Augmented Reality Experiences and Sensation Seeking

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Citation:

Park, S., & Stangl, B. (2020). Augmented reality experiences and sensation seeking. *Tourism Management*, *77*, 104023.

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Abstract

Studies about augmented reality (AR) largely discuss the design of applications and adoption behaviours of the AR system. Attempts to understand user experiences with AR are scarce, especially in the field of tourism. This paper contributes to this gap by identifying travellers' experiences with AR applications when obtaining travel information. More specifically, this study applied the concept of sensation-seeking to segment travellers to better understand their AR experiences. An online questionnaire was designed and completed by a sample of 1,042 study participants who all used an AR app in the course of this study. The results demonstrate the applicability of sensation-seeking to explain heterogeneous AR experiences. Of the four sensation-seeking elements, experience-seeking and boredom-susceptibility were identified as key elements to classify the travel groups in the context of AR applications. Managerial implications for tourism marketers are suggested.

Keywords: User experiences, augmented reality, sensation-seeking, mobile services, typology representing network analysis, market segmentation

Introduction

The constant development of information technology (IT) along with context-aware computing environments has revolutionised the way in which people access and share information in everyday tasks. In particular, advanced mobile technology provides services without constraints of time and place (MacKay & Vogt, 2012), accelerating the feasibility of augmented reality (AR). AR systems integrate virtual information into a person's actual environment so that the individual can perceive the information as existing in his or her circumstances (Butchart, 2011; Höllerer & Feiner, 2004; Yung & Khoo-Lattimore, 2019).

AR provides substantial benefits to the tourism field. Given the characteristics of travellers, who are, in general, unfamiliar with the destinations that they visit, AR applications allow people to gain adaptable and real-time information about an object of interest that is placed in the surroundings (Chou & ChanLin, 2012; Yovcheva, Buhalis, & Gatzidis, 2012). Recognising the considerable potential of AR applications in terms of enhancing travel experiences, researchers have mainly investigated computing algorithms for engineering the design of AR (Weng et al., 2011) and identified factors that affect the adoption of AR with regard to perceived quality (Jung, Chung, & Leue, 2015), technology readiness (Chung, Han, & Joun, 2015), and the technology adoption model (TAM) (Chung et al., 2015; Jung et al., 2015). Indeed, while numerous studies have explained adoption behaviours, academic attempts to understand actual user experiences of AR services in tourism are limited (see Olsson, Lagerstam, Kärkkäinen, & Väänänen-Vainio-Mattila, 2013; Yovcheva, Buhalis, Gatzidis, & van Elzakker, 2013). The identification of user experiences is a vital issue because it can provide insights into the design of AR systems. Better designed AR applications that incorporate travel behaviours enhance their usefulness as a type of travel information source.

Tourism scholars have identified substantial numbers of factors to explain travel behaviours. Personality traits, conveying a sense of consistency or continuity about a person, have been regarded as some of the most powerful concepts to understand differences in behavioural patterns and preferences (Gretzel, Mitsche, Hwang, & Fesenmaier, 2004; Park, Tussyadiah, Mazanec, & Fesenmaier, 2010). Specifically, previous research has shown that sensation-seeking is a biosocial and/or genetic basis of a personality trait (e.g. dopamine) (Hur & Bouchard, 1997). Sensation-seeking reflects a quality of seeking intensity and novelty in a sensory experience that may be expressed in multiple areas of personal life (Pizam et al., 2004). People who appear to be highly sensation-seeking are associated with specific types of travel styles; for instance, explorer and drifter tourists (Lepp & Gibson, 2008). That is, high sensation-seekers are more likely to enjoy adventurous, exciting, and risky activities as well as seeking novel experiences than low sensation-seekers (Leung & Law, 2010).

From an information-processing perspective, the influence of sensation-seeking reflects people's attitudes towards, and preferences for, external stimuli to which they are exposed (Lu, Chi, & Lu, 2014). Individuals who score highly in sensation-seeking tend not only to have needs for complex and adventurous experiences but also require stimuli that arouse strong emotional reactions. Currently, the novelty value that AR provides is captivating and inspiring experiences (Olsson et al., 2013). It implies that sensation-seeking explains heterogeneous experiences in using AR as an online source to obtain information about a travel destination. Therefore, the aims of this research are: (1) to discuss the applicability of a sensation-seeking personality in the context of IT and to apply it to segment travellers and (2) to understand different user experiences with AR applications when obtaining travel information across sensation-seeking segments. To identify the sensation-seeking segments, the authors use the typology representing network analysis, which is a non-parametric cluster analysis approach (Mazanec, 1992), using the neural gas algorithm

(Martinetz & Schulten, 1991). Different travel and information evaluation behaviours as well as user experiences with AR across the classified groups are identified. Specifically, built on the study of Olsson and Salo (2011), this study evaluates two categories of user experiences regarding interaction with AR services, namely (1) characteristics of experiences containing pragmatic and emotional aspects and (2) design requirements for AR.

Literature Review

Augmented Reality (AR)

AR has been initiated in the field of computer science. Milgram and Kishino (1994) proposed a continuum of mixed reality combining 'real' and 'virtual' environments and stated that AR is part of it (see Figure 1). Mixed reality is defined as 'the integration and merging of the real and virtual worlds in which physical and virtual objects complement and interact with each other' (Olsson et al., 2009, p. 20).

[Please insert Figure 1 here]

The virtual continuum includes the real environment, which comprises, solely, real objects at one end of the continuum and the virtual environment, which consists merely of virtual objects, at the opposite end (Kim, Hwang, Zo, & Lee, 2014). AR joins real and digital information in the user's view of the physical real world in such a way that they appear as one environment (Höllerer & Feiner, 2004; Olsson et al., 2013). This new reality of integrated information can be engaged in real time, allowing people to utilise their senses and skills, and the capability of networked computing (Olsson et al., 2013). As shown in Figure 1, AR is related to the concept of virtual reality (VR). VR takes it one step further; instead of adding digital information to the real world, like AR, it creates an artificial world that people

can experience and explore through their visual, audio, tactile, and other senses. While both AR and VR involve interactive experiences, the main objective of AR is to supplement the real world with virtual objects superimposed on the actual environment rather than producing an entire synthetic environment (Azuma, 1997; Chou & ChanLin, 2012). AR provides an enhanced solution concerning personal awareness of the surrounding context. In this vein, AR can be defined as 'one that combines real and computer-generated information in a real environment, interactively, and in real time, and aligns virtual objects with physical ones' (Höllerer & Feiner, 2004, p. 2).

The development of mobile technologies, such as enhanced cameras, location-awareness, and sensor identification systems, provides the required technological enablers for producing AR services that facilitate interaction with the augmented information in a convenient way (Choi & Choi, 2014; Olsson et al., 2013). The new realm, i.e. AR, of integrated digital and physical world information via human–computer interactions suggests the potential to reform the way in which information is accessed and presented to people (Chou & ChanLin, 2012; Höllerer & Feiner, 2004). In the context of tourism, where visitors generally have limited knowledge about their destinations, AR systems enable travellers to increase their social awareness of contexts and unfamiliar places. AR allows travellers to have interactive, diversified, and personalised travel experiences and to improve their travel outcomes (Chung et al., 2015; Jung et al., 2015). For example, with the installation of GPS on smartphones, travellers can point their devices towards a travel attraction in their surroundings. Subsequently, extra virtual information superimposed on top of the real world is presented to them. The formats and contents of information within virtual settings are different depending on the types of application systems, such as images, videos, sounds and texts (Yovcheva et al., 2012, 2013). Along with geo-fencing systems, users can also obtain recommended travel services.

Recognising the large potential of AR in everyday life, numerous researchers have investigated the application of AR in marketing (Bulearca & Tamarjan, 2010), education (Wu, Lee, Chang, & Liang, 2013) and campus-touring (Chou & ChanLin, 2012) as well as tourism-related areas such as heritage sites (Casella & Coelho, 2013; Martínez-Graña, Goy, & Cimarra, 2013), theme parks (Jung et al., 2015; Weng et al., 2011), and urban destinations (Yovcheva, Buhalis, & Gatzidis, 2013). Considering the previous studies related to the tourism field, there are two main research streams, namely AR adoption (Leue, Dieck, & Jung, 2014; Olsson & Salo, 2011; Rese, Schreiber, & Baier, 2014) and engineering the design of the system (Choi & Choi, 2014). Jung et al. (2015) employed the concept of perceived quality (i.e. AR content quality, system quality, and personalised quality) to examine its influence on AR satisfaction leading to the intention to recommend the system. Chung et al. (2015) proposed a model that combines technology-readiness and adoption with stimuli (visual appeal) and situational factors (facilitating conditions). Other researchers in computer science have focused mainly on the development of specific computing systems or algorithms and assessed the application of the system to contexts of the tourism industry, such as theme parks, museums, historical sites, and city destinations (Casella & Coelho, 2013; Mine, Rose, Yang, van Baar, & Grundhöfer, 2012; Yovcheva et al., 2013). This implies that, while academic attempts to identify the factors motivating adoption behaviours of AR have been conducted widely, the understanding of user experiences with AR is limited. Recognising the high penetration of AR services into everyday life, it is an essential issue to elucidate AR experiences in the travel industry.

Olsson et al. (2013) conducted a comprehensive study to identify expected user experiences regarding interaction with AR services. The findings revealed two categories of user expectations from an AR system: (1) characteristics of experiences including pragmatic or utility-oriented aspects (e.g. efficiency/accomplishment and increased knowledge) and

emotional/hedonic aspects (e.g. captivation, connectedness, creativity, and playfulness/entertainment); and (2) design requirements to facilitate pleasurable experiences, such as interactivity, ease of use, and reactivity (Olsson & Salo, 2011). These characteristics reflecting the expectations of AR systems are consistent with important variables discussed in the TAM (Chung et al., 2015; Jung et al., 2015) and the flow theory (Kim et al., 2014) as well as the concepts of perceived benefits (Leue, Dieck, & Jung, 2014), interactivity (Kim et al., 2014), information quality (Kim et al., 2014), and attitude towards AR (Chung et al., 2015). The following paragraph briefly introduces the various concepts mentioned above.

The TAM, rooted in the theory of reasoned action (Davis, 1989), is a model explaining users' acceptance of IT, which suggests two key beliefs: perceived ease of use and usefulness (Jung et al., 2015). Flow is an important construct for depicting human–computer interactions, referring to the state in which individuals are so highly involved in an activity of using IT that nothing else seems to matter (Nusair & Parsa, 2011). Webster, Trevino, and Ryan (1993) proposed three dimensions of flow in human–computer interactions, namely control, attention, and curiosity. Kim et al. (2014) proposed multiple constructs leading to continuous usage of AR applications, including information quality (the extent to which AR services are correct, reliable, and certified to be free of error) and interactivity (the extent to which individuals can take part in revising the structure and content of a technologically mediated environment in real time). It has been identified that the two elements directly affect the perceived beliefs about AR as well as indirectly influence the continuous intention to use the system. The perceived benefit has been recognised as a critical component to form perceived value against perceived costs in the consumption of services. In the IT field, it has been identified that the perceived benefit, referring to the expected gains when using a technology, influences people's continuous adoption behaviour regarding a new IT (Leue et al., 2014; Park & Huang, 2017). Lastly, the attitude towards IT refers to user's feelings about

IT and has been well recognised as an antecedent to the generation of usage intentions (Chung et al., 2015). Therefore, this research considers those elements that are pertinent to the concepts/theories listed in examining AR experiences.

Regarding the social constructivism of reality, AR is the place associated with a virtual world accessible through the Internet (Gottschalk, 2010). Users create the objects and themes of various types of social spaces that are used for socialising, playing games, and searching for information. This may connote the challenge that not every person can manage the virtual world and gain positive experiences from it (Boostrom Jr, 2008). For example, those who have a personality entailing reluctance to explore new things are likely to have limited knowledge about advanced technology (e.g. AR or VR) and remove themselves from the new environment (Rauschnabel & Ro, 2016). To take this into account, this study applied the concept of a sensation-seeking personality not only to classify users but also to understand heterogeneous user experiences about AR as a travel information source. A detailed discussion about the notion of sensation-seeking and the applicability of the sensation-seeking concept is provided in the following two sections.

Definition of Sensation-Seeking

Sensation-seeking is a biosocial basis of a personality trait associated with genetic (Hur & Bouchard, 1997) and hormonal activities (e.g. dopamine, serotonin, and norepinephrine) (Zuckerman, 2006). From a psychophysiological perspective, the initial notion of sensation-seeking is related to the concept of individual differences concerning the optimal level of arousal (OLA). This implies that people who have high scores of sensation-seeking are likely to pursue more stimulation to reach their OLA (Zuckerman, 1979). In other words, people with higher levels of arousal are more optimistic and facilitative and hence, tend to require stronger stimulation to achieve a level that is perceived as satisfying. It infers

that sensation-seeking reflects the propensity to engage in risk-taking and novelty-seeking behaviours. Hence, high sensation-seekers are likely to have a strong need for varied, novel, and complex sensations and are willing to take physical, legal, and/or financial risks to satisfy their desire for such stimulation (Litvin, 2008; Lu et al., 2014; Zuckerman, 1994).

Given the early understanding of sensation-seeking, marked by a need for novelty and complexity of stimulation, Arnett (1994) focused on intensity of stimulation, denoting the quality of sensation-seeking, and emphasised the role of socialisation in changing any biological and/or genetic propensity for sensation-seeking. He claimed that sensation-seeking is regarded as the trait formed by biological predispositions in interaction with the social environment. Accordingly, sensation-seeking 'is not only a potential for risk-taking but is, more generally, a quality of seeking intensity and novelty in sensory experience, which may be expressed in multiple areas of a person's life (Arnett, 1994, p. 290).

According to Zuckerman's study (1983), there are four dimensions of sensation seeking: (1) experience-seeking (ES), representing the desire to seek experience through the mind and senses, manifested as travel and an unconventional lifestyle; (2) boredom-susceptibility (BS), representing an aversion to invariant repetition and routine, invariant circumstances, and restlessness when things do not change; (3) thrill- and adventure-seeking (TAS), reflecting a desire to engage in risky, impulsive, and adventurous activities involving speed or danger; and (4) disinhibition (Dis), expressing the desire to be socially and sexually disinhibited (see Hoyle et al., 2002; Litvin, 2008; López-Bonilla & López-Bonilla, 2010, 2012). Various studies have examined the associations of sensation-seeking with other personality traits, such as impulsivity, dominance, surgency, and autonomy (Michel et al., 1998; Zuckerman et al., 1978). Sensation-seeking is likely to be related to extraversion (Eysenck & Eysenck, 1975), because individuals with extravert traits appear as assertive, gregarious, excitement-seeking, and emotionally positive (Li & Tsai, 2013; Zuckerman,

1994). According to the travel personality typology proposed by Plog (2002), allocentrics (or adventurers) are closely linked to sensation-seekers who, not only have an internal locus of control and are less anxious but engage in various adventurous activities (Lepp & Gibson, 2008).

Numerous studies have stressed the importance of sensation-seeking to predict and reveal the differences in people's behaviours. For example, sensation-seeking has been found to be correlated positively with a tendency to disclose personal thoughts and feelings, antipathy to structured and formal situations, the tendency to avoid repetition and law-abidance (or the use of illicit drugs) (Hoyle et al., 2002), a tendency towards disinhibition, sexual risk-taking, reactivity to social rules, alcohol use and reckless driving (Hoyle, Fejfar, & Miller, 2000), a liking of intense experiences (Galloway & Lopez, 1999), proneness to boredom under restrained and repetitive situations (Nickerson & Ellis, 1991), a preference for social interactions (Litvin, 2008), and attempts to try novel food under conditions of low arousal (Galloway & Lopez, 1999).

Sensation-Seeking in Travel Behaviours

Tourism scholars show different travel behaviours between high and low sensation-seekers, such as activities in national parks, mountaineering adventures, international travel, wine tourism, casinos, as well as the perception of destination image (Leung & Law, 2010). The consented finding is that high sensation-seekers are likely to have a strong need for varied, novel, and complex experiences. More specifically, Pizam et al. (2002) concluded that travellers with a high score on sensation-seeking prefer to participate in extreme sports, whereas those with a low level of sensation-seeking are likely to visit cultural/heritage attractions, artificial attractions, natural attractions, and watching sporting games. In terms of travel arrangements, high sensation-seekers favour arranging their trips with friends or

themselves, while low sensation seekers tend to travel with tour groups and packaged tours. Consistently, the study by Eachus (2004) revealed that those who score highly on sensation-seeking prefer adventurous experiences and want excitement, night life, and dangerous activities. In other words, those who score higher in sensation-seeking play explorer and drifter roles (Lepp & Gibson, 2008). Therefore, it can be said that high sensation-seeking travellers tend to favour the travel activities that provide them with high levels of stimulation.

Those who are higher in sensation-seeking also have a higher propensity to engage in risky activities (Lepp & Gibson, 2008). This cognitive difference between high and low sensation seekers may explain the different levels and types of participation in travel-related activities. Pizam et al. (2004) proposed an index combining risk-taking and sensation-seeking (i.e. the RSS index) and determined that travellers who have a high RSS index want active, spontaneous, fast-paced, and less comfortable vacations. Further evidence also reveals that sensation-seekers prefer new experiences including exotic international destinations (Li & Tsai, 2013), new casino experiences (Hong & Jang, 2005), meeting new people while travelling (Zuckerman, 1979), mountaineering (Pomfret, 2006), ski jumping, and rock climbing (Breivik, 1996). The studies conducted by Galloway (2002) and Galloway and Lopez (1999) applied a cluster analysis to classify sensation-seeking based on the sensation-seeking scale by Zuckerman (1994). They found that travellers with different levels of sensation-seeking have a variety of different attitudes towards behaviours in national parks. From an information-search perspective, different extents and uses of information sources across the levels of sensation seeking were identified: for example, sensation-seekers are more likely to use brochures and pamphlets as well as recommendations from others but less likely to use park guides (Galloway, 2002). In an online context, high sensation-seekers prefer website features that are quick to access and save time during trip preparation, while low sensation-seekers look for features that allow them to socialise (Stangl, 2009). So far

there is no travel related research examining the impact of sensation-seeking in an AR context.

Sensation-Seeking in Information and Communication Technology

Interestingly, the research investigating individual personality differences, particularly in relation to sensation-seeking in terms of IT experiences, has been quite limited (López-Bonilla & López-Bonilla, 2012). Leung and Law (2010) stated that, while the Internet is a popular communication tool in tourism, a limited number of studies have examined the relationship between human personality traits and website experiences.

Advanced information and communication technology (ICT), such as AR, provides opportunities for high arousal and stimulation (Weisskirch & Murphy, 2004). Lin and Tsai (2002) stated that various online activities can broadly be regarded as global high-tech adventure and a form of sensation-seeking. Thus, it can be argued that sensation-seeking is an appropriate personality trait to understand the heterogeneous experiences of users of IT. A series of studies conducted by López-Bonilla and López-Bonilla (2008, 2010, and 2012) elucidated the applicability of sensation-seeking in such a way as to explain the use of the Internet, perceived innovation, and e-shopping behaviours. Internet users have higher scores in sensation-seeking measured using a brief sensation-seeking scale (BSSS) (Hoyle et al., 2002) than non-Internet users. Those who have purchased products online also score higher than those who use the Internet just to collect information. Among the four dimensions of sensation-seeking mentioned above, experience-seekers appear to be the most relevant when it comes to innovative, technological behaviour (see López-Bonilla & López-Bonilla, 2012). In tourism, Pizam et al. (2004) confirmed that high RSS travellers are more likely to obtain destination information via the Internet and tend to purchase travel products online.

In summary, sensation-seeking is not only an indicator to predict the behaviours of people engaged in sensation-seeking activities but is also involved in high achievement, because the desire for novelty can be expressed as creative, divergent-thinking (Arnett, 1999). Sensation-seeking is linked with individual assessments (or attitudes) of the external information that individuals obtain (Lu et al., 2014). The features of AR, such as connectivity and interactivity, enable people to form an avenue for sensation-seeking. There is evidence that the primary motivations to use AR systems are curiosity about AR and personal traits desiring new experiences that achieve OLA (Olsson & Salo, 2011). Thus, it can be argued that, travellers who appear to have different scores on sensation-seeking may perceive experiences differently when using AR to search for travel-related information.

Methodology

Measurement Development

An online questionnaire consisting of five sections was developed. The first part asked the respondents about their most recent travel behaviours, including types of travel (i.e., sun/beach, alpine/rural, cruise, guided round trip, and other), and past travel experiences (Prebensen & Kleiven, 2006). The next section measured the levels of sensation-seeking using the brief sensation-seeking scale (BSSS) (Hoyle et al., 2002; Litvin, 2008; Lu et al., 2014). While Zuckerman's sensation-seeking scale-V (SSS-V) is comprehensive and inclusive in many respects, it has a number of limitations. The lengthy survey of the SSS-V, containing over 40 survey items, provokes fatigue among respondents. The forced-choice format also poses difficulties for respondents and may create response bias. With regards to the survey contents, a subset of items directly denotes problem behaviours, such as alcohol and drug use, which are not relevant to the context of this study. Some informal words and phrases used in the measurement items are not appropriate and may create measurement

errors in our study (Litvin, 2008; Michel et al., 1998). Hoyle et al. (2002) proposed the BSSS for the tourism field and provided empirical evidence of scale suitability and reliability (Leung & Law, 2010).

To make sure that all participants in the survey actually have experience with an AR application, the researchers asked them to download the Layar application on their mobile phone. Layar (www.layar.com) is the global leader and the most popular player in the AR industry, which encompasses over 10 million installs and 9,000 developers as well as 2,500 individual AR applications (Kounavis, Kasimati, & Zamani, 2012; Layar, 2019). Furthermore, Layar is available for Android, iOS, and Blackberry and thus covers most mobile operating systems (Olsson & Salo, 2011). The request to download and use the app was announced in the invitation message as well as in the third section of the questionnaire.

The AR examples incorporated into the questionnaire were all tourism-related (Figure 2): (1) the AR annotation of the cover page of the New Orleans magazine brought a video about a campaign alive, (2) the tourism destination Grisons in Switzerland offered a postcard that allowed for a 360 degree view using Layar, and (3) Lonely Planet augmented 42 European city guide books (Cameron, 2012); we used the cover page of Rome as an example in which the AR app brought sights alive.

[Please insert Figure 2 here]

In the description the researchers also explained that, even though the way in which the app is used is exactly the same as in this survey setting, to fully understand what the AR app is achieving, one has to be aware that the examples presented are scanned versions of printed documents. This means that, in a non-survey environment, travellers would scan the actual guide book, the postcard, the magazine, and so on. People were asked to try the AR app by scanning at least one of the examples presented. To test potential confounding effects,

there has been insignificant response to the AR experiences according to different themes of AR app used.

Once the respondents had actually used AR, the fourth section of the survey asked about their experiences in terms of the TAM (ease of use, usefulness, and enjoyment) (Chung et al., 2015; Davis, 1989), flow (control, attention, and curiosity) (Landers, Beatty, Wang, & Mothersbaugh, 2015; Webster et al., 1993), perceived benefits (functional, symbolic, and experiential benefits) (Orth et al., 2004), information quality (Lee, Strong, Kahn, & Wang, 2002), interactivity (Wu, 1999), and attitude (Davis, 1989). The last section included demographic questions.

Data Collection

A large pre-test among 88 people was used not only to reveal and eliminate the limitations of the questionnaire, such as spelling errors, grammatical mistakes, and flaws, but also to ensure the feasibility of capturing AR application usage experiences. As AR is an application that is not widely used yet (Goldman Sachs, 2016) and the population of travellers who are interested in using AR is unknown, we used a non-probability technique, namely snowball sampling, to collect data. Atkinson and Flint (2001) argued that the snowball technique has its limitations in terms of being a non-probabilistic method but that these can be addressed by collecting a large sample. In addition, an ascending method, such as snowballing, is useful and appropriate in social contexts and social computing research in which one must locate people on the ground to answer a research question (Bernstein, Ackerman, Chi, & Miller, 2011). Using selected people as a starting point, one can work upwards to collect comprehensive data that allow knowledge gaps to be filled (van Meter, 1998). In summary, one can say that the drawbacks of the snowball technique can be limited by collecting a larger sample, and it is seen as a valid method especially in a social context

and in social computing research. We started by distributing the invitation message to participate in the survey, including the link to the online questionnaire, to a compiled email list of travellers who have a particular interest in information and communication technology. Following the snowball technique, we asked them to forward the invitation to friends and relatives. As a result, in total, 1,042 responses were collected and used in the data analysis.

Data Analysis

This study applied a confirmatory factor analysis using PLS-SEM to check validity (convergent and discriminant validities) and reliability of constructs reflecting AR experiences. Specifically, the authors used cross-loadings of Confirmatory Factor Analysis (CFA), Average Variance Extracted (AVE) with cut-off value over 0.50, and latent correlation analysis (Chin 2010). Then, the basis for assessment of composite reliability was internal consistency reliability with a cut-off level of 0.80 (Chin 2010).

A series of statistical analyses were then used to identify numbers of sensation-seeking clusters. First, the data-driven typology representing network analyses (TRN) (Martinetz & Schulten 1994; Mazanec 2008) applying the neural gas algorithm (Martinetz & Schulten 1991) was used to measure the Euclidian distance. As suggested by Dolnicar (2002), the TRN analyses was repeated 50 times to test for stability of the results. Using the revealed clusters, correspondence analysis was used to test the differences between sensation-seeking groups and types of travel taken in the most recent trip (Park & Kim 2009). Last, a series of Chi-square and analyses of variance (ANOVA) were utilized to compare different demographics and AR experiences across different sensation-seeking clusters.

Results

Profiles of Respondents

There are slightly more female (n = 593; 56.9%) than male (n = 449; 43.1%) in the sample. Around 40% (n = 404) of respondents obtained a university bachelor degree or above. The average age was 25.00 (SD=9.40). Asking their most recent travel behaviours, 40.8% (n = 425) of respondents did a pleasure trip visiting an urban area followed by sun/beach holiday (30.4%), a guided round trip (14.8%), alpine/outdoor (6.7%), cruise (3.5%), and others (3.6%). Respondents, on average, stayed 11.6 nights (SD=14.2).

Estimating Constructs of AR Experiences

As an initial step, we assessed validities and reliabilities of the constructs reflecting AR experiences. To do so, this study applied a confirmatory factor analysis (CFA) to estimate 12 constructs, such as ease of use, enjoyment and usefulness in TAM, control, attention and curiosity in the flow theory, interactivity, functionality, symbolic and experiential benefits in perceived benefit, information quality, and attitudes toward the AR system. Checking the results of PLS-SEM analysis, indicator reliability (or loadings) was confirmed with a cut-off of over 0.65 (Hair, Ringle, & Sarstedt 2011). The factor loadings, reflecting the corresponding constructs, are also higher than the ones with other principal constructs, which confirms discriminant validity. The AVEs are larger than the cross-correlations between the constructs, which suggests that each construct is distinctive from the other constructs (see Table 1). The square root of AVE is over 0.75, which shows that the latent variables account for the variance of indicators more than error. This result confirms convergent validity of the measurement model. Lastly, as shown in Table 1, the composite reliability shows levels (over 0.80) to satisfy tolerable reliability (Hair et al. 2011).

[Please insert Table 1 here]

Psychographic Segmentation with Sensation-Seeking

This section describes how the sensation-seeking clusters were generated by adopting typology-representing network analyses. Specifically, the eight sensation-seeking variables of BSSS (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew 2002) were used to perform a cluster analyses using the TRN32 tool (Mazanec 2008). Based on the weighted Simple Structure Index (wSSI), the reasonableness of cluster sizes and the stability of the results, a four-cluster solution is chosen. The wSSI is at a satisfying level of 0.53 and the uncertainty reduction of 50 replications yields 94.39%, providing evidence for stable results. The authors labelled the segments based on a thorough interpretation of the cluster prototype tables and a comprehensive literature review.

Cluster I is called "High Sensation-Seekers". This segment comprises a third of the sample (n=344, 33.0%). The prototypes presented in Table 2 show that this segment has the highest level of agreement to all items. Cluster II is labelled "Moderate Sensation-Seekers" as they answer in around the mid-range (3-4) to all the items. This was the second largest group (n=305, 29.3%). Cluster III are high experience-seekers (ES), boredom-susceptibility (BS), low thrill/adventure (TAS), and disinhibition-seekers (DS). As they score high in half of the BSSS items and low in the others, we call them "Ambivalent Sensation-Seekers" (n=205, 19.7%). Cluster IV is called "Low Sensation-Seekers" (n=188, 18.0%). Hence, results reveal a continuum of four different sensation-seeking levels ranging from high to low sensation-seekers.

[Please insert Table 2 here]

Comparisons of Sensation-Seeking Clusters in AR Experiences

This section elucidates different demographics as well as AR experiences among the four sensation-seeking groups identified above. Chi-square and ANOVA were conducted to

compare the four sensation seeking-clusters in terms of demographics, such as gender, age, and education (see Table 3). In line with previous studies by López-Bonilla & López-Bonilla (2010), Michel et al. (1999), and Zuckerman (1983), high sensation seeking travellers tend to be male and younger than those who are low sensation-seeking travellers. Slight variations have been observed. For example, high and Ambivalent Sensation-Seekers include relatively higher proportions of those who have high/middle school degrees than other two groups. Within Ambivalent and Low Sensation-Seekers, the subjects who have a doctoral degree appear within the top five education levels.

[Please insert Table 3 here]

Correspondence analysis was employed to visually examine and show the relationship between sensation-seeking clusters and travel types (Chi-square = 36.10 and $p < .01$) (see Figure 2). The horizontal axis (Dimension 1) of travel types accounted for 55.3% and the vertical axis (Dimension 2) of the clusters explained 40.4%. The association of sensation-seeking clusters and travel-types were mostly explained on two dimensions (95.7%). The result shows that Cluster I and III (i.e. High Sensation-Seekers and Ambivalent Sensation-Seekers) appear to have close lineages to alpine and sun/beach activities. While Cluster II (i.e. Moderate Sensation-Seekers) has an association with city visit, Cluster IV (i.e. Low Sensation-Seekers) is close to guided round trips.

[Please insert Figure 3 here]

Table 4 shows AR experiences of the four clusters. ANOVA results confirm that there are significant differences between the clusters concerning AR experiences for ease of use (F-value = 27.00 and $p < 0.001$), enjoyment (F-value = 16.69 and $p < 0.001$), usefulness (F-

value = 16.76 and $p < 0.001$), control (F-value = 16.57 and $p < 0.001$), attention (F-value = 13.41 and $p < 0.001$), curiosity (F-value = 14.48 and $p < 0.001$), functional benefit (F-value = 17.35 and $p < 0.001$), symbolic benefit (F-value = 12.68 and $p < 0.001$), experiential benefit (F-value = 9.99 and $p < 0.001$), interactivity (F-value = 12.50 and $p < 0.001$), information quality (F-value = 10.20 and $p < 0.001$), and attitudes towards AR (F-value = 12.35 and $p < 0.001$). In brief, travellers who score high in sensation-seeking are likely to have more positive experiences when using AR for a travel related search than those who score low. Consistently, Cluster 3 appears to have the lowest mean values on most of the constructs regarding AR experiences.

[Please insert Table 4 here]

Summary of Sensation-Seeking Cluster Profiles

Table 5 provides a summary of the key results containing the profiles of the clusters.

[Please insert Table 5 here]

High Sensation-Seekers (33.0%): Compared to other clusters, a higher proportion of travellers in this group was male (48.8%) and younger (22.5 years). This group tended to travel to visit beaches or engage in alpine activities. In terms of AR experiences, the cluster steadily exhibited the highest satisfactory levels in variables reflecting TAM (ease of use = 2.90; enjoyment = 2.72; usefulness = 2.73), flow theory (control = 2.76; attention = 2.70; curiosity = 2.61), perceived benefits (functional benefit = 2.96; symbolic benefit = 2.31; experiential benefit = 2.59), interactivity (2.62), information quality (2.73) and attitude towards AR (2.93).

Moderate Sensation Seekers (29.3%): While it was slightly less than in Cluster I (High Sensation-Seekers), the proportion of male (48.2%) in this group is larger than the other two clusters. The average age of Moderate Sensation Seekers is 23.3 years, and they are inclined towards visiting urban destination in their recent trips. With regards to AR-usage, travellers assigned to Cluster II reported the second lowest level of satisfactory experiences for ease of use (2.36), usefulness (2.26), flow elements (control = 2.47; attention = 2.29; curiosity = 2.22), experiential benefit (2.21) and interactivity (2.23), whereas the value of symbolic benefit (1.99) was the second highest in all four groups. It is also found that Cluster II (Moderate Sensation Seekers) show the lowest levels of AR experiences for enjoyment (2.20), perceived information quality (2.35), functional benefit (2.50) and attitude towards AR (2.52).

Ambivalent Sensation-Seekers (19.7%): This group was recognised as ES and BS seekers consisting of individual's scoring higher in ES and BS, and lower in TAS and DI. This group comprises 36.6% male respondents and are, on average, 26.3 years old. Similar to Cluster I (High Sensation-Seekers), based on their last trip, this group is likely to look for beach or alpine travel activities. Respondents in this cluster showed the second highest satisfaction levels of AR experiences (i.e., ease of use = 2.66, enjoyment = 2.57; usefulness = 2.56; control = 2.56, attention = 2.54; curiosity = 2.40; functional benefit = 2.86; experiential benefit = 2.34; interactivity = 2.46; information quality = 2.70; attitude = 2.89) except for symbolic benefit. The symbolic benefit was just higher than Cluster IV (Low Sensation Seekers) (1.98).

Low Sensation-Seekers (18.0%): Cluster IV appeared to have the lowest values across all four dimensions of sensation-seeking, thus it was labelled Low Sensation-Seekers. This group

comprised a relatively smaller proportion of male (31.4%) respondents and older people (30.6 years old) than the other three groups. They are likely to have guided round trips. For AR experiences, the Low Sensation-Seekers reported the lowest levels in most AR experience concepts (i.e., ease of use = 2.20, usefulness = 2.18; control = 2.12, attention = 2.17; curiosity = 2.03; symbolic benefit = 1.62; experiential benefit = 2.13; interactivity = 2.19). However, they indicated higher values on enjoyment (2.24), functional benefit (2.56), information quality (2.41) and attitude toward AR (2.60) than Cluster II (Moderate Sensation-Seekers).

Discussion and Implications

With the development of ICTs, AR has become an important information source that seamlessly combines the real world and the virtual environment. This allows travellers to obtain more detailed and real-time information comprising various forms of messages presented in multiple formats (e.g. video and 360 degree), leading to revolutionising the ways of experiencing tourism destinations and services. Recognising the large potential of AR, tourism scholars have focused on examining the adoption (e.g. Chung et al., 2015; Jung et al., 2015) and engineering aspects of AR services (Mora, Boron, & Divitini, 2012). The attempt to understand user experiences of AR in tourism is, however, quite limited. Based on the essential role of personality, which predicts individual preferences, needs, and behaviours (Li & Tsai, 2013), this research applied the sensation-seeking personality to better comprehend user experiences of AR.

The findings of this study identified four clusters of online travellers regarding sensation-seeking: ‘Cluster I (High Sensation-Seekers)’, ‘Cluster II (Moderate Sensation-Seekers)’, ‘Cluster III (Ambivalent Sensation-Seekers)’, and ‘Cluster IV (Low Sensation-Seekers)’. The four sensation-seeking clusters have different demographic profiles: for example, High Sensation Seekers are male and younger (López-Bonilla & López-Bonilla,

2010). In addition, both High Sensation-Seekers and Ambivalent Sensation-Seekers had enjoyed sun/beach and alpine environments on their recent trips. This finding is consistent with Eachus (2004), who concluded that ES is a crucial element of sensation-seeking to predict adventure holiday preferences.

AR is an emerging human–computing platform that provides people with opportunities for high arousal and stimulation (Weisskirch & Murphy, 2004), because a range of virtual objects superimposed onto the actual environment is considered as high-tech adventure (Azuma, 1997; Chou & ChanLin, 2012). In this vein, the results of this study revealed different AR experiences across the four sensation-seeking groups in terms of travel information-seeking behaviours. Cluster I (High Sensation-Seekers) reported the highest positive experiences in all the constructs representing AR experiences. This implies that High Sensation-Seekers are likely to enjoy AR that offers travellers stimulation to reach the optimal levels of arousal associated with a risk-taking and novelty-seeking propensity (Martin, Sherrard, & Wentzel, 2005). This suggests that High Sensation-Seekers may experience a high level of arousal when using AR (Olsson & Salo, 2011; Pizam et al., 2004; Zuckerman, 1979). Cluster III (Ambivalent Sensation-Seekers), to some extent, showed similar AR experience levels to Cluster I (High Sensation-Seekers). This result supports the findings by López-Bonilla and López-Bonilla (2012), who concluded that ES is the most influential element of sensation-seeking to represent innovative behaviour in the use of ICTs.

Furthermore, the BS dimension is of importance in the adoption stage of the Internet, followed by the ES dimension (López-Bonilla & López-Bonilla, 2010). This suggests that ES is the most critical sub-dimension of sensation-seeking to predict not only travel activities but also AR usage behaviours. Comparing Cluster II (Moderate Sensation-Seeking) and Cluster IV (Low Sensation-Seeking), Cluster II generally indicated higher satisfactory experiences when using AR than Cluster IV, except for perceived information quality, functional benefit,

and attitude towards AR. This implies that Cluster IV is more likely to utilise AR as a tool to obtain information about a destination than Cluster II.

This research provides several academic implications. Firstly, to the authors' knowledge, this is the first study to apply a biosocial basis, namely sensation-seeking, to understand IT experiences in tourism. More importantly, the identification of heterogeneous user experiences with exposure to AR across different sensation-seeking clusters contributes to the knowledge base of traditional findings related to personality traits in an ICT context. This is related to a foundation of information system research that infers that finding a good match between travellers' interests and cognitive capability and the offered services is of the utmost importance to enhance technology usability and travel experiences (Gretzel, Hwang, & Fesenmaier, 2012). Accordingly, this paper sheds light on the appropriateness of a sensation-seeking concept to classify travellers and identify different AR experiences. Besides, this research determined that, of the four sub-components of sensation-seeking, ES and BS are key elements to classify the travel groups expecting different travel activities and, particularly, to predict the AR experiences for a specific travel purpose.

From the perspective of practical implications, this research suggests how to develop personalised services offering information and designs for AR systems to match AR applications with the different needs of sensation-seekers. Tourists tend to decide to visit a specific destination when the promotional information regarding that destination matches their travel motivation (Baloglu & Uysal, 1996). For example, tourism marketers need to offer information about adventure and activities at destinations to High Sensation-Seekers and high ES and BS travellers. Conversely, it is suggested that Moderate Sensation Seekers should be provided with information about city destinations and Low Sensation Seekers information about multi-destination trips.

Regarding AR design, marketers can highlight distinctive features of AR to High Sensation-Seekers who want to explore novel experiences and optimise arousal levels with innovative stimuli. While a similar approach can be applied to high ES and BS travellers, it is recommended to focus less on symbolic (or social) benefits for this specific group. For Low Sensation-Seekers, online marketers should stress AR applications that provide detailed and instantaneous information.

Limitations and Future Research

There are several limitations to this research. First, the subjects of this study were relatively young; thus, we analysed a group that is relatively more familiar with the specific technological systems. Hence, future research extending the range of the age distribution of the research participants is suggested. The focus of this research was on the pre-travel stage, investigating how people use AR to obtain virtual information about a destination. The tourism literature has suggested heterogeneous information needs and motivations across different stages of travel planning (Hwang & Park, 2015). Accordingly, understanding AR experiences during the trip and/or in the post-trip phase is an important topic for future research. Lastly, this study used the sensation-seeking personality trait to comprehend user experiences of AR. Based on reviews of personality research in tourism (see Leung & Law, 2010), other personality concepts (e.g. the big five) are suggested for consideration.

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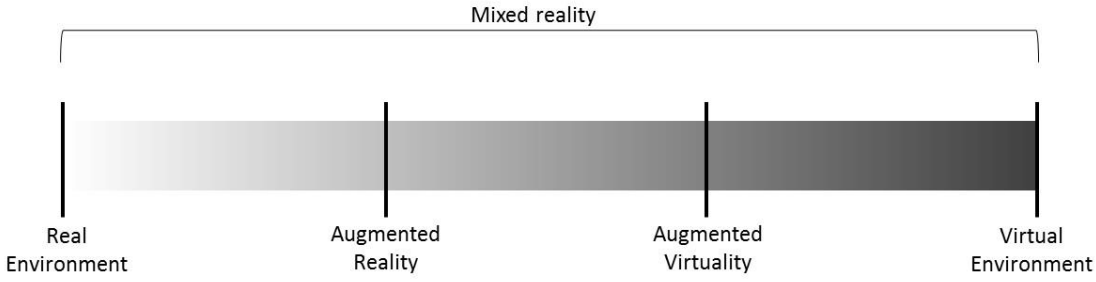
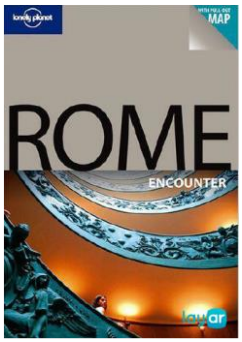


Adopted: Milgram and Kishino (1994)

Figure 1. Virtuality Continuum

1st page of the "Best of New Orleans" Magazine[1]	Postcard of Grisons, Switzerland[2]	Cover page of the Lonely Planet guide book of Rome[3]
		

[1] Using the Layar app "Tallulah — a certified therapy dog that was once adopted from the Louisiana SPCA (the Best of New Orleans 2013 best non-profit winner) — traveled from one location to the next interacting with some of the Best of New Orleans winners" (https://bit.ly/2vUAmWO, last accessed 28.04.2018) .
[2] With Layer one can turn 360 degree showing not only the view on the postcard itself but also the view all the way around from where the picture of the postcard was taken (by My Switzerland).
[3] Lonely Planet augments 42 European city guides showing live weather, city tour videos, updated event listings, hotel prices and availability. In our study we used the cover page of Rome.

Figure 2. Examples of AR Annotated Print Media Used in the Study

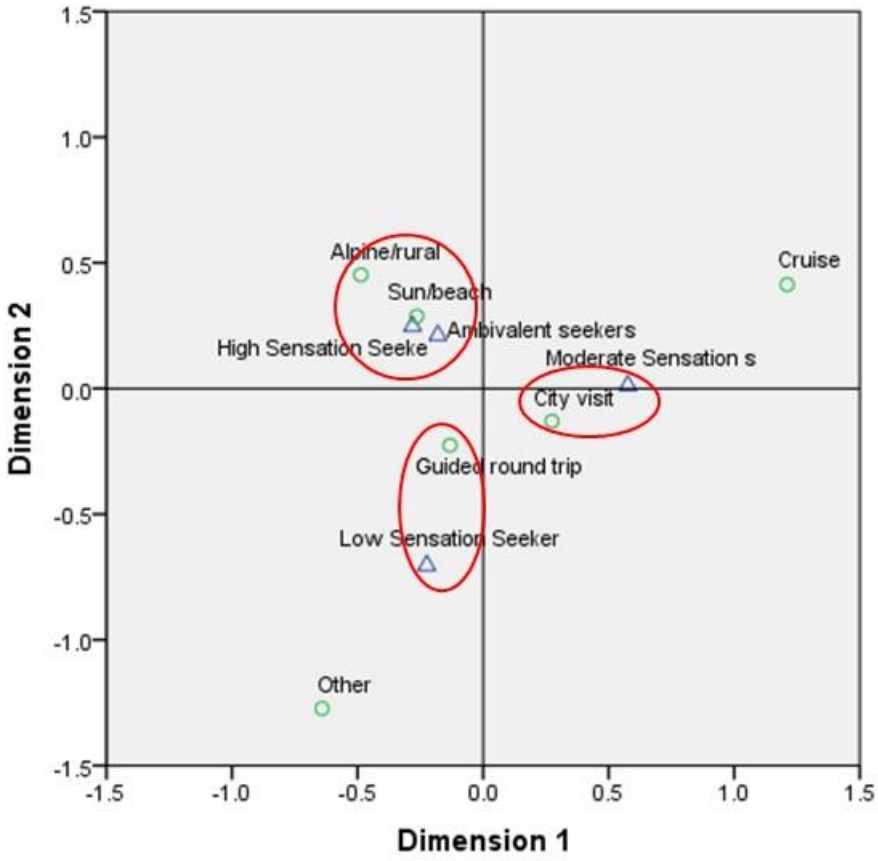


Figure 3. Correspondence Analysis between Travel Types and Sensation Seeking Clusters

Table 1. Discriminant Validity

	Cronbach α	Composite Reliability	1	2	3	4	5	6	7	8	9	10	11	12
1. Ease of Use	0.916	0.941	**0.894**											
2. Enjoy	0.896	0.928	0.714	**0.873**										
3. Usefulness	0.893	0.933	0.735	0.750	**0.908**									
4. Control	0.859	0.934	0.670	0.577	0.611	**0.936**								
5. Attention	0.858	0.934	0.608	0.638	0.629	0.712	**0.936**							
6. Curiosity	0.840	0.904	0.568	0.676	0.623	0.671	0.779	**0.870**						
7. Interactivity	0.837	0.892	0.598	0.647	0.652	0.667	0.676	0.716	**0.823**					
8. Functional benefit	0.878	0.925	0.642	0.620	0.639	0.680	0.639	0.630	0.721	**0.897**				
9. Symbolic benefit	0.902	0.939	0.475	0.549	0.508	0.604	0.620	0.687	0.691	0.547	**0.914**			
10. Experiential benefit	0.857	0.913	0.565	0.670	0.620	0.619	0.673	0.740	0.804	0.659	0.778	**0.882**		
11. Attitude	0.886	0.929	0.628	0.642	0.640	0.667	0.649	0.683	0.696	0.734	0.555	0.711	**0.902**	
12. Information quality	0.883	0.928	0.567	0.627	0.635	0.632	0.636	0.666	0.707	0.684	0.568	0.690	0.831	**0.900**

Note: Items on the diagonal (in bold) represent AVE scores

Table 2. Prototype Table of the Cluster Results Based on Sensation Seeking

	Sensation Seekers			
	High	Moderate	Ambivalent	Low
	Cluster I (33.0%)	Cluster II (29.3%)	Cluster III (19.7%)	Cluster IV (18.0%)
ES 1: I would like to explore new places.	4.67	3.55	4.7	3.58
ES 2: I would like to take off on a trip with no pre-planned routes or timetables.	4.04	2.3	4.03	1.02
BS 1: I get restless when I spend too much time at home.	4.04	2.38	3.95	2.14
BS 2: I prefer friends who are excitingly unpredictable.	4.06	2.79	3.45	1.59
TAS 1: I like to do frightening things.	3.93	2.62	1.99	0.69
TAS 2: I would like to try bungee jumping.	4.06	3.06	1.68	0.8
DS 1: I like wild parties.	3.96	2.95	2.07	1.09
DS 2: I would love to have new and exciting experiences, even if they are illegal.	3.75	2.32	1.19	0.59

Note: ES refers to experience seeking, BS refers to boredom susceptibility, TAS refers to thrill and adventure seeking, and DS refers to disinhibition seeking.

Table 3. Comparing Demographics between Sensation Seeking Clusters

	Cluster I (n = 344 33.0%)	Cluster II (n = 305 29.3%)	Cluster III (n = 205 19.7%)	Cluster IV (n = 188 18.0%)	Statistics
Female Male	176 (51.2%) 168 (48.8%)	158 (51.8%) 147 (48.2%)	130 (63.4%) 75 (36.6%)	129 (68.6%) 59 (31.4%)	Chi-square = 21.92***
Age	22.54[a] (5.75)[b]	23.34 (6.60)	26.34 (10.71)	30.62 (13.63)	F-value = 38.52***
Top five most frequent education	High/middle school (42.2%) Bachelor degree (34.6%) Master's degree (9.6%) Technical college (6.1%) Elementary/ primary school (2.9%)	Bachelor degree (42.1%) High/middle school (34.5%) Technical college (6.9%) Master's degree (6.9%) Vocational school (2.6%)	High/middle school (43.4%) Bachelor degree (32.7%) Master's degree (12.7%) Technical college (7.8%) Doctorate (1.5%)	Bachelor degree (36.4%) High/middle school (34.8%) Master's degree (12.8%) Technical college (9.1%) Doctorate (2.1%)	Chi-square = 35.40*

Note: *** p value < 0.001; *p value < 0.05"a" refers to mean values; "b" refers to standard deviation.

Table 4. Differences of AR Experiences between Sensation Seeking Groups

	Cluster I (n = 344 33.0%)	Cluster II (n = 305 29.3%)	Cluster III (n = 205 19.7%)	Cluster IV (n = 188 18.0%)	F-value
TAM					
Ease of Use	2.90[ac]	2.36[ad]	2.66[df]	2.20[cf]	27.00***
Enjoyment	2.72[ac]	2.20[ad]	2.57[df]	2.24[cf]	16.69***
Usefulness	2.73[ac]	2.26[ad]	2.56[df]	2.18[cf]	16.76***
Flow					
Control	2.76[ac]	2.47[ae]	2.56[f]	2.12[cef]	16.57***
Attention	2.70[ac]	2.29[a]	2.54[f]	2.17[cf]	13.41***
Curiosity	2.61[ac]	2.22[a]	2.40[f]	2.03[cf]	14.48***
Benefits					
Functional benefit	2.96[ac]	2.50[ad]	2.86[df]	2.56[cf]	17.35***
Symbolic benefit	2.31[abc]	1.99[ae]	1.98[bf]	1.62[cef]	12.68***
Experiential benefit	2.59[ac]	2.21[a]	2.34	2.13[c]	9.99***
Interactivity	2.62[ac]	2.23[a]	2.46	2.19[c]	12.50***
Information quality	2.73[ac]	2.35[ad]	2.70[df]	2.41[cf]	10.20***
Attitude toward AR	2.93[ac]	2.52[ad]	2.89[df]	2.60[cf]	12.35***

Note: ANOVA was used to compare the mean differences; *** p value < 0.001. Scheffe's post-hoc analysis was used to compare mean differences between clusters; In the following superscripts: a = the comparison between Cluster I and Custer II; b = the comparison between Cluster I and Cluster III; c = the comparison between Cluster I and Cluster IV; d = the comparison between Cluster II and Cluster III; e = the comparison between Cluster II and Cluster IV; f = the comparison between Cluster III and Cluster IV.

Table 5. Summary of Sensation Seeking Cluster Profiles

	Cluster I "High sensation seekers" (n = 344, 33.0%)	Cluster II "Moderate sensation seekers" (n = 305, 29.3%)	Cluster III "Ambivalent seekers" (n = 205, 19.7%)	Cluster IV "Low sensation seekers" (n = 188, 18.0%)
Gender	48.8% of male	48.2% of male	36.6% of male	31.4% of male
Age	22.5 years old	23.3 years old	26.34 years old	30.62 years old
Travel types	Sun/beach or Alpine	City visit	Sun/beach or Alpine	Guided-round trip
AR experiences	• The most satisfied experiences when using AR	• Somehow satisfied for symbolic benefit • Not very satisfied in rest of AR experiences (ease of use, usefulness, Flow, experiential benefit, and interactivity) • The least joyful, perceived information quality, functional benefit and attitude towards AR	• Somehow satisfied in AR experiences: • But, not very satisfied in symbolic benefit	• Somehow satisfied in enjoyment, functional benefit, information quality and attitude toward AR • The least satisfied in rest of AR experiences

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