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The impact of virtual, augmented and mixed reality technologies on the customer experience

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ABSTRACT

The arrival of Virtual-Reality, Augmented-Reality, and Mixed-Reality technologies is shaping a new environment where physical and virtual objects are integrated at different levels. Due to the development of portable and embodied devices, together with highly interactive, physical-virtual connections, the customer experience landscape is evolving into new types of hybrid experiences. However, the boundaries between these new realities, technologies and experiences have not yet been clearly established by researchers and practitioners. This paper aims to offer a better understanding of these concepts and integrate technological (embodiment), psychological (presence), and behavioral (interactivity) perspectives to propose a new taxonomy of technologies, namely the "EPI Cube". The cube allows academics and managers to classify all technologies, current and potential, which might support or empower customer experiences, but can also produce new experiences along the customer journey. The paper concludes with theoretical and managerial implications, as well as a future research agenda.

1. Introduction

Recent technological developments are changing the ways people experience the physical and the virtual environments. Specifically, Virtual Reality (VR) is likely to play a key role in several industries (Berg & Vance, 2016), such as retail (Bonetti, Warnaby, & Quinn, 2018; Van Kerrebroeck, Brengman, & Willems, 2017a), tourism (Griffin et al., 2017), education (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014), healthcare (Freeman et al., 2017), entertainment (Lin, Wu, & Tao, 2017) and research (Bigné, Llinares, & Torrecilla, 2016; Meißner, Pfeiffer, Pfeiffer, & Oppewal, 2017). Recent reports show that sales of VR Head-Mounted Displays (HMD) have, for the first time, exceeded one million in a quarter (Canalys, 2017); the value of VR devices sold is expected to increase from US$1.5 billion in 2017 to US $9.1 billion by 2021 (CCSInsight, 2017); importantly, younger generations (Y and Z) are the most interested in VR technology (Greenlight, 2015). Upcoming releases of standalone VR HMD (e.g., Oculus GO, HTC Vive Focus; FastCompany, 2018), together with the declining prices of these devices, can hugely increase the future usage of VR (Canalys, 2017). In addition to VR, Augmented Reality (AR) and Mixed Reality (MR) are ranked in the top 10 strategic trends for 2018 (Gartner, 2017). Sales of these technologies in 2020 are forecasted to be 21 times higher than in 2016 (from US$2.9 billion to US$61.3 billion; Superdata Research, 2017). These data support the positive expectations about the future of these technologies.

Within the marketing discipline, these reality-virtuality Information and Communication Technologies (ICTs) can significantly affect the customer experience, defined as the "customer's cognitive, emotional, behavioral, sensorial, and social responses to a firm's offerings during the customer's entire purchase journey" (Lemon & Verhoef, 2016; p. 71). Customers have different contact points (touchpoints) with companies in multiple phases of their decision-making (before, during and after consumption), and these sensory, affective, behavioral and intellectual sub-experiences form the fundamental customer shopping experience (Brakus, Schmitt, & Zarantonello, 2009). Managing the customer experience is paramount for businesses (Accenture, 2015; Rawson, Duncan, & Jones, 2013; Teixeira et al., 2012) and encompasses several marketing functions (e.g. brand management, market research, promotion and advertising; Barnes, 2016). The integration of technology is especially important since companies are able to provide their customers with added value propositions to generate optimal customer experiences with the combination of virtual-physical touchpoints (Breidbach, Brodie, & Hollebeek, 2014; Kumar, Dixit, Javalgi, & Dass, 2016; Patrício, Fisk, & Falcão e Cunha, 2008). In this way, the use of reality-virtuality technologies allows consumers to have a more dynamic and autonomous role in their experiences (Ostrom, Parasuraman,

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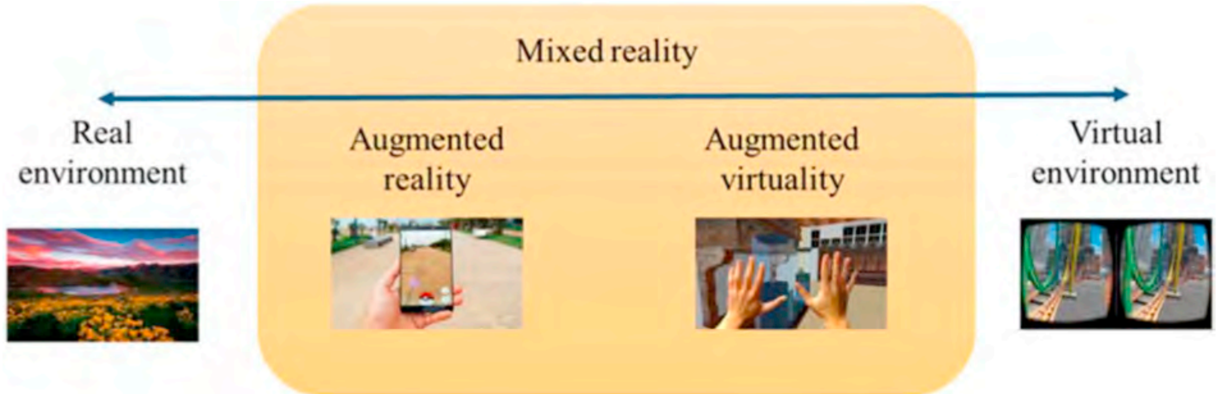


Fig. 1. Reality-virtuality continuum (Milgram & Kishino, 1994).

Bowen, Patricio, & Voss, 2015), leading to higher perceptions of value (Patrício, Fisk, Falcão e Cunha, & Constantine, 2011). Therefore, several consumer-end industries (e.g. retailing, tourism, fashion, entertainment, automotive, services) can provide their customers with improved experiences by using these cutting-edge, reality-virtuality technologies. For example, in pre-purchase situations, the consumer may foresee how their living room would look with new decoration - or to "try on" clothes before going to a store - with AR applications, or anticipate the experience of riding a roller coaster with a VR HMD. During consumption situations, consumers might use VR devices to study the wine making process during a wine-tasting session. Or they might look at real-time GPS information on their windshields while driving, thanks to AR developments. In the post-purchase stage of the journey, the consumer might receive immediate assistance as to how to repair a washing machine, using MR glasses, or create a 360-degree VR video about a recently taken trip.

Despite their potential, the boundaries between different realities (virtual, augmented, mixed) have not been properly defined in the literature, and there seems to be no consensus in practitioners' use of these terms when developing and releasing new devices (PCWorld, 2017). Similar to other cutting-edge technologies (e.g. AI), theoretical confusions exist about what these technologies mean for the marketing field. Therefore, it is necessary to provide guidance to researchers and practitioners to develop this emerging research area (Kumar et al., 2016). In this regard, the "Reality-Virtuality continuum", proposed by Milgram and Kishino (1994), has served for more than two decades as the reference framework for classifying the different realities (Jeon & Choi, 2009; Mann, 2002; Schnabel, Wang, Seichter, & Kvan, 2007). However, several authors note the inconsistency in the use of the terms describing the different realities (Jeon & Choi, 2009; Yung & Khoo-Lattimore, 2017). In addition, recent developments cast doubts on what VR, AR, and MR really mean for both researchers and practitioners.

This study contributes to the literature by examining the role of reality-virtuality technologies and their application during the customer experience. Firstly, this research reviews previous proposals and clarifies some terminological misconceptions in an attempt to establish clear limits and standardize the use of the terms describing the different realities. With this goal in mind, we revise and extend the "Reality-Virtuality continuum" (Milgram & Kishino, 1994), to help academics and practitioners to select the appropriate term for each reality (virtual, augmented or mixed). Secondly, we integrate different disciplines related to ICT and to customer experience (technological, psychological and behavioral) to propose a three-dimensional cube which can classify all the current and potential new reality-virtuality technologies. This proposal will help to increase the understanding of the impact of these technologies on the customer experience. It can also help managers to decide which is the most appropriate technology with which to design more valuable customer journeys. Finally, we outline how reality-virtuality technologies can alter customer experiences at different company-customer touchpoints by supporting, empowering or creating new experiences. These guidelines can help companies create better and more memorable experiences and to provide their customers with added value propositions during the different stages of their purchase journey. The paper concludes with a series of implications and offers a future research agenda.

2. From reality to virtuality: review of concepts and realities

Following Paré, Trudel, Jaana, and Kitsiou (2015), a critical review was conducted with the aim of critically analyzing previous studies that classified realities to reveal weaknesses, inconsistencies or contradictions. This methodology highlights problems or disparities in the existing knowledge about a particular area, to constructively inform and provide an appropriate focus and direction for future studies. We conducted literature searches with keywords ("virtual reality", "augmented reality", "mixed reality", "reality", "virtuality" and "taxonomy", "classification") in four databases (ScienceDirect, Scopus, Web of Science, Google Scholar) to identify studies which classified the different realities. We discovered that the previous research had barely addressed the categorization of the different realities, in spite of the need for studies to classify and clarify these terminological issues (Yung & Khoo-Lattimore, 2017). As stated in previous literature (Jeon & Choi, 2009; PCWorld, 2017; Yung & Khoo-Lattimore, 2017), there is a lack of consistency in the use of these terms in both the academic and professional fields. Our proposal aims to address this issue by extending previous classifications to delineate the realities.

Among all the revised taxonomies, the "Reality-Virtuality Continuum" proposed by Milgram and Kishino (1994), has been the starting point for researchers to classify the wide variety of realities. This classification ranges from real to virtual environments at the extremes of the continuum (Fig. 1). Real Environments (RE) encompass the reality itself. This includes direct or indirect (through a video display) views of a real scene (Milgram & Kishino, 1994). Virtual Environments (VE) are completely computer-generated environments in which objects that do not actually exist are "displayed" on a device and where users interact in real-time through a technological interface. Within this category, Virtual Worlds (VW; e.g. Second Life), are continuous virtual environments, open 24/7, which enable users to be represented by avatars so as to create, play and interact in real time with other avatars (Penfold, 2009; Schroeder, 2008). Virtual Reality (VR) is a computer-generated environment where the user can navigate and interact, triggering real-time simulation of his or her senses (Guttentag, 2010), providing a sensory immersive experience.

The authors state that, as we move to the right of the continuum, there is an increase in the degree of computer-generated stimuli. The existing realities between these extremes were termed Mixed Reality

(MR) environments. Thus, MR was conceived as the different points of the continuum at which real and virtual objects were merged (Milgram & Kishino, 1994; Pan, Cheok, Yang, Zhu, & Shi, 2006; Tamura, Yamamoto, & Katayama, 2001). Consequently, Augmented Reality (AR) and Augmented Virtuality (AV) are part of MR (Fig. 1). On the one hand, AR modifies the user's actual physical surroundings by overlaying virtual elements (images, videos, virtual items; Azuma, 1997; Javornik, 2016; van Krevelen & Poelman, 2010; Yim, Chu, & Sauer, 2017). The explosion in popularity of AR, thanks to the videogame Pokémon Go, has attracted worldwide attention (Rauschnabel, Rossmann, & tom Dieck, 2017), which highlights its potential to offer memorable experiences to the customer (Jung, Chung, & Leue, 2015; Yaoyuneyong, Foster, Johnson, & Johnson, 2016). Less explored is AV, which superimposes real-world elements on virtual environments (Regenbrecht et al., 2004; Tamura et al., 2001).

Other taxonomies have extended Milgram and Kishino's (1994) continuum, and describe new realities that have appeared with the advent of more sophisticated technologies. Mann (2002) added the concept of mediation to the continuum. Mediation is the effect by which some devices are able to modify (not superimpose information) real or virtual environments by altering sensory inputs. In his “reality, virtuality, mediality” taxonomy, four realities are proposed: augmented reality, augmented virtuality, mediated reality and mediated virtuality. Schnabel et al. (2007) incorporated new dimensions into the “Reality-Virtuality Continuum”: amplified reality (where an amplified object can control the flow of information), mediated reality (Mann, 2002) and virtualized reality (similar to 360-degree videos). Jeon and Choi (2009) also added a new sensory dimension to Milgram and Kishino's (1994) proposals, related to sense of touch (degree of virtuality in touch). Their “visuo-haptic reality-virtuality continuum” encompasses nine environments ranging from the real world (visual and haptic reality) to interactive virtual simulators (visual and haptic virtuality).

However, previous categorizations built upon the reality-virtuality continuum show limitations as technologies evolve to generate different realities. Mann's (2002) “mediality” proposal consists of accidentally altering the user's sensory experience (either real or virtual), and AR and AV are still included within MR. Schnabel et al. (2007), also based on Mann (2002), add dimensions which are not actually applied in current technologies (e.g., amplified and mediated realities). In addition, technological developments affirm a clear practical difference between AR, AV and MR; thus, they should be treated separately. Finally, although the sensory component in Jeon and Choi (2009) may be useful in classifying technological devices, realities and experiences are multisensory and should not be considered as a sum of different, isolated senses.

As stated before, Milgram and Kishino's (1994) view of MR included any plane where real and virtual elements were presented together in a single display, thus considering AR and AV as part of MR. Jeon and Choi (2009) also noted that the terms AR and MR have been used interchangeably in the literature and Yung and Khoo-Lattimore (2017) draw the attention to clearly delineate the terminology related to VR/AR to avoid current confusions. In the ICT industry, recent launches have been labeled as MR (such as Windows Mixed Reality), but users are placed in a completely digital world, which is the main feature of VR (PCWorld, 2017).

Therefore, there is a need to set clear boundaries between the realities that current technologies are able to create; particularly those concerning MR. MR must no longer be the broad part of the continuum that includes AR and AV, as noted by Milgram and Kishino (1994). It should be regarded as an independent dimension falling between AR and AV and characterized by the total blend of virtual holograms with the real world. Thus, we adjust the Reality-Virtuality Continuum proposed by Milgram and Kishino (1994) by differentiating the independent dimension of “Pure Mixed Reality” (PMR) (Fig. 2). The differences between the realities are reflected in Table 1.

Virtual content in PMR is not superimposed on the physical environment (as in AR) but virtual objects are rendered so that they are indistinguishable from the physical world. Visual coherence is a basic element of pure mixed reality (Collins, Regenbrecht, & Langlotz, 2017). Users can interact with both virtual and real objects in real-time and, simultaneously, these objects can interact with each other. This “environment awareness” implies that not only virtual objects can act in the real environment, but real objects can also modify the virtual elements, regardless of where the experience is taking place. For instance, in a pure MR, users would not be able to see a virtual box under a table unless they bent down to look at it; in an AR, the box would be overlaid and it would be unnecessary to bend down. Currently, the only technological developments that can truly be considered to be generating pure mixed realities are the holographic devices Microsoft Hololens (https://goo.gl/QNrvm1) and the upcoming Magic Leap (https://goo.gl/8HJfMZ), which integrate virtual and real objects in a real-time display.

In the light of the previous discussion, we now summarize the different realities of the continuum. The Real Environment is an actual setting where users interact solely with elements of the real world, whereas Virtual Environment is a completely computer-generated environment where users can interact solely with virtual objects in real-time. Between these extremes, we found technology-mediated realities where physical and virtual worlds are integrated at different levels. Augmented Reality (AR) is characterized by digital content superimposed on the users' real surroundings; Augmented Virtuality involves real content superimposed on the user's virtual environment. Finally, in Pure Mixed Reality (PMR), users are placed in the real world and digital content is totally integrated into their surroundings, so that they can interact with both digital and real contents, and these elements can also interact.

Our proposal attempts to provide a clear classification system to standardize the terms used to describe the realities, which could be useful to maximize the benefits derived from operating with them. Recent technological advances which integrate physical and virtual elements at different levels have changed conceptions about the realities. Our proposal creates a pragmatic taxonomy whereby all current and future technologies would always fall within one or other of the proposed reality categories.

3. Toward a new categorization of reality-virtuality technologies

Once the boundaries among realities have been established, our second goal is to classify the wide variety of associated technologies. Dix (2017) extended the concept of human-computer interaction, stating that Human-Technology Interaction (HTI) is the knowledge area focused on the process in which technologies and humans are the main agents, through carrying out actions, that take part in the interaction. Following this approach, our classification of technologies is based on three factors directly related to HTI: a technological factor (embodiment), a human dimension (presence), and a behavioral factor derived from the interaction between technology and the human (interactivity). Next, we discuss these factors to classify all the existing technologies.

3.1. Embodiment as the technological factor

Recent technological developments have changed the HTI process. Some of these cutting-edge technological devices are not only smaller and portable, they are also wearable (tom Dieck, Jung, & Han, 2016; Tussyadiah, Jung, & tom Dieck, 2017) and, in some cases, are integrated into the human body. These technologies are included in the users' personal space to improve their experiences and extend their sensory, cognitive and motor functions (Ihde, 1990). In his theory of human-technology mediation, Ihde (1990) regarded embodiment as situations in which technological devices mediate the users' experience and, as a consequence, the technology becomes an extension of the human body and helps to interpret, perceive and interact with one's

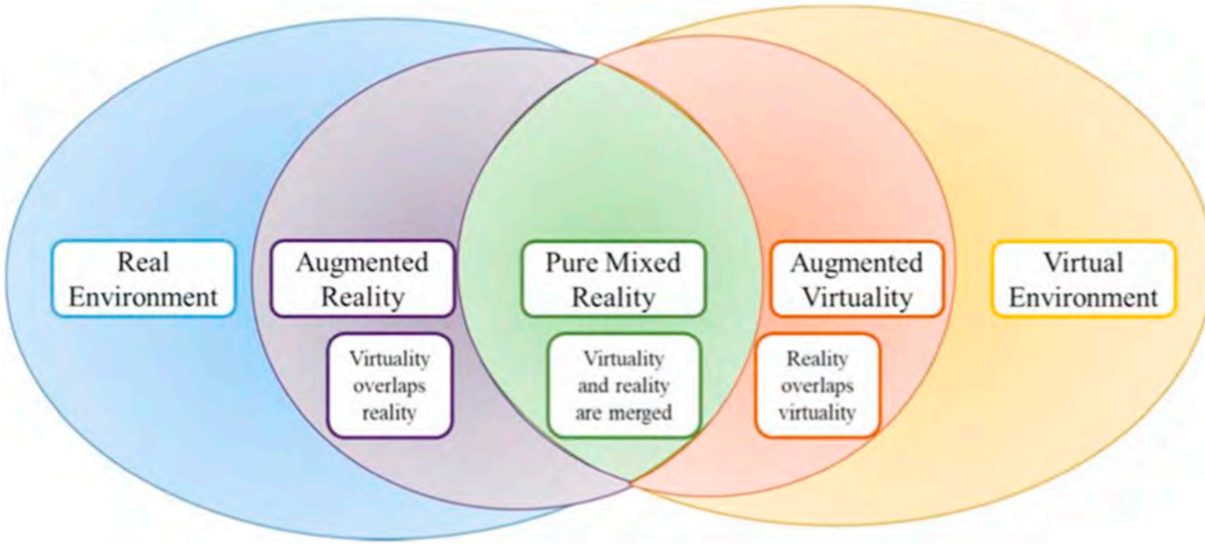


Fig. 2. Proposed reality-virtuality continuum.

immediate surroundings.

The maximum level of technological embodiment can generate a human-technology symbiosis, leading users to a state where the technology is an unnoticeable part of their bodies. Both ownership (feeling that the technological tool belongs to the body) and location (coincidence between the placement of the technological device and its equivalent in the body) are essential elements to explain this state of disappearance of the technology (Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008). As embodiment increases, the technology becomes part of the user's actions (e.g., information visually displayed is considered as their own vision) and improves their capacities (perceptual skills: vision, etc.).

Embodiment has been recently related to user experiences with wearable computing (Tussyadiah, 2014; Tussyadiah et al., 2017). Current technologies are increasing the user's sense of integration between the body and the devices. Therefore, technological embodiment plays a key role in creating immersive experiences due to its ability to involve the human senses (Biocca, 1997). Immersion allows users to better focus on what is in front of them and extend their perception of time, which may result in positive effects on satisfaction with the experience (Rudd, Vohs, & Aaker, 2012). For instance, fully immersive VR equipment offers a sense of embodiment since users see themselves as components of the virtual environment, feeling that the VR devices (HMD, gloves, etc.) belong to their own bodies (Shin, 2017). Other artifacts, such as AR and PMR glasses, are expected to revolutionize consumers' behavior by extending their perceptual body, adapting the technological capabilities to the users' skills (Tussyadiah, 2014). Accordingly, technological embodiment involves the integration of the technological devices into the human body and this, as a consequence, will serve to extend the participants' natural abilities by enhancing their motor and perceptual skills, improving their experiences (Tussyadiah et al., 2017).

The National Research Council (2012) regarded cognitive artifacts as the technological systems that serve to complement and improve users' cognitive abilities. They created a taxonomy based on two dimensions: the "reality-virtuality continuum" (Milgram & Kishino, 1994) and the "mobility continuum". This mobility continuum is related to the degree of integration of the device into the human body (i.e. embodiment). Different levels were proposed, ranging from minimum or no embodiment (e.g. stationary external devices such as desktop computers) to full integration, devices which are implanted in the body (such as microchips or smart contact lenses). At intermediate levels, we may find portable external devices (e.g., mobile phones) and more advanced tools between portable and implanted devices, which are commonly regarded as wearables (e.g., HMD) (Tussyadiah et al., 2017).

In sum, our proposal classifies technological devices according to their degree of embodiment, that is, the degree of contact with the senses (see Fig. 3): *internal devices* are fitted into the human body (wearables and implanted devices) and *external devices* are unintegrated in the human body (stationary and portable external devices). Technological embodiment encompasses two important factors discussed in the ICT literature: immersion (Biocca, 1997; Shin, 2017) and sensory stimulation (Biocca, 1997; Tussyadiah, 2014). Higher levels of technological embodiment create a sensation of closeness between the technology and the senses and generate more immersive experiences. Companies must consider the degree of technological embodiment that might be incorporated into their customers' experiences.

3.2. Presence as the human factor

Presence is defined as the user's sensation of being transported to a distinct environment outside the real human body (Biocca, 1997). For this research, presence is regarded as a psychological stage (not related to a specific technology) and the medium is simply the way to arrive at that stage (Thornson, Goldiez, & Le, 2009). Presence can be triggered by reading a book, listening to a song, watching a movie or playing a videogame (Coelho, Tichon, Hine, Wallis, & Riva, 2006). Although the medium is relevant in inducing presence, the user's psychological interpretation of what is in front of him/her is key to developing a sense of presence (Baños et al., 2004). This psychological approach has been previously adopted in the literature (Heeter, 1992; Lee, 2004; Lombard & Ditton, 1997). Lombard and Ditton (1997) stated that perceptual presence has a subjective nature, given that it depends on different sensory, cognitive and affective processes. Presence is related to transportation (Biocca, 1997) in the sense that users' consciousness is being transported to an alternative place, completely different from where they actually are, and they feel and act as if they were in a real place (Sanchez-Vives & Slater, 2005).

Thus, we concur with previous research and consider the technological quality of the media as immersion (as a part of technological embodiment) and the psychological perception of the user as the sense of presence (Slater, 2003; Thornson et al., 2009). In this way, media characteristics are antecedents of presence (Coelho et al., 2006). For instance, presence can be provoked by a sensation of "place illusion" generated inside a virtual environment (Slater, 2009). VR systems can generate responses in the virtual world regarding users' positions and

Table 1
Summary of differences between the reality-virtuality realities.

	Real Environment (RE)	Augmented Reality (AR)	Pure Mixed Reality (PMR)	Augmented Virtuality (AV)	Virtual Environment (VE)
The main environment is the virtual world (V) or the real (R) world.	R	R	R	V	V
Users interact with the virtual (V), real (R) or both (R-V) worlds in real time.	R	R-V	R-V	R-V	V
Digital content is superimposed on the real environment.	–	√	–	–	–
Real content is superimposed on the virtual environment.	–	–	–	√	–
Digital content is merged into the real world so that both digital and real content can interact in real-time.	–	–	√	–	–

actions (tracking), show images, synchronize audio, and provide haptic information, depending on their location and orientation (Sherman & Craig, 2003).

Our proposal regards perceptual presence as a continuum ranging from the sense of being in the actual location to the sense of being elsewhere. At this point, we must note different presence sub-continuums depending on the level of technological embodiment of the devices (see Fig. 4). As previously stated, immersion is an antecedent of presence, and is dependent on the technology's capabilities. Thus, internal and external devices can generate different levels of immersion (Slater, 2009). Specifically, internal devices can transport and immerse users into distant locations (virtual or physical, real or digital) to a greater extent than external devices, due to their highly immersive capacity and to their sensory attachment. External devices (e.g., computer screens, smartphones) set boundaries between the physical and virtual world due to their interfaces and they require users to make an extra mental effort to feel themselves elsewhere. The content displayed in these devices has to be immersive and engaging enough to increase the sense of presence in that location by decreasing the users' awareness of their surroundings (Takatalo, Häkkinen, Kaistinen, & Nyman, 2010). Therefore, although low levels of presence (the feeling of “being here”) can be perceived by both internally and externally embodied technologies, the high level of presence (“being elsewhere”) can be much greater with internal than with external devices.

3.3. Interactivity as the behavioral factor

For the present research, interactivity is defined as the users' capacity to modify and receive feedback to their actions in the reality where the experience is taking place (Carrozzino & Bergamasco, 2010; Muhanna, 2015). We focus on what Hoffman and Novak (1996) called human-machine interactivity, where the participants interact with the mediated environment, which responds according to their actions. Steuer (1992) described interactivity as the “extent to which users can participate in modifying the form and content of a mediated environment in real time” (p. 14). Thus, interactivity is a behavioral factor in that users have the ability to control and manipulate the environment that is in front of them (Sohn, 2011).

This behavioral approach regards interactivity as a dynamic process based on the interaction between two main agents: users and technologies. Consequently, this perspective implies the integration of both technological and perceptual standpoints (Domagk, Schwartz, & Plass, 2010). As for the technological perspective, the structuralist or mechanistic approach (Mollen & Wilson, 2010) considers interactivity as the response to the attributes of the technology and proposes that it can be enhanced through the development of these technologies. Some elements, like joysticks or more sophisticated haptic devices like gloves or suits, enable users to modify the state of what is before their eyes, by actions such as grabbing or moving objects (Slater, 2009). As for the perceptual perspective (McMillan & Hwang, 2002; Wu, 1999), interactivity is referred to as the user's psychological state during the interaction with the technological tool, which is not only related to the actual interactive capabilities of the medium, but also to the situational characteristics (Sohn, 2011). Wu (1999) determined that perceived interactivity is based on two dimensions: “internally based self-efficacy” (perceived control with respect to where users are and where they are going in the technological system) and “externally-based system efficacy” (how responsive a system is to the participants' actions). Therefore, for human-technology interaction to occur, behavioral interactivity is the core process in which the two agents interact in order to behave in a certain way in the environment (Dix, 2009).

Different media offer different levels of interactivity and, therefore, the interactivity continuum cannot be categorized as dichotomous (Fortin & Dholakia, 2005). Instead, there is a continuum ranging from low behavioral interactivity (navigation control) to high interactivity (capacity to control and modify the environment) (Bowman & Hodges,

Fig. 3. Technological embodiment continuum.

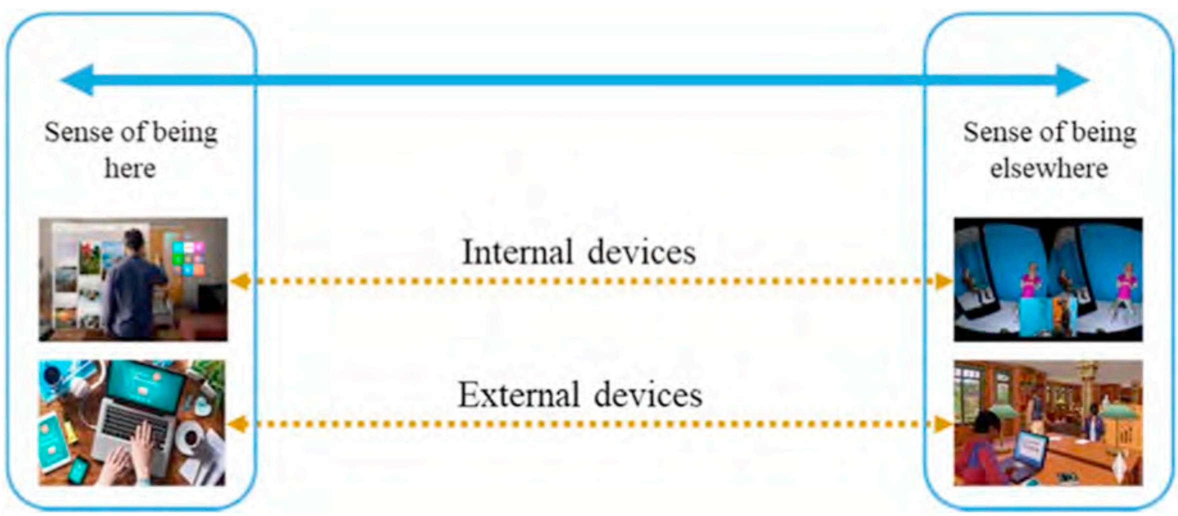


Fig. 4. Perceptual presence continuum.

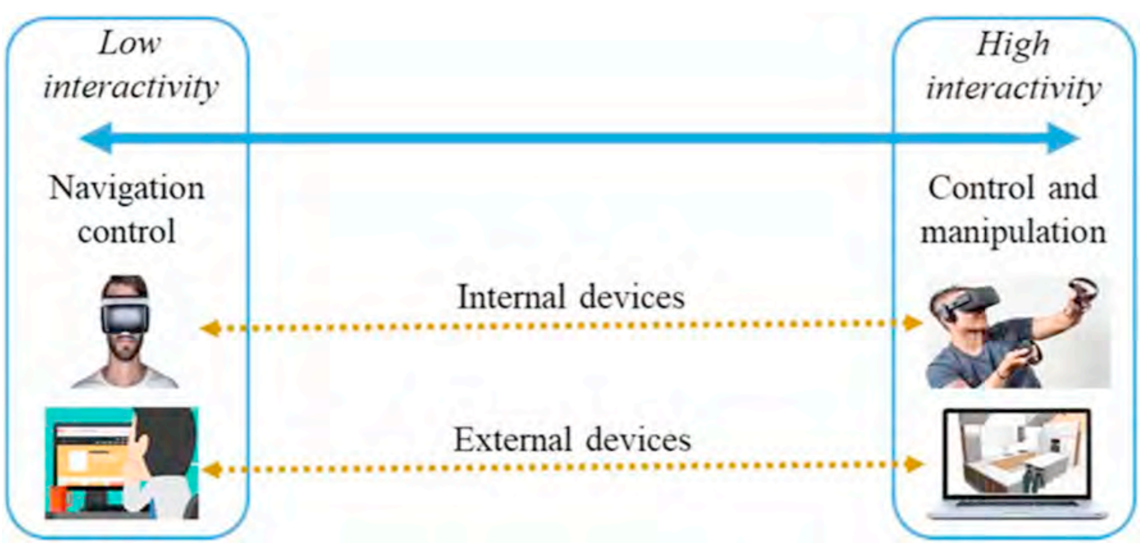
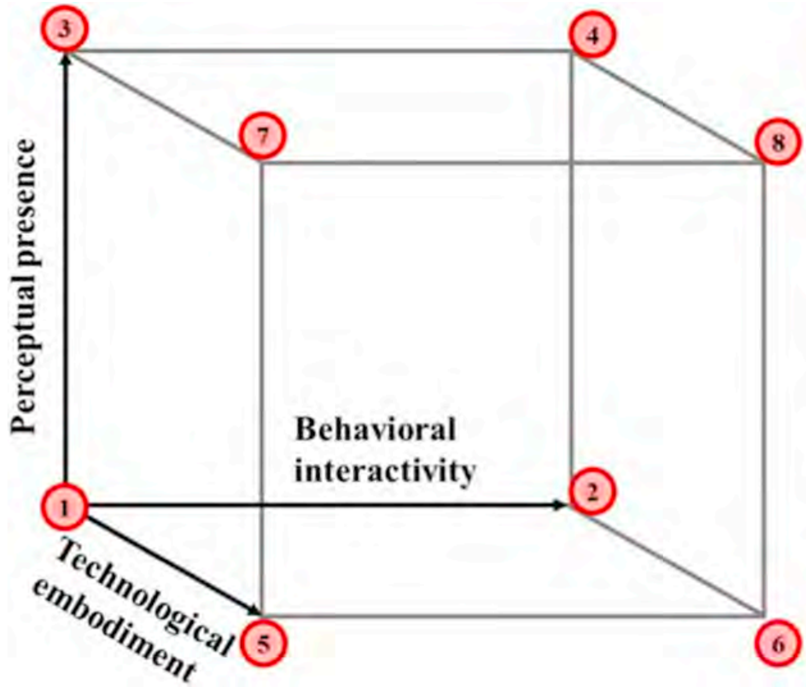


Fig. 5. Behavioral interactivity continuum.

1999; Muhanna, 2015). In addition, the fact that every typology of technology has a different space for possible user actions must be taken into consideration (Janlert & Stolterman, 2016). Thus, we distinguish interactivity between internal and external embodied technologies (Bailenson et al., 2008) (see Fig. 5). Internal technological tools, such as HMD or haptic gloves, provide direct and sensory-based levels of interactivity due to their greater capacity for behavioral tracking (gestures, movements and gazes). In our case, the approach will be based on



Vertex	Radical examples of technologies
1	Computer Web 1.0.
2	Website online simulators
3	Video Wall
4	Virtual Worlds (Second Life)
5	Augmented reality glasses
6	Mixed reality glasses (Holographic devices)
7	360-degree video HMD (fixed position)
8	Virtual reality HMD with haptic devices

Fig. 6. The "EPI Cube" and associated extreme examples of technologies.

Bowman and Hodges (1999) study about interactivity in immersive environments. Viewpoint motion control (or travel) is the basic level of interactivity and is founded on the idea that users' visual orientation and location change as a result of their movements. The maximum level of behavioral interactivity is based on the concept of manipulation in the sense of being able to modify the position, orientation, or some features (e.g., shape, scale) of previously selected objects. On the other hand, external devices, such as computers or smartphones, provide an indirect interactivity through clicking and pressing keys that transform these actions into activities shown on the screen. In this case, the control stage is related to the navigability in the media (changing the "content" that is displayed), while manipulation is the ability to change the features (shape, position, state, etc.) of previously selected content (changing the "form"; Steuer, 1992).

3.4. The "EPI Cube" of technologies

Based on the integration of variables stemming from different areas, which cover all the factors involved in a HTI process, the embodiment-presence-interactivity, or "EPI Cube", is proposed (Fig. 6). A wide variety of existing technologies is placed on the different faces of, and inside, the cube, in accordance with their positions relative to the corresponding factors (see Appendix A). In addition, potential technological advances can be placed on the cube according to these criteria.

Vertices of the "EPI Cube" represent radical examples of technologies in their corresponding situation (Fig. 6). External devices are placed in vertices 1 to 4. In vertex 1, we highlight computer 1.0 websites and traditional media (TV, radio) as radical examples of technologies unintegrated in the body, where users feel themselves in the actual location and they can only control the content display (not modify it). Vertex 2 is similar to vertex 1, but users can also manipulate the environment (e.g., website online simulators, such as Ikea Planner -https://goo.gl/Zr5uMs-, allow users to modify the form and shape of displayed content). In vertex 3, we find external devices with a low degree of behavioral interactivity (control only of displayed content) and through which users may feel they are in a place other than where they actually are (high levels of presence). Video Wall or 3D cinema can be considered as radical examples of these technologies. Finally, vertex 4 offers high levels of behavioral interactivity, where users can also manipulate the content. Examples of this are videogames and virtual worlds/platforms (Second Life, The Sims, etc.), where users can freely manipulate the virtual environment and the content is engaging enough to make them forget their immediate surroundings (Takatalo et al., 2010). Users can establish their virtual identity in these virtual platforms by creating avatars, which are designed according to their desires and expectations (Nagy & Koles, 2014a). Although some real life features persist in this process, some other private elements, such as thoughts, emotions or hidden/idealized aspirations, seem also to be reflected in their virtual profiles (Koles & Nagy, 2012; Nagy & Koles, 2014b).

Internal devices are placed in vertices 5 to 8. In vertex 5 we find technologies that fit into the human body, that allow participants to control (not modify) content and make them remain in their immediate, real surroundings. Augmented Reality glasses (such as Google Glass Enterprise, https://goo.gl/HP5XjZ) are in this vertex, since users can control only the digital content overlaying a real scene (not manipulate its position or size). Pure Mixed Reality glasses (holographic devices) are one radical example of vertex 6, as they allow users to modify the form of the content displayed and to interact these virtual elements with the real world that they are viewing in their actual location. Vertex 7 involves internal technologies through which users can control only content, but they feel they are elsewhere. When interacting with 360-degree HMD videos, users are placed in a fixed position and can feel as if they are in a different location, but they cannot modify the form or the position of the elements in that location. Finally, in vertex 8 the level of behavioral interactivity is high. For instance, users wearing virtual reality HMD, and some haptic suits that track their movements, are able to move through the virtual location and change the shape and position of the digital objects.

Appendix A shows how a total of 24 different technologies are contained within the EPI Cube. Some clarifications might now be made. First, AR hand-held systems (e.g. smartphones, tablets; see Fig. A.1c) can be classified as image-based and location-based systems (Cheng & Tsai, 2013; Wojciechowski & Cellary, 2013). Image-based AR technologies use image recognition techniques to detect particular signals in the real environment (marker-based AR: artificial markers as QR codes or 2D labels; marker-less AR: natural markers of real objects or landscapes) to locate the virtual contents. Location-based AR technologies are based on geo-location information (GPS, digital compass and accelerometer) and show different computer-generated information according to the users' location. In addition, projection-based AR technologies do not need real object recognition to display digital content on the real location (e.g. Ikea Place, https://goo.gl/kMtTiX). This last typology is more interactive than other AR technologies, as it allows users to manipulate content, while the others only display a picture or a video over the marker and, generally, their interactivity level in this regard is more limited. Second, playing a 360-degree video on a mobile phone may generate a higher sense of presence than on a desktop PC (Fig. A.1a), since its gyroscope function allow users to control what is being displayed by turning the device, thus creating a sense of harmony between their position and the content. On a computer screen, the user can only control the content by clicking on an arrow, which is not as natural. Finally, binaural audio is different from stereo audio because it tries to generate a 3D sensation, imitating how human ears interpret sounds (see Fig. A.1e, and A.1f).

The EPI Cube offers an integrated framework for a more complete taxonomy of existing (and potentially new) reality-virtuality technologies, which allows researchers to better understand their impact on the customer experience. In addition, the EPI Cube is a practical tool for managers, which can help them select the most appropriate technologies with which to design added value propositions for consumers.

4. Building technology-enhanced customer experiences

The last goal of this research is to analyze how the technologies classified in the EPI Cube can be used to add value by providing better, more memorable customer experiences. Customer experiences are internal and personal responses of the consumer to any direct or indirect contact with firms (Brakus et al., 2009; Meyer & Schwager, 2007). As previously stated, customers have touchpoints with companies throughout the purchase journey. Companies need to effectively manage these "moments of truth" to create memorable and enduring experiences (Brakus et al., 2009) that generate positive cognitive, affective, emotional, social and physical responses (Carlson, Rahman, Rosenberger, & Holzmüller, 2016; Lemon & Verhoef, 2016; Verhoef et al., 2009).

The importance of customer experience management across customer touchpoints has been stressed by practitioners and researchers. According to Forrester (2016), improving customer experience is the top priority for 72% of businesses, and providing emotionally engaging customer experiences during the purchase journey is acknowledged as a marketing trend for 2018 (Forbes, 2017). As an emerging research area, practice-oriented authors (Rawson et al., 2013) and academic authors (Teixeira et al., 2012; Verhoef et al., 2009) advocate effectively managing customer experiences, especially in the service and multichannel marketing domains (Lemon & Verhoef, 2016). In the service landscape, some authors stress the relevance of providing not only an efficient journey but also the design of optimal customer experiences (Patrício et al., 2008; Teixeira et al., 2012) that overcome the traditional interpersonal and physical contact between consumers and service providers (Breidbach et al., 2014). In the multichannel literature, offering a seamless experience through channel integration is essential to create stronger customer experiences (Brynjolfsson, Hu, & Rahman, 2013; Flavián, Gurrea, & Orús, 2016; Verhoef, Kannan, & Inman, 2015), offering the advantages of the different channels (Breidbach et al., 2014; Grohmann, Spangenberg, & Sprott, 2007). Both marketing disciplines rely on the role of technologies to design optimal and seamless customer experiences.

The technologies described in the EPI Cube can be considered as channels that mediate customer-firm contacts (Froehle & Roth, 2004) or touchpoints (Payne & Frow, 2004). Therefore, human-technology interactions in the different realities can be used to improve customer experiences. The integration of ICTs into companies' commercial offers can enhance the experience and increase the value provided to customers (Neuhofer, Buhalis, & Ladkin, 2014), resulting in "technology-enhanced customer experiences".

The "experience hierarchy" proposed by Neuhofer et al. (2014) consists of four main levels of experience: conventional experiences (level 1) are one-directional in essence (companies to customers) and the role of technology is non-existent or limited; in technology-assisted experiences (level 2), technology plays a facilitating role by assisting customers but does not let them interact or co-create their experiences (e.g. Webs 1.0.); when technologies (e.g. Webs 2.0.) allow consumers to take an active role and shape their experiences, technology-enhanced experiences are offered (level 3). Finally, the fourth and highest level is technology-empowered experiences, where technologies are required for the experiences to happen. Immersive technologies are at this level, offering customers added value derived from high levels of involvement and possibilities for co-creation.

However, the framework proposed by Neuhofer et al. (2014) has shortcomings that this research tries to overcome. First, they focus on extreme real and virtual world technologies, rather than on intermediate levels where reality and virtuality are mixed at different integration levels. As noted previously, there is a plethora of technologies in the reality-virtuality continuum with great potential to add value to customer experiences. Second, recent technological developments call for a reinterpretation of the different levels of the experience hierarchy, which we build upon the adapted reality-virtuality continuum and the EPI Cube. Finally, Neuhofer et al.'s (2014) definition of empowered experiences is limited to the use of highly immersive technologies, and this may not always be the case.

Therefore, we follow and extend the experience hierarchy (Neuhofer et al., 2014) by redefining the existing levels and adding new levels based on reality-virtuality technologies. This classification represents a pragmatic guide for the use of the EPI Cube to design better and more memorable purchase journeys and to reshape the current

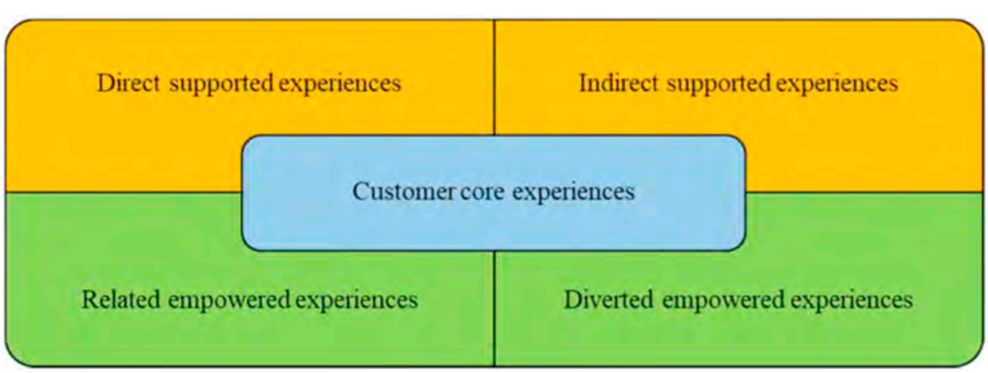


Fig. 7. Technology-enhanced customer experiences.

customer experience landscape. In the next section we define the different levels of the technology-enhanced experiences (Fig. 7) and illustrate how the technologies described in the EPI Cube can support and/or empower the customer experience in a particular industry (i.e. tourism).

First, we define a customer's "*core experience*" as the baseline experience, which includes the basic, conventional experience where technology is absent or plays a limited or secondary role. Defining the core experience is paramount for any research and company, since this is the point of departure for building enhanced experiences through reality-virtuality technologies. Human-technology interactions can be added to these core experiences to create *technology-enhanced experiences*, resulting in better, more valuable customer experiences.

Once the core experience is properly defined, the reality-virtuality technologies of the EPI Cube can generate *supported experiences*. The core experience is supported by technologies either directly or indirectly. In *directly supported experiences*, technologies assist the customer's core experience by directly acting on the real world. This dimension is an addition to Neuhofer et al.'s (2014) model, since it includes recent advances in AR and PMR technologies which integrate the physical and digital worlds at different levels. On the other hand, *indirectly supported experiences* involve technologies assisting customers' core experiences in a way that is not integrated with the real world. Due to current technological developments (Web 3.0.), it seems unnecessary to distinguish between "technology-assisted experiences" (Web 1.0.) and "technology-enhanced experiences" (Web 2.0.), as proposed by Neuhofer et al. (2014).

Moving to a different level, *empowered experiences* involve the technology itself playing a key role in creating new experiences within the customers' core context. In other words, the technology creates a new experience with a singular entity, and this experience can be related or unrelated to the customer's core experience. Contrary to Neuhofer et al.'s (2014) proposal, empowered experiences do not need to be based only on immersive technologies. Specifically, we distinguish between related and diverted empowered experiences. In *related empowered experiences*, the new experience created by the technology is closely related to what consumers are experiencing, and complements the user's core experience. Finally, in *diverted empowered experiences*, the technology itself creates a new experience that is not directly related to the user's core experience but influences what they are actually experiencing. The purpose of diverted empowered experiences is to divert consumers from their core experience. Diverted empowered experiences can have either positive or negative effects on the final outcomes of the experience. For instance, a Cave Automatic Virtual Environment (CAVE) can be installed in a museum so that consumers can experience this novel technology. On the positive side, consumers will consequently be attracted to the museum and the potential for visits might greatly increase. Moreover, consumers might develop more positive attitudes toward the museum and generate positive word of mouth (post-purchase behavior). However, the increase in traffic might disturb other visitors who want to view the pieces of art in a peaceful atmosphere, or divert customers from their true purpose (to experience the physical museum).

It must be noted that our proposal does not register situations in which the technology itself creates new experiences irrespective of the situational context of the user. Pine and Gilmore (1998) stated that the arrival of new technological devices, such as multiplayer games, chat rooms and VR technologies, would generate new experiences. Specifically, technologies have the capacity of creating experiences (*technology-generated new experiences*); without the technology, the experience would not exist. Almost a century ago, the invention of the television created one of the first technology-generated experiences. Consumers acquired TVs to live that experience and, without a TV, it was not possible to have it. However, over time the consumer got accustomed to the TV and the novelty effect faded; today, watching TV is as a conventional core experience. With this core experience, other technologies are used to support or empower it, creating technology-enhanced core experiences. Novel technologies can generate experiences of awe (situations in which users' emotions arises as a consequence of facing new, complex situations) that, as a result, influence final decisions and satisfaction (Rudd et al., 2012). However, as innovations spread and become widely adopted over time (Diffusion of Innovations Theory; Rogers, 2010), the newness effect of the experience provided by the technology dissipates, and novel technology-generated experiences turn into conventional core experiences. Today, technologies, such as VR glasses, are creating new experiences by transporting users to remote locations and virtual worlds. Nevertheless, the effect of the experiences based on these technologies may diminish as time passes and they become commonplace.

4.1. Application of technology-enhanced experiences to the customer journey

To illustrate our proposal of technology-enhanced experiences, we focus on the tourism industry, for three important reasons: first, its importance in the economy of most developed countries (WTTC, 2017); second, its defining features (service domain, hedonic, intangible and experiential nature; Carlson et al., 2016; Casaló, Flavián, & Guinalíu, 2010; Hyun & O'Keefe, 2012; Tussyadiah, Wang, Jung, & tom Dieck, 2018) offer an ideal study context; third, the recent advances in VR, AR and MR technologies have been made in this industry, showing their potential in this sector (Chung, Han, & Joun, 2015; Jung, tom Dieck, Lee, & Chung, 2016; Tussyadiah et al., 2018).

The core experience which will serve as a basis on which to build the technology-mediated experiences is a visit to classic art gallery. We offer examples of technology-mediated experiences throughout the entire customer journey regarding this core experience. In relation to pre-experiences (before actually visiting the gallery), a directly supported pre-experience would consist in scanning the art gallery brochure with an AR app to access additional information, which would be superimposed on the brochure. In an indirectly supported pre-experience, the brochure would include links to information on a website (e.g. history about the art gallery, opinions, videos). A related empowered pre-experience would consist of a 360-degree HMD video that potential visitors could watch at home to plan the visit to the gallery to view the artworks they want to see. Finally, a diverted empowered pre-experience would consist of playing in a virtual world (accessed from the company's website) with historical avatars. Although the company may attract traffic to their website, playing the videogame may distract potential visitors away from the true purpose of the pre-experience (i.e. obtaining information about the gallery).

In the experience stage (visiting the gallery), a directly supported experience would be the use by visitors of AR glasses to view digital information (history, opinions, etc.) superimposed onto the piece of art they are viewing. In addition, the art gallery might encourage visitors to scan QR codes throughout their visit to access informative YouTube videos (indirectly supported experience). A related empowered experience would be a visit to a CAVE installed in the gallery, showing a video about the creative processes of different pieces of art. Lastly, in a diverted empowered experience, visitors could use VR glasses to be "transported" to a remote location, just as they enter the gallery, to induce a state of pleasure or relaxation. As for post-experiences (after visiting the gallery), a directly supported post-experience would consist of inviting visitors to rate the paintings and gallery services (pictures sent by email) through an AR application in which the rating system appears superimposed on their smartphone screens. Encouraging visitors to share their opinions and photographs of their experiences in social networks would represent examples of indirectly supported post-experiences. In a related empowered post-experience, the art gallery might stage a contest in which visitors would record 360-degree videos of their visit to be subsequently uploaded onto YouTube. Finally, a diverted empowered post-experience would consist of an invitation to use AR technologies to take pictures and record videos, with filters and lenses, related to the art world. This post-experience might generate engagement but not necessarily related to the experience of visiting the art gallery.

These examples show how the use of technologies with the EPI Cube might help researchers and practitioners to reshape the customer experience landscape and to add more value to customer experiences in the different stages of the journey. Nevertheless, it should be noted that previous literature (Cheong, 1995; Perry Hobson & Williams, 1995; Williams & Perry Hobson, 1995) suggests that VR technologies might be considered as a substitute for tourism for several reasons (e.g. tailored virtual environments, enjoyable experiences, lower costs, higher convenience). However, recent studies highlight the key role that VR might play in providing potential visitors with a "try-before-you-buy" experience of the destination, which could translate into greater visit intention (Marasco, Buonincontri, Niekerk, Orlowski, & Okumus, 2018; Tussyadiah et al., 2018). The persuasive power that this technology has for tourism lies in its capacity to overcome its intangibility and increase consumers' confidence before actually visiting the destination (Yung & Khoo-Lattimore, 2017). In addition, VR technologies represent pseudo-experiences that cannot induce the same kind of feelings that visiting the real place generates; thus, they should not be considered as a substitute for the real experience but a valuable complement to the customer experience (Guttentag, 2010).

5. Summary and implications

This study highlights the influence that recent technological breakthroughs in reality-virtuality realities can have on customer experience. Given the lack of consensus in the academic (Jeon & Choi, 2009) and managerial (PCWorld, 2017) fields about the conceptual boundaries between the different realities, we reviewed the relevant literature to clearly define and establish the limits between them, especially those which differentiate pure mixed reality, augmented reality and augmented virtuality. At the theoretical level, this paper goes a step further in the process of establishing the boundaries between the different existing realities. Contrary to previous proposals, we note that all realities are independent from each other and identify the main features that characterize them, so that all future technologies will fall into one or other of the categories of this improved continuum. Managerially, we highlight the role that technologies related to different realities may play in the near future, emphasizing the importance of VR in generating a greater sense of engagement (Nielsen, 2016) and positive attitudes (Van Kerrebroeck, Brengman, & Willems, 2017b). In addition, the distinctions between realities will allow companies to properly name their products and describe the associated experiences.

Furthermore, we offer a classification of the existing (and potential) technologies based on these realities. In our EPI Cube, three dimensions are extracted from the main components of the HTI process (Dix, 2017): technological embodiment, perceptual presence, and behavioral interactivity. Technologies are placed along the different faces of, and inside, the cube, in accordance with their positions relative to the corresponding factors (Appendix A). We highlight the role of technological embodiment since new technologies tend to be integrated into the human body, generating greater closeness with the human senses and a higher degree of immersive experience. Additionally, the EPI Cube is a valuable tool for managers since they can choose the most suitable technology for their marketing strategy to achieve their strategic and business goals. For instance, if a company wants users to be transported to another location but there is no need for them to manipulate this environment, they can employ technologies in Vertices 3 and 7 of the EPI Cube (e.g. VideoWall, HMD 360-degree video in a fixed position; see Fig. A.1c, Appendix A).

Finally, we extend Neuhofer et al.'s (2014) experience hierarchy framework by proposing how different technologies in the EPI Cube can affect customer experiences along his or her purchase journey. Customer experience management is a hot topic in marketing research and practice (Lemon & Verhoef, 2016) and VR, AR and PMR-based technologies can play a key role in adding value to the customer experience throughout the different stages of their journey. In the pre-experience stage, these technologies allow consumers to obtain more detailed and personalized information and to be more able effectively to compare or customize products/services so as to make better decisions (Marasco et al., 2018). During the experience stage, they provide customers with the necessary tools to obtain in-situ information or have innovative and memorable experiences that eventually result in the generation of feelings, such as enjoyment (Tussyadiah et al., 2018) or engagement (Nielsen, 2016). In the post-experience stage, the EPI Cube technologies may assist consumers in their evaluations of the experience or help them create content related to their experience. These actions may lead to an increased loyalty to the brand (destination), intention to repurchase the product (revisit the destination) or to carry out actions such as recommending the experience to others or to interact with other brand enthusiasts via social networking sites (Casaló, Flavián, & Ibáñez-Sánchez, 2017).

Therefore, the combination of technology-mediated experiences and current customer core experiences results in integral technology-enhanced experiences, which increases the value provided to customers. When designing and implementing technology-enhanced experiences, customer experience managers must focus not only on satisfying customers' novelty-seeking behaviors with technologies (Dabholkar & Bagozzi, 2002; Lin, 2003), but also on how these technologies improve and provide more value to their customers' core experiences. To do so, they must first clearly define their customers' core experience, so that supporting or empowered experiences can be added to offer more value along the different stages of customer journey. This may be especially important in the case of diverted empowered experiences, given that they may have either positive or negative effects on business performance. If the new technology-enhanced experience diverts customers from the true business model of the company, it might not be advisable to make the noticeable investment of incorporating the technology-enhanced experience into the customer's purchase journey. Therefore, managers should balance the potential gain and loss of designing and creating technology-enhanced experiences. In addition, we focus on individual tourist experiences, but we are aware that tourism experiences have an important social component (Carlson et al., 2016) since consumers usually travel with other people. Thus, managers should take into account this fact when designing optimal experiences with these technologies.

6. Agenda for future research

The goals of this article were to state clearly the conceptual boundaries between the different realities in the reality-virtuality continuum and provide an overview of how reality-virtuality technologies can affect customer experience in the marketing discipline. We now propose an agenda which hopefully will stimulate research in this emerging area.

First, we establish the main features that characterize the existing realities, focusing on the boundaries in the intermediate levels of the reality-virtuality continuum (Milgram & Kishino, 1994). Focusing on AR, PMR and VR, future research might address the following questions:

- Do customers perceive the integrated realities (AR, PMR, AV) in the same way?
- How do the realities affect the customer's purchase journey?
- How do users' cognitive, emotional, behavioral, sensorial and social responses operate in the realities? Which are the dominant variables?
- What is the future of AR, PMR and AV for driving customer behavior? Will AV reach the same state of adoption as AR? And what about PMR?
- In which industries are the realities more suitable?

The second contribution of our study is based on the EPI Cube's capacity to classify reality-virtuality technologies according to their level of technological embodiment, perceptual presence and behavioral interactivity. Although this comprehensive and concise classification might cover all existing and potential new technologies, future studies should test this three-dimension proposal. Specifically, the following research questions can be posed:

- What is the role of technological embodiment in driving customer behavior? Are embodied technologies more immersive and multisensory than external technologies?
- How does the level of invasiveness of embodied technologies affect their development and the customer's experience?
- How do users' characteristics (e.g. previous experiences, demographic and personality variables) affect their sense of embodiment when using the technologies?
- Which dimension of the EPI Cube influences HTI processes the most? Are the influences context-dependent?

Finally, we propose a new taxonomy of technology-enhanced experiences which can add value to the customers' core experiences during the different stages of the customer journey. We see much room for additional research in this area, such as:

- Are there differences in the process of building technology-enhanced customer experiences if core experiences are based on goods/services?
- While we have mostly focused on the positive side of applying reality-virtuality technologies to experiences, how can negative technology-based experiences affect the global customer experience? Are there negative effects?
- What is the effect of the passage of time on the customer experience with a particular technology? What is the effect of novelty in the experience?
- Considering that the use of technology is rather individual but that many service experiences are social in nature: what is the effect of social experiences on the use of these technologies?
- How can the combination of different types of technology-based experiences affect the brand image of a product or service?

Although human-technology interactions have been studied for decades, the rapidity of technological advances is changing the ways individuals perceive the environment and the ways consumers interact with companies and experience products. This research has sought to bring together what is known about this marketing phenomenon. We hope that researchers and practitioners may benefit from our conceptual clarifications and classifications.

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Appendix A

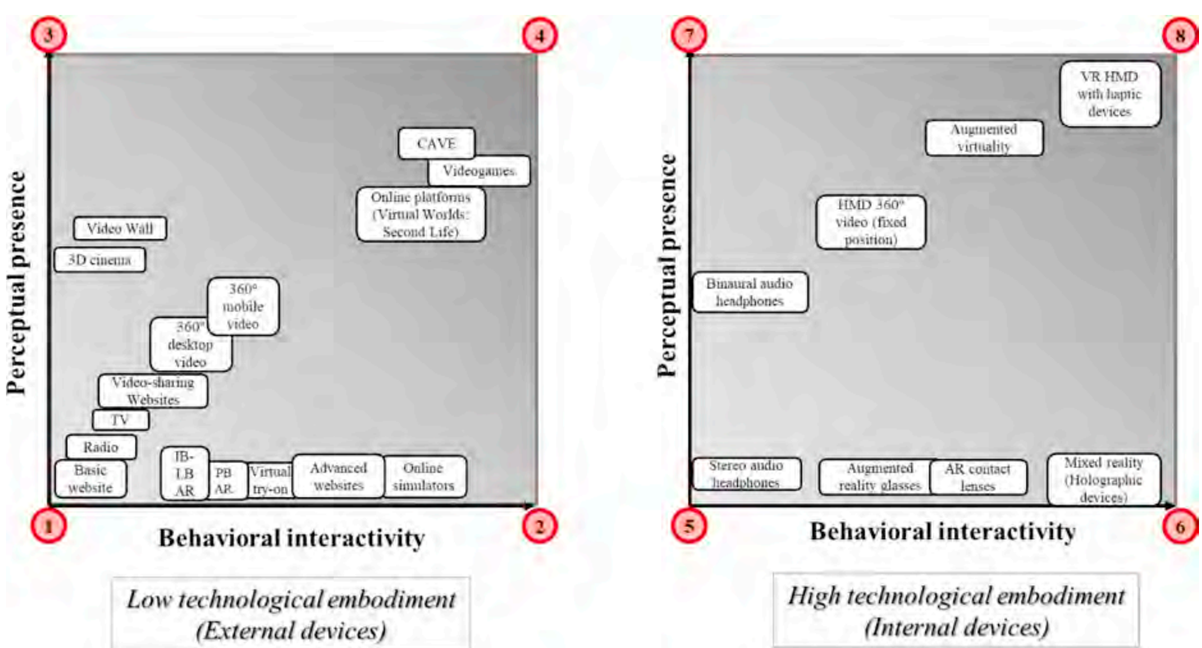

Fig. A.1a and A.1b. Technologies placed on the faces of the "EPI Cube" (Extreme levels of technological embodiment).
Notes: *IB-LB AR = image-based and location-based augmented reality; PB AR = projection-based augmented reality.*

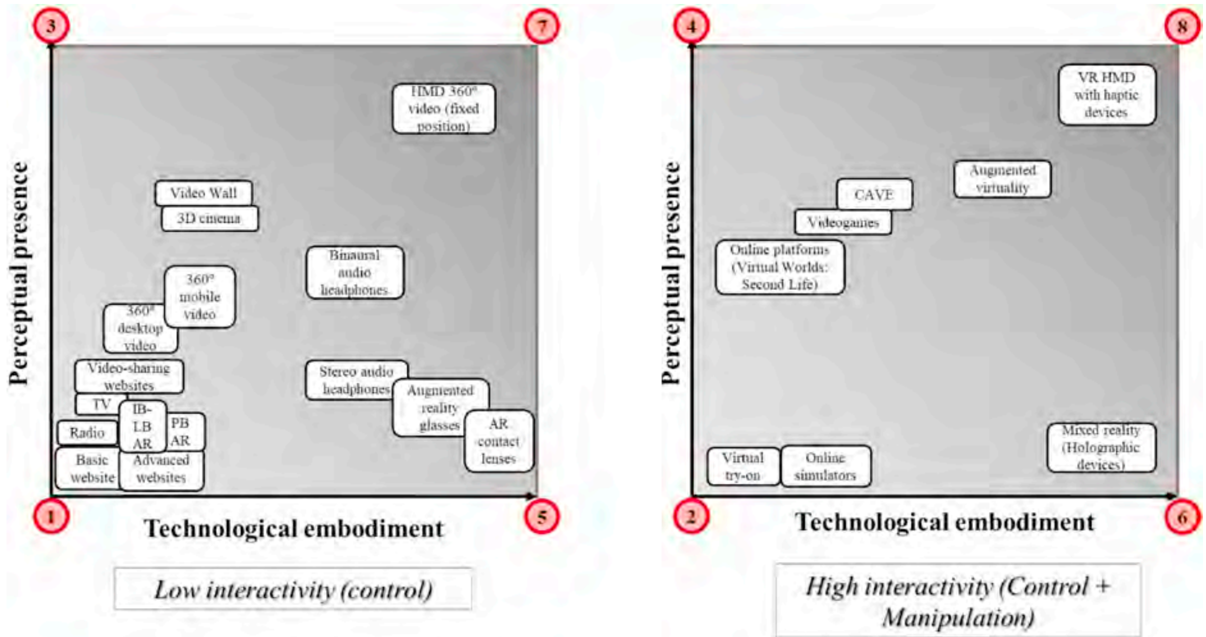

Fig. A.1c and A.1d. Technologies placed on the faces of the "EPI Cube" (Extreme levels of behavioral interactivity).
Notes: *IB-LB AR = image-based and location-based augmented reality*; *PB AR = projection-based augmented reality*.

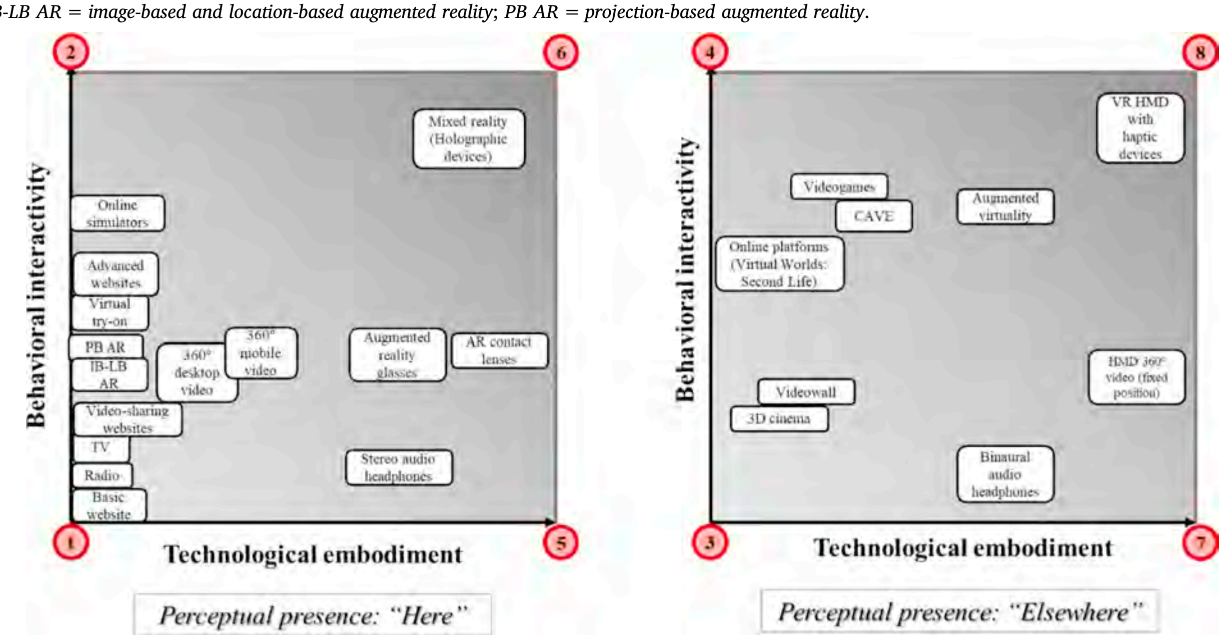

Fig. A.1e and A.1f. Technologies placed on the faces of the "EPI Cube" (Extreme levels of perceptual presence).
Notes: *IB-LB AR = image-based and location-based augmented reality*; *PB AR = projection-based augmented reality*.

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