that is characterized by deep involvement in the present moment” (p. 212).

In leisure and tourism, escape experiences necessitate a strong state of immersion (Oh, Fiore, & Jeoung, 2007). The participant either escapes from his/her ordinary life (Pine & Gilmore, 1999) or escapes to a new destination (Oh et al., 2007) such as the new environment associated with a VR experience.

In the technological literature, the notion of immersion can occur as an objective description of the immersive properties of the system, with the assumption that subjective immersion follows. Thus, Milgram and Kishino (1994) define the immersive properties of systems along a “virtuality continuum” ranging from the completely virtual to the completely real. This continuum concerns all possible variants and compositions of real and virtual objects.

Various output devices, such as computer or television screens, or more sophisticated head-mounted devices, such as helmets, goggles or glasses can be used, providing varied levels of immersion. In some cases, these are supplemented by floor-supported displays (FSD), panoramic projections and/or virtual tables, immersive cocoons or a CAVE in order to improve the immersion experience (Guttentag, 2010). Similarly, immersion plays a role in more recent technologies such as augmented reality experiences (Jung et al., 2016; Tussyadiah et al., 2018).

The concept of immersion is similar to, but distinct from the notion of “presence” (Lombard & Ditton, 1997), where users undergo a perceptual illusion of unmediated experience in a setting mediated by human technology - typical of VR environments. Presence is also linked to the feeling of “being there”, but immersion is broader than presence. For example, losing one's awareness of time and being deeply involved can occur in activities such as reading a book, solving a mathematics problem or playing a non-immersive game such as solitaire, where a sense of presence is not necessarily experienced.

In the experience literature, immersion is related to the concept of “flow”, where participants enter into an extreme version of immersion, losing self-consciousness and experiencing a modified sense of time (Csikszentmihalyi, 1990). The work of Jennett et al. (2008), and Brown and Cairns (2004) suggest that flow differs from immersion in that it is a fleeting, optimal moment during immersion. In other words, people can feel immersed to varying degrees during an activity, whereas flow is an all or nothing experience. In addition, flow always corresponds to a positive emotional valence (Csikszentmihalyi, 1990), whereas

immersion does not presuppose positive emotions.

Research in gaming interfaces or in socially oriented virtual worlds shows that there is a plethora of factors enhancing immersion. These include realism and interactivity of the virtual environment, ease of use of the technological interface (Gutiérrez et al., 2008; Sutcliffe, 2016), the identification of the player with the environment (Nagy & Koles, 2014; Shin, 2018), enjoyment (Tussyadiah et al., 2018; Vella, 2016), and social interactions (Cairns et al., 2013; Grinberg et al., 2014; Vella, 2016).

Most work on immersion in experiences other than training or learning has tended to focus either on describing immersion – its measurement and similarity or difference to other constructs- or on its predictors. To our knowledge, a very limited number of studies look at immersion as an independent variable and investigate its effect on consumer outcome variables. These few studies show negative effects of immersion on well-being (Vella, 2016) in single-player and multiple player video games, negative effects on performance on unrelated post-immersion tasks (Jennett et al., 2008), also in a gaming setting, and heightened emotional arousal dependent on immersion during viewing a 3D animated movie (Visch, Tan, & Molenaar, 2010). These negative empirical results tend to contradict the general idea in the literature of immersion as being a positive contributor to a valuable experience, but the relatively small number of empirical investigations in this area (e.g. Tussyadiah et al., 2018), does not provide much robust evidence for immersion effects.

In spite of these sparse findings, other studies indirectly suggest that immersion can lead to increased satisfaction and loyalty. In a 3D fully immersive VR experience in a shopping mall, Van Kerrebroeck, Brengman, and Willems (2017) found that a VR experience offered in a shopping mall, increased both satisfaction and loyalty in terms of both recommendation and return intentions, through the mechanism of relieving irritation with crowding in the mall experienced before participating in the virtual experience. The authors did not measure immersion per se, assuming that the immersive system would produce the subjective experience. Jung and tom Dieck (2017) also found in a qualitative study that immersion affected behavioral intentions to repeat VR tourism experiences.

If we move away from the VR literature, studies in leisure and tourism generally show positive effects of immersion on satisfaction and loyalty (Cuny, Fornerino, & Helme-Guizon, 2015; Hansen & Mossberg, 2017; Oh et al., 2007). We therefore suggest that:

H1. Immersion has a positive effect on satisfaction in a VR experience.

H2. Immersion has a positive effect on loyalty in a VR experience.

2.2.2. Person-environment interaction

In her seminal paper, Bitner (1992) provided a new, holistic consideration of the customer service environment termed the servicescape. The author suggested that an appropriately designed servicescape in terms of ambient conditions, space and symbols would lead to improved customer perceptions resulting in approach behaviors, such as exploration of the servicescape, social interaction and return intentions.

More recently, researchers in the area of tourism have taken up these ideas, emphasizing the importance of providing an “experienescape” which includes people, products and a physical environment within which the tourist interacts, creating his/her own optimal experience (Mossberg, 2007; O'Dell & Billing, 2005).

With the advent of digital technology, and the concomitant shift towards customer-centric value creation, the ability of customers to engage and interact freely with the digital environment has become vital in creating positive service experiences (Pralhad & Ramaswamy, 2004).

A principal difference between a virtual and physical experience occurs in the replacement of the real with the virtual experiencescape,

mediated by a digital interface. The concern with providing a realistic experiencescape by increasing interactivity and thus immersion is implicit in much of the VR literature. Thus, for example Daugherty, Li, and Biocca (2008), find that interaction with a “3D” virtual product, which customers can rotate and zoom into, even on a computer screen, has a similar effect to physical contact with the “real” object on brand attitudes and purchase intention.

The literature around design for user engagement in VE (see Sutcliffe, 2016 for an overview) shows that interactive features such as sliders, zoom control, responsive objects, mouseover effects and pop-up features allow the user to explore and control the virtual world and to become more “present” or immersed. In the context of socially-oriented VEs, Nagy and Koles (2014) extend this reasoning to suggest that interaction with virtual objects, (for example the purchase of clothing or weaponry) increases immersion through heightened individual identification with the VE. Tussyadiah et al. (2018) also show that increasing interactive features in tourism VR experiences can be linked to immersion. Overall, the literature suggests that interaction between an individual and his/her environment, by allowing the person to identify with, or explore and control that environment, increases engagement or immersion in an experience. Our hypothesis is therefore:

H3. Person-environment interaction has a positive effect on immersion in a VR experience.

2.2.3. Social interaction

Along with interactions with the environment, social interactions are significant to customers in a servicescape (Bitner, 1992) or experiencescape (Mossberg, 2007). These person-to-person interactions can take place between the service provider and customers or customer-to-customer. The focus on the exchanges between human actors within the servicescape has resulted in new stream of research into value co-creation, shifting the emphasis from production and delivery towards value created by and with the customer at the heart of the experience (Babin & James, 2010; Vargo & Lusch, 2008).

Social interaction is a particularly recognised theme in leisure and tourism research where fulfilling social needs as well as utilitarian and psychological needs is vital for customer satisfaction (Choo & Petrick, 2014; Debenedetti, 2003; Matson-Barkat & Robert-Demontrond, 2018). Meaningful interaction between customers and service staff as well as between customers and other customers is of prime importance in the experience. Previous research has shown that active participation of tourists in the co-creation of experiences with service staff can lead to a competitive advantage (Payne, Storbacka, & Frow, 2008) and value has been shown to increase when tourists and service providers participate together in a staged performance at a theme park (Minkiewicz, Evans, & Bridson, 2014). Choo and Petrick (2014) find that companions and other customers, as well as hosts, all have an influence on customer satisfaction and intentions to revisit in a tourism context. Taking a consumer culture theory approach, Arnould and Price (1993) show that relationships between customers and tour guides as well as between customers and other customers create meaning and lead to satisfaction and the desire to repeat adventure tourism experience.

Closer to the current study, Jung and tom Dieck (2017) illustrate that augmented reality (AR) adds to a tourism experience and encourages visitors to share their experience with others, but these interactions take place in the real world, rather than in the virtual world. Similarly, a study of users' experience of AR in the exploration of an urban tourism destination shows that there is a clear relationship between the physical and the virtual in the person's whole experience (Yovcheva, Buhalis, Gatzidis, & van Elzakker, 2014). With the increase in both virtual reality experiences, and the enhancement of technology which will increasingly allow for interactive experiences in the virtual world, it is therefore important to test whether or not these observations can be transposed to a virtual tourism experience. Unlike previous studies, the social interactions taking place in this work involve only

interactions within the virtual world.

Overall, therefore, previous work in the areas of customer value co-creation and tourism experience suggest that social interactions have positive impacts on consumer outcomes. Extending these findings to a purely virtual tourism experience, we hypothesise that:

H4. Increased social interaction positively influences satisfaction in a VR experience.

H5. Increased social interaction positively influences loyalty in a VR experience.

2.2.4. Social interaction and immersion: moderation effects

In contrast to the ideas developed in the preceding section, some research indicates that social interaction may not always lead to solely positive customer outcomes. In the case of cruise holidays for example, Huang and Hsu (2010) note that the quantity of social interactions does not influence satisfaction, while the quality and the closeness of the relationship (family) have a positive effect. This notion of a negative aspect of social interaction finds echoes in the work of Andersson and Mossberg (2004), who find that customers may avoid crowded restaurants, indicating that not all individuals seek social interaction to satisfy their experiential expectations. These themes also appear in the literature on solo travel and tourism (Laing & Crouch, 2009; Santana-Jiménez, Sun, Hernández, & Suárez-Vega, 2015), where tourists value experiences which distance them from human contact. These considerations therefore lead us to consider the mechanism by which increased social interactions can negatively affect customer outcomes. We can reasonably ask the question of whether social interactions might in some circumstances interfere with other elements of an experience, such as immersion, causing a knock-on negative effect on satisfaction and loyalty.

To consider this question, it is useful to understand the context of our study, which involves a fully immersive interactive VR underwater seascape trialled with visitors at a Marine Life Center. Each participant appears to the others as an underwater helmet of a different colour in the VE. Thus, participants are able to “see” and interact with each other during their exploration. Social interaction VR attractions such as this are somewhat unusual, which is not surprising given the complexity of design and development of this type of experience. There are some examples from other new-technology experiences such as socially-oriented interactive tourism experiences in Second Life and the Itchy Feet travel community (Berger et al., 2007; Gärtner, Seidel, & Berger, 2008; Guttentag, 2010). In general, however, individual VR experiences prevail.

To discuss social interaction-immersion relationships, we therefore turn to the literature on multi-player gaming (Cairns, Cox, & Nordin, 2014; Vella, 2016) and general 2D or 3D environments with different degrees of immersive features (Sutcliffe, 2016). This body of research generally finds that the presence of computer generated avatars, human-based avatars or real others leads to greater immersion in the virtual world. One reason put forward for this effect is that the presence of others makes the virtual world feel more like the real world (Sutcliffe, 2016), where most individuals live and interact socially in environments peopled by other humans.

A second argument for social interaction enhancing immersion relies on shared goals, particularly in achieving player aims during video games (Cairns et al., 2013; Vella, 2016). By communicating and exchanging around how to win, be it a competitive or cooperative game, players become involved together in reaching their goals, and thus more immersed.

Similarly, from the work done on socially-oriented experiences, such as Second Life, it is clear that social interactions are key to becoming immersed in a virtual world designed to facilitate and develop human activities and relationships such as shopping, having a “virtual” drink at a bar or eating at a virtual restaurant (Grinberg et al., 2014). In

these contexts, the presence of virtual others can create a sense of intimacy, group identity, entry into a virtual culture and an alternative life narrative (Nagy & Koles, 2014).

Intriguingly, however, there are references to the opposite occurring. For example, De Kort and Ijsselstein (2008) generally follow the view that social interaction leads to higher meaning and engagement, but note that the presence of others may have an evaluative or monitoring component, which can lead to apprehension on the part of the player. More relevant to our study, is the notion that social interactions can be in conflict with experiences of immersion. Immersion involves escaping from, and forgetting all elements external to the virtual world, losing a sense of reality and time, and 'being in' the virtual world. As such, social interaction can bring the individual "out" of the immersive experience and back into the real world of social relations. Sweetser and Wyeth (2005) explicitly state that '*social interaction is not an element of flow, and can often interrupt immersion in games*' (p.10).

We suggest that an experience of an underwater seascape differs from the other VR experiences discussed previously in several ways. First, it provides the potential to escape into an alternative world, where human presence is incongruous. As such, interaction with others brings the visitor back to the human, everyday world, detracting from the illusion of really being underwater. Second, the notions of co-operation or competition in achieving goals which occur in multiplayer games are absent from this experience, whose goals are individual exploration and learning. Third, unlike a socially-oriented virtual space, there is no sense of becoming part of a community or identifying with a group, and so social interactions would not increase involvement in this environment populated by fauna and flora, rather than other humans. These three particularities of the virtual experience under study here, lead to the idea that while immersion leads to higher satisfaction and loyalty, social interaction will detract from immersion and thus weaken the effect of immersion on satisfaction and loyalty:

H6. Social interaction will negatively moderate the effect of immersion on satisfaction.

H7. Social interaction will negatively moderate the effect of immersion on loyalty.

3. Methods

3.1. Research setting, participants, and procedures

We carried out a field study using a cross-sectional survey design to trial the VR technology, and to test our hypotheses. Data collection took place over ten days during a trial of an immersive underwater VR experience in a popular Marine Life Center in the west of France.

A research assistant approached visitors to the center during their visit, and asked them if they wished to participate in the VR trial and our study, explaining briefly the experience and the purpose of the study. Thus, a self-selected sample of tourists, the core target market for the VR experience was obtained.

These visitors to the center participated in groups of 3–4 people in a 15-min virtual visit of an underwater seascape in two scenes. The four participants each completed a consent form and pre-experience questionnaire asking them to fill in their demographic details and to indicate their relationship to others in the group. They then received a brief explanation on safety and on how to use the VR headset, and went on to explore the first scene consisting of a visual and audio ocean world populated with animated flora and fauna. Participants interacted with the VE and each other by means of their own visible, virtual hand, which tracked their real hand movements. By moving and pressing their virtual hands, visitors activated a laser beam to point at animals and objects in the seascape. They were also able to take virtual photos of any object in the VE, including themselves and the three other participants, represented by individually colored underwater helmets with

matching colored hands. Various ocean-dwelling animals appeared and disappeared during the scene, including a playful seal swimming in through the group, a whale swimming "above" their heads, schools of fish and scuttling crabs on the seabed. The participants walked around the "sea floor" to explore their surroundings – in real life walking across a large room bounded by a movable barrier. On pointing at an object in the VE, an information bubble appeared by their hand, providing details of the animal or plant in question as well as a gold star. A gaming element included collecting as many stars as possible. An audio track explained certain elements of the sea world such as the story of a crashed plane visible in the distance, or the migration habits of the whale, or some little-known facts about the plants, fish and sea mammals present.

The second, shorter 3-min scene followed on directly from the exploration, and showed the planet earth rising from the sea floor, with an audio description and visual illustration of the effects of climate change on the oceans. Interaction with the planet occurred by pointing at parts of the globe to activate written information bubbles. Post-experience, the participants individually completed a questionnaire measuring their degree of immersion, interaction with each other, as well as satisfaction, word of mouth and revisit intentions.

3.1.1. Sample

The final sample consisted of 234 visitors, having eliminated one incomplete questionnaire due to a technical error. Females made up 55% (N = 130) of the sample, and we obtained evenly distributed age groups of 12–18 (23% N = 53), 19–25 (26% N = 61), 26–40 (21% N = 48), 41–60 (24% N = 58) but fewer older participants > 60 (6% N = 14). The majority of the participants was French (94% N = 219), and the remaining 6% either spoke fluent French (Nationalities: British, N = 2; Russian, N = 1; American N = 1) or were native French speakers (Belgian, N = 3; Swiss, N = 8). Education levels varied from secondary school level (45% N = 106) through undergraduate (32% N = 75) to postgraduate (23% N = 53).

3.2. Measures

Because most existing measures for subjectively experienced immersion and interaction arise from gaming or online experiences, we needed to develop or adapt scales for the particular VR experience in this study. For this purpose, we carried out a pre-test of the virtual experience with two groups of eight individuals, with focus group discussions before and after the trial. Focus groups provide an opportunity to encourage interaction within a group enabling participants to produce data and facilitating exposure of their feelings about common experiences and concerns (Krueger & Casey, 2014) which is important in the context of a shared experience such as the one used in this study. The first group consisted of master's level students aged 22–26 years old from a European business school (2 males, 6 females), and the second of four mother-child pairs. The young participants were 14–15 years old, two boys and two girls. The volunteers took part in a focus group to discuss their expectations and feelings before the experience, and to describe the experience immediately after immersion in the VE. As well as allowing for the development of measures, the use of two data collection methods added rigour to the research, enabling comparison and confirmation of observations across qualitative and quantitative methodologies.

After transcription of the focus groups, we used theoretical thematic analysis (Braun & Clarke, 2006) using NVivo 11 software to identify major themes arising linked to immersion and interaction. The two researchers who had facilitated the focus groups coded the corpus progressively in parallel with each other, allowing for discussions regarding interpretations and thereby enriching the coding process. The themes associated with immersion allowed us to select appropriate items from Jennett et al.'s (2008) scale for use in the final study, concerning feeling immersed, detached from the outside world, "being in"

the virtual world and forgetting one's daily life. Analysis of the social interaction theme finally generated four items concerning awareness of others, communication with others, complicity with others, and interaction with others. Coding for interaction with the seascape led to three items concerning freedom to explore, interact with and move around the environment. Seven professionals from the VR development company, academia and the Marine Life Center checked the items for face validity and wording. A maximum of four items per variable was necessary in order to find a compromise between practicability and analytical rigour, and to enable both younger and older participants to reply with ease.

For pre-existing scale items, we created French versions following the standard translation-back-translation procedure (Brislin, 1986).

Immersion Following the focus group study results, we used four items adapted from Jennett et al.'s (2008) scale, measured on a 7-point likert scale. 'I could interact with the seascape as if I was in the real world'; 'I felt detached from the outside world'; 'I felt completely immersed'; 'I forgot about my everyday concerns', anchored with 1 = not at all; 7 = a lot ($\alpha = 0.77$).

Person-VE interaction used three items developed from the focus group findings measured on a 7-point Likert scale 1 = not at all; 7 = a lot. The items were: "I felt free to: interact with the environment; explore/look where I wanted; move around in the environment". ($\alpha = 0.66$).

Social interaction consisted of four items 'I was aware of the other participants'; 'I communicated with the other participants'; 'I was complicit with the other participants'; 'I interacted with the other participants' 1 = not at all; 7 = a lot. ($\alpha = 0.86$).

Satisfaction used one item (Anderson, 1998): 'Please indicate your satisfaction with the Virtual Arctic Expedition experience' on a 7-point item anchored by '1 = very dissatisfied; 7 = very satisfied'.

Loyalty consisted of three items (Zeithaml & Berry, 1996) covering positive word of mouth, 'I will say positive things to others'; recommendation intentions 'I will encourage my friends and/or my family to come and try it'; and re-visit intentions 'I will come back to visit this virtual world' preceded by the phrase: 'concerning this experience'. Anchors for the 7-point Likert scale were 1 = very unlikely, 7 = very likely. Inter-item reliability tests gave $\alpha = 0.77$ **Control variables: Social ties.** Vella (2016) suggests that social ties (known vs unknown others) between participants have a salient role in gaming experiences. We therefore controlled for this variable by asking participants to identify other member of their group as family, friend, partner, colleague/acquaintance, unknown. We coded these as one of four categorical variables per respondent indicating whether that person's group included: one to three *family members* (including partner), *friends* (including colleagues), *family and friends*, or *all strangers*. Four way ANOVA on all five main variables showed that social ties had a significant effect only on the *social interaction* variable ($F(3, 4230) = 8.54, p = .000$). In line with Vella (2016) the only effect was between known and unknown others. Thus, post-hoc Tukey tests indicated that social interaction was significantly lower between groups where *no social ties* existed and the other three groups. No significant differences according to the closeness of the tie (family or friend) existed.

Gender bias tests using independent samples *t*-tests showed no significant effects on any of the variables. Similarly, **education level** effects using ANOVA were non-significant. An effect of **age** occurred, with the 12–18 year-old group showing significantly higher interaction with the VE than other, older age groups ($F(4,228) = 3.46, p = .009$).

For the subsequent moderated mediation analyses, we included social ties (dummy variable 0 = unknown; 1 = known others) and age variables as controls.

4. Results and hypothesis testing

Table 1 displays the correlations, means and standard deviations for the variables.

The mean values for satisfaction, loyalty, person-virtual

environment interaction and immersion are all high, indicating that participants generally had very positive experiences with strong satisfaction and loyalty outcomes. Social interaction was relatively low, with a high standard deviation suggesting that interaction with others varied substantially in the sample. Significant positive correlations exist between all five main variables except between social interaction and immersion, providing initial support for the notion that immersion does not covary with social interaction. The control variable correlations indicate negative correlations between age and other variables except loyalty, and a positive relationship between social interaction and social ties between participants.

4.1. Hypothesis testing

To test our hypotheses, we applied the procedure developed by Preacher and Hayes (2008) using model 14 in PROCESS, SPSS v.24 for moderated mediation models. We calculated bias-corrected bootstrap confidence intervals (with 5000 bootstrap samples) for the indirect effect of person-VE interaction on satisfaction through immersion, the latter relationship moderated by social interaction (*Model 1*). *Model 2* tests the same relationships replacing satisfaction with loyalty as the outcome variable. Age and social ties acted as control variables in the models. The results of the analyses are in Table 2.

The indirect effect of immersion on satisfaction was significant, with the lower bound of the 95% bias-corrected confidence interval -0.0629 and the upper bound -0.0056 , as was the indirect effect of immersion on loyalty (LLCI = -0.0723 ; UCLI = -0.0066). Thus, H1 and H2 found support. Table 2 also shows the significant effect of Person-VE interaction on immersion (LLCI = 2.9012 ; UCLI = 4.3068), supporting H3. H4 and H5 suggested that social interaction would have positive effects on satisfaction and loyalty respectively, and the results also support these two hypotheses (Satisfaction: LLCI = 0.1815 ; UCLI = 0.8760 . Loyalty: LLCI = 0.2478 ; UCLI = 0.9086). Social interaction reduced the effect of immersion on satisfaction (LLCI = -0.1306 ; UCLI = -0.0166) and loyalty (LLCI = -0.1390 ; UCLI = -0.307) as predicted by H6 and H7 respectively. Age and social ties had no significant effects on the model.

Post hoc conditional probing in PROCESS of the moderation relationship highlights the effects of immersion at different levels of social interaction. Table 2 shows that at low levels of social interaction the effect of immersion on both satisfaction and loyalty are high, and that this effect diminishes as the level of social interaction rises. For the purposes of illustration, simple slopes analysis (Dawson, 2014) shows the (standardized) independent variable (immersion) effects on satisfaction and loyalty at one standard deviation below the mean for "low" and one standard deviation above the mean for "high" social interaction. Fig. 2 shows these effects.

The depiction in Fig. 2 is useful in that it reveals that in absolute terms satisfaction and loyalty are generally somewhat greater when social interaction is higher. However, the steeper gradient seen for low social interaction shows that immersion has a stronger effect on satisfaction when social interactions remain relatively low, further substantiating the notion that social interaction interferes with the positive effects of immersion on satisfaction and loyalty.

5. Conclusions and implications

The findings in this study make four contributions to the customer experience literature in the specific setting of a virtual reality experience. First, the research confirms that the notion suggested by Belk (1988) that experiences rest on the triple pillars of "things, surroundings and other people" is transferable to virtual experiences. The model tested showed that interaction with objects in the virtual world played an important role in increasing immersion in the virtual surroundings, and that social interaction and immersion, each taken separately, had significant positive effects on customer satisfaction with the experience

Table 1
Means, standard deviations, reliability and correlations^a.

Variable	Mean	s.d.	1	2	3	4	5	6
1. Satisfaction	6.18	0.92						
2. Loyalty	6.36	0.82	0.64***					
3. Person-VE interaction	5.84	0.95	0.44***	0.29***				
4. Immersion	6.00	0.83	0.51***	0.46***	0.52***			
5. Social interaction	3.31	2.09	0.26***	0.19**	0.17*	0.10		
6. Age	–	–	–0.19**	–0.12	–0.18**	–0.16*	–0.16*	
7. Social tie	–	–	–0.01	–0.08	0.02	–0.02	0.28***	–0.08

^a N = 234.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

as well as on loyalty.

Three further contributions lie in the results concerning the mechanism by which the variables of person-VE interaction, immersion and social interaction interrelate, and their effects on satisfaction and loyalty. First, we see that interaction with the VE has a positive effect on immersion, supporting the notion that designing VEs with interactive features will lead to more immersive experiences (Sutcliffe, 2016). The model also suggests that interaction with the virtual world act on satisfaction and loyalty through the mediating effect of immersion.

Second, the results highlight an implicit, but rarely investigated effect in a VR setting in that immersion increases experience satisfaction and loyalty. Previous work has suggested negative links with well-being (Vella, 2016), performance (Jennett et al., 2008) and increased emotional arousal (Visch et al., 2010), but effects on satisfaction and loyalty remain understudied.

The third, and most counter-intuitive contribution lies in the finding that while social interactions contribute positively to overall satisfaction, they also moderate or interfere with the impact of immersion on satisfaction. In other words, the effect of immersion on satisfaction and loyalty is stronger when social interactions are low and weaker when social interactions are high. This contrasts with findings from studies in multiple player gaming environments (Cairns et al., 2013; Vella, 2016) or suggestions from socially-oriented VEs (Nagy & Koles, 2014), where

social interaction enhances immersion. The moderation effect does however support the idea put forward by Sweetser and Wyeth (2005) that social interaction interrupts flow and immersion, and by extension would diminish the positive effect of immersion on satisfaction and loyalty. We suggest that this effect is particularly salient in the type of immersive virtual experience studied in this paper, which does not involve achievement of group or social goals. This contribution is important in itself, and was possible due to a technical innovation in VR allowing person-to-person interaction.

The results also reveal information of interest to practitioners in the tourism industry who are considering expanding their attractions with the inclusion of a VR experience. The research confirms that both social interaction and immersion can lead to satisfaction and loyalty in the VR entertainment industry. Consequently, visitors who experience either of these will be happy to repeat these experiences and to recommend them to others. This corroborates findings from the non-VR experience economy, illustrating similarities in customer experience across VR and non-VR leisure experiences.

Our findings are salient to many tourism contexts, where developing Virtual Reality experiences can generate demand and repeat business through offering novelty. Positive VR experiences are important not only for enhancing the offering of a particular tourism site but also to encourage visitors to renew or extend their stay in the region, benefiting the economy in a general sense. Also of importance to many

Table 2
Results of moderated mediation models P-VE interaction, immersion, social interaction on satisfaction and loyalty.

	Model 1. Effects on satisfaction				Model 2 Effects on loyalty			
	Coeff	s.e.	t	p	Coeff	s.e.	t	p
Person-VE interaction to immersion	0.45	0.05	8.88	0.000	0.45	0.05	8.88	0.000
Immersion to dependent variable	0.62	0.11	5.60	0.000	0.67	0.11	6.31	0.000
Social interaction to dependent variable	0.53	0.18	3.00	0.003	0.58	0.17	3.46	0.001
Person-VE to dependent variable	0.20	0.06	3.29	0.001	0.04	0.06	0.65	0.513
Immersion × social interaction to dependent variable	–0.07	0.03	–2.54	0.012	–0.085	0.03	–3.09	0.002
Partial effect of age on dependent variable	–0.05	0.04	–1.11	0.266	–0.010	0.039	–0.26	0.796
Partial effect social tie on dependent variable	–0.17	0.16	–1.07	0.287	–0.285	0.148	–1.92	0.057

Bootstrapping results for indirect effects	Estimate	s.e.	95% CI		Estimate	s.e.	95% CI	
			LL	UL			LL	UL
Index of moderated mediation	–0.0329	0.0144	–0.0629	–0.0056	–0.0379	0.0171	–0.0723	–0.0066
$R^2 = 0.36$, $F(6,226) = 21.06$, $p = .000$					$R^2 = 0.28$, $F(6,226) = 14.80$, $p = .000$			

Post-hoc probing: immersion on DV at different levels of social interaction

Social interaction ± 1SD	Immersion effect	Boot se	LLCI	UCLI	Immersion effect	Boot se	LLCI	UCLI
1.21	0.24	0.048	0.147	0.338	0.25	0.056	0.151	0.375
3.30	0.17	0.037	0.102	0.251	0.17	0.039	0.108	0.263
5.39	0.10	0.047	0.006	0.192	0.09	0.050	0.002	0.197

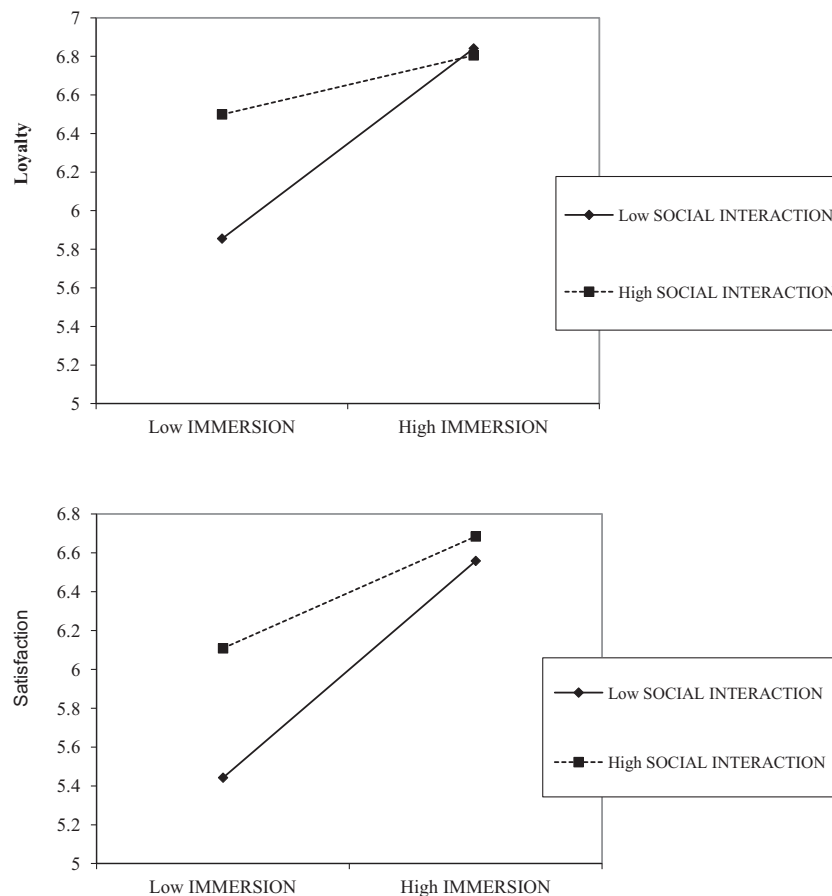


Fig. 2. Moderation: Social interaction on immersion → satisfaction and immersion → loyalty.

tourism attractions and regions, satisfaction with a VR experience can generate extra revenue through upselling (Radde, 2017; Tromp, 2017) for an existing tourism site. These new attractions can also be mobilised in tourism marketing communications because they create a clear competitive advantage as with other Virtual Experiences (Jung & tom Dieck, 2017), by adding enjoyment and entertainment value (Chung, Lee, Kim, & Koo, 2018; Guttentag, 2010; Jung et al., 2018). This is perhaps especially so in the case of more traditional, education-based tourism attractions such as the Marine Life Centre studied here.

The study also suggests that visitors wishing to engage strongly with, and become as one with the VE environment, seek a personal, rather than a social experience. From a marketing viewpoint, these findings imply that positioning of VR experiences should promote either strong social interaction or high levels of immersion. In developing VR experiences, providers should either focus their attention on a target market which will be most satisfied with a highly interactive, social experience, or on the other hand, choose a target market which will prefer a more private, immersive experience. In either case, the positioning of the VR experience with one of these target markets in mind will be preferable and should go hand in hand with the company's brand and communications.

More generally, this study contributes to the understanding of the eTourism Ecosystem where much remains to be explored and understood. Importantly, it calls for caution when transposing observations from the real world to the virtual world, showing that immersion and social interaction, which are often experienced simultaneously in real life experiences, do not sit comfortably together in the Virtual World, or at least not in the context studied. With this in mind, we call for similar research in other contexts.

6. Limitations and future research

As VR occupies an increasingly important place in the leisure and tourism industries, this paper calls for further research to enhance understanding of consumer behaviour in this field. In particular, the arrival of augmented reality technologies onto the tourism market shows promise as a clear contributor to the tourism experience, combining the real and the virtual in new and exciting ways (Chung et al., 2018; Jung & tom Dieck, 2017; Yovcheva et al., 2013; Yovcheva et al., 2014).

One limitation of this study is its specificity in terms of setting, meaning that the findings cannot be generalised to other VR experiences. The Marine Life Center setting possibly implies a particularly immersive and escapist experience. Future research could usefully compare these results with other VR experiences, such as game-based, educational, cultural or even other escapist environments such as immersive experiences in a land-based context where human presence is not incongruous.

It would also be interesting to test VE behaviour across age groups, to confirm the observations concerning generation Alpha (12–18 year olds) who engage in more social interaction than other age categories, as this can have consequences for the future development of VR experiences.

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