Immersion revisited

A review of existing definitions of immersion and their relation to different theories of presence

Nilsson, Niels Chr.; Nordahl, Rolf; Serafin, Stefania

[Link to publication from Aalborg University](#)

IMMERSION REVISITED: A REVIEW OF EXISTING DEFINITIONS OF IMMERSION AND THEIR RELATION TO DIFFERENT THEORIES OF PRESENCE

Niels Christian Nilsson
Department of Architecture, Design and Media Technology
Aalborg University Copenhagen
Denmark

Rolf Nordahl
Department of Architecture, Design and Media Technology
Aalborg University Copenhagen
Denmark

Stefania Serafin
Department of Architecture, Design and Media Technology
Aalborg University Copenhagen
Denmark

Abstract: *The term immersion continues to be applied inconsistently within and across different fields of research connected with the study of virtual reality and interactive media. Moreover, immersion is oftentimes used interchangeably with the terms presence and engagement. This article details a review of existing definitions of immersion originating within the study of video games, virtual environments, and literary works of fiction. Based on this review, a three-dimensional taxonomy of the various conceptualizations of immersion is proposed. That is, the existing definitions of immersion may be broadly divided into three categories, each representing a dimension of the taxonomy: immersion as a property of a system, a subjective response to narrative contents, or a subjective response to challenges within the virtual environment. Finally, four distinct theories of presence are introduced and, based on the established taxonomy, we discuss how the individual theories relate to existing definitions of immersion.*

Keywords: *immersion, presence, virtual reality, virtual environments, video games.*

INTRODUCTION

It seems reasonable to assume that most people will find it relatively trivial to explain the meaning of the concept *immersion* in relation to an object being submerged into a body of fluid. However, the same unambiguity does not exist when the term is used in relation to a user's experience of media, such as the experience of virtual reality (VR). Following Blascovich and Bailenson (2011), we use the term *virtual reality* in a broad sense to describe any form of mediated reality and reserve the term *virtual environment* (VE) for systems relying on high fidelity tracking and displays to facilitate natural perception and interaction within an artificial environment. Indeed, McMahan suggested that immersion has become "an excessively vague, all-inclusive concept" (McMahan, 2003, p. 63). The term has come to stand for a multitude of different types of experiences and it is oftentimes used more or less interchangeably with concepts such as *presence*, *involvement*, and *engagement* (e.g., Lombard & Ditton, 1997; McMahan, 2003; Ryan, 2003). The inconsistent usage of the term immersion in definitions proposed by researchers probably has been exacerbated by the fact that it has been applied within a variety of domains. These domains include, but are not limited to, VE research (Slater, 2003; Witmer & Singer, 1998), video game studies (Adams & Rollings, 2006; Brown & Cairns, 2004; McMahan, 2003), film studies (Rooney, Benson, & Hennessy, 2012; Visch, Tan, & Molenaar, 2010), music studies (Dura, 2006; Ihde, 2007), and research dealing with linear and interactive works of literary fiction (Ryan, 2003). Furthermore, according to Lombard and Ditton (1997), the concept of presence has gained interest within a range of academic disciplines, including communication, cognitive science, computer science, engineering, philosophy, psychology, and the arts. The VE research and video game studies domains are particularly relevant because the two fields seemingly are converging (Zyda, 2005).

The problem of inconsistent usage of the term immersion is twofold: The term has become diluted due to inconsistent usage, and the interchanged use of this and other terms may potentially confound the study of concepts such as presence that has been, and continues to be, regarded as central in relation to the study and application of VEs (Zahorik & Jenison, 1998). Consequently, through our research documented in the current paper, we sought to explore two questions: What meanings are associated with the term immersion and how do these meanings map onto existing views of presence? This paper provides readers with a review of the range of various meanings associated with the term immersion and clarifies how these views of immersion relate to different theories of presence.

The remainder of the paper is organized as follows. First, we present a review of four general views of immersion: immersion as a property of the system used to display the virtual world, immersion as a perceptual response to that system, immersion as a response to narrative contents, and immersion as a response to challenges within the virtual world. This section is concluded with the introduction of a three-dimensional taxonomy of the different conceptualizations of immersion. Subsequently, we introduce four different theories of presence and discuss how the three dimensions of the taxonomy relate to the individual notions of presence. Finally, we present implications of our research and summarize and conclude upon the discussion detailed throughout the paper.

METHODOLOGICAL APPROACH

In order to explore what meanings are associated with the term immersion and how these meanings related to existing views of presence, a narrative literature review (Cook, Mulrow, & Haynes, 1997) was performed. Thus, unlike critical reviews, the selection of sources did not involve a comprehensive search of all potentially relevant work based on reproducible criteria. Instead, the review of literature related to immersion was based on relatively well-known articles from dissimilar fields of study. That is, most of the selected articles have been cited more than 100 times and originate from VE research, video game studies, and research on linear and interactive works of literary fiction. For each of the conceptualizations of immersion we identified its relation to form, content, and the response of the user. The four theories of presence similarly originated from fairly well-known articles. Moreover, these four theories were selected because they represent different views of how presence relates to form, content, and the user's response. The limitations of adopting this approach are discussed in the concluding section of the paper.

CONCEPTUALIZATIONS OF IMMERSION

In her frequently cited book, *Hamlet on the Holodeck*, Murray (1997) provided the following description of immersion that both explained the term's origins and implicitly highlighted the reason for its ambiguous usage:

> Immersion is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus. (Murray, 1997, p. 98)

The general consensus seems to be that immersion involves being or feeling surrounded by something (e.g., Ermi & Mäyrä, 2005; McMahan, 2003; Ryan 2003; Slater, 2003; Witmer & Singer, 1998). However, a number of alternate propositions address what it is that surrounds the individual. One of the most prominent differences between existing views of immersion is the distinction between immersion as technology and immersion as a subjective experience. To use Murray's water metaphor, some believe immersion to be an expression of how deeply one is submerged into a body of fluid, while others believe it to be the subjective experience of being submerged. More specifically, it seems reasonable to distinguish between four general views of immersion: (a) immersion as a property of the system used to present the virtual world; (b) immersion as a perceptual response to that system; (c) immersion as a response to an unfolding narrative, the characters inhabiting the story world, or the depiction of the world itself; and (d) immersion as a response to challenges demanding the use of one's intellect or sensorimotor skills. Throughout the following subsections, we present a review of these definitions of immersion. The definitions have been organized based on whether they qualify as a property of the system, a perceptual response, a response to narratives, or a response to challenges. The definitions are summarized in Table 1. It should be stressed that several of the cited authors adhere to multidimensional views of immersion, such as the one we propose.

Table 1. Summary of the Presented Definitions of Immersion.

Authors	A property of the system	A perceptual response	A response to narratives	A response to challenges
Slater (2003)	***System immersion:*** A property of the technology mediating the experience. The higher the fidelity of displays and tracking, the greater the level of immersion.			
Witmer and Singer (1998)		**Immersion:** A feeling of being enveloped by, included in, & interacting with the virtual environment.		
Arsenault (2005)		**Sensory immersion:** A sensation of being enveloped by the multisensory representation of the virtual world delivered via high-fidelity displays.	**Fictional immersion:** The sensation of being mentally absorbed by fictional stories, worlds or characters.	**Systemic immersion:** The mental absorption experienced when facing challenges that match one's capabilities, including the challenges involved when exposed to nonparticipatory media.
McMahan (2003)		**Perceptual immersion:** The sensation of being surrounded by the virtual environment that increases proportionally with the number of modalities provided with artificial stimuli.	**Psychological immersion (immersion on a diegetic level):** The mental absorption experienced during exposure to the world of a game's story.	**Engagement (immersion on a nondiegetic level):** The state of focused attention on the game brought about by the desire for gaining points and/or devising a winning or spectacular strategy.
Adams and Rollings (2006)			**Narrative immersion:** A state of intense and focused attention on the story world & the unfolding events and acceptance of these as real.	**Strategic and tactical immersion:** A state of intense preoccupation with observation, calculation, & planning or with swift responses to obstacles.
Ermi and Mäyrä (2005)		**Sensory immersion:** The feeling of being surrounded by the multisensory representation of virtual worlds delivered through large screens and powerful sounds.	**Imaginative immersion:** The sensation of being mentally absorbed by a game's story, its world, or its characters.	**Challenge-based immersion:** The mental absorption experienced when facing challenges requiring mental or motor skills.
Ryan (2003; 2008)			**Narrative immersion:** A state of intense focus on a narrative; can be divided into 3 subcategories: *immersion* (elicited by a strong sense of place and the joy of exploration), *temporal immersion* (caused by a desire to know what will happen next), and *emotional immersion* (brought about by emotional attachment to characters).	**Ludic immersion:** A state of intense absorption in the task currently being performed.

Immersion as Technology or the Experience of Technological Envelopment

In relation to the study of VEs, the term immersion has been used to describe both the technology surrounding the user and the user's response to being surrounded by technology. Slater (2003), a proponent of the former view, provided the following account of his view of immersion:

> Let's reserve the term "immersion" to stand simply for what the technology delivers from an objective point of view. The more that a system delivers displays (in all sensory modalities) and tracking that preserves fidelity in relation to their equivalent real-world sensory modalities, the more that it is "immersive." (Slater, 2003, "Immersion and Presence," para. 1)

Immersion is therefore regarded as an objectively measurable property of the system and not the product of the user's reaction to being enveloped by technology (Slater, 2003). Henceforth, we will use the term *system immersion* (Slater, 1999) when referring to this conceptualization of immersion.

Proponents of the second view of immersion include Witmer and Singer (1998), who argued that, in relation to VEs, immersion may be viewed as a "psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (Witmer & Singer, 1998, p. 227). Following this view, the subjective experience of immersion is influenced by at least three factors: (a) the extent to which the user is isolated from the external physical environment, (b) the sense of self-inclusion within the mediated environment, and (c) egocentric motion perception and the ability to interact naturally with the environment. It is worth noting that Witmer and Singer (1998) distinguished between immersion and involvement. The former relates to the sensation of being enveloped by the environment and the latter refers to the act of assigning great focus and attention to perceived stimuli and occurring events. Similar conceptualizations have been used to describe immersion in relation to video games. McMahan (2003) distinguished between *perceptual immersion* and *psychological immersion* that correspond to attentional surrender caused by system immersion and captivating stories and spaces, respectively. Particularly, McMahan described that perceptual immersion is "accomplished by blocking as many of the senses as possible to the outside world and making it possible for the user to perceive only the artificial world, by the use of goggles, headphones, gloves, and so on" (McMahan, 2003, p. 77). In a similar vein, Ermi and Mäyrä (2005) introduced the concept *sensory immersion*, referring to the audiovisual presentation of games. The authors described sensory immersion as follows:

> Digital games have evolved into audiovisually impressive, three-dimensional and stereophonic worlds that surround their players in a very comprehensive manner. Large screens close to the player's face and powerful sounds easily overpower the sensory information coming from the real world, and the player becomes entirely focused on the game world and its stimuli. (Ermi & Mäyrä, 2005, p. 43)

Based on the presented definitions of immersion, it would seem that proponents of both views hold that immersion may be closely connected to media form, that is, the properties of the technological system used to mediate the experience. However, the fundamental difference is that immersion following one view is regarded as a property of media form, while the other

view stipulates that immersion corresponds to the subjective experience of the media form. Table 2 summarizes the two opposing views of immersion outlined in the preceding paragraph.

Immersion as a Response to Narratives

When discussing immersion in relation to video games, McMahan (2003) distinguished between the sensations of being immersed on a *diegetic level* versus a *nondiegetic level*. The diegetic level refers to the level of the game's diegesis, that is, the fictional world in which the events of the unfolding narrative occurs (Prince, 2003). When immersed in a game on a diegetic level (i.e., psychological immersion), the player is mentally preoccupied by the world of the game's story (McMahan, 2003). Adams and Rollings (2006) conceptualized immersive experiences in a similar manner and have dubbed players' immersion with a game's story as *narrative immersion*. Narrative immersion is defined as "the feeling of being inside a story, completely involved and accepting the world and events of the story as real" (Adams & Rollings, 2006, p. 30). Notably, a number of alternate definitions exist that resemble this one, albeit under different names. These include *imaginative immersion* proposed by Ermi and Mäyrä (2005) and Arsenault's (2005) slightly modified notion of *fictional immersion*. In short, Arsenault discarded the label *imaginative* in favor of *fictional* based on the argument that this form of immersion needs not be explicitly dependent upon the imagination of the individual. According to Adams and Rollings (2006), an exhilarating plot, interesting character, and dramatic situations are prerequisites for the experience of narrative immersion. Thus, the term immersion has been used beyond descriptions of experiences elicited by interactive VR. Ryan (2003) described how reading may give rise to narrative immersion. Even though Ryan used the act of reading as her point of departure, she did not reserve immersion for experiences of nonparticipatory media. That is, narrative immersion may arise from any narrative work, including digital games where the user assumes control of the story's protagonist or antagonist. Thus, Ryan's conceptualization is similar to the one proposed by Adams and Rollings (2006). However, Ryan provided an even more detailed account of what causes individuals to become immersed by narratives. Narrative immersion may be described in terms of the three subcategories: *temporal*, *spatial* and *emotional*. Even though her description of the three has

Table 2. Immersion as Technology and Immersion as a Reaction to Technological Envelopment in Terms of Form, Content, and User Response.

Terms	Form	Content	User response
System immersion (e.g., Slater, 2003)	A property of media form describing the degree to which a system is able to faithfully reproduce natural perception and action through multisensory displays and tracking.	System immersion is separate from content because it is used to describe the technology used to present the content rather than the content itself.	Although system immersion may influence the user response, the reverse is not true.
Immersion (Witmer & Singer, 1998), *perceptual immersion* (McMahan, 2003) and *sensory immersion* (Ermi & Mäyrä, 2005).	Form factors, such as isolation from the physical environment and interfaces allowing for natural interaction, are believed to influence the experience of immersion.	Content is generally not viewed as a factor influencing the subjective sensation of immersion.	Immersion is view as a sensation of being enveloped by, included in, and interacting with an environment

its roots in reading experiences, it may be pertinent to other forms of VR. Arsenault (2005) proposed that the three forms of immersion potentially could be used as subcategories of fictional immersion. Just as Adams and Rollings (2006) suggested that exhilarating plots are constituent to the experience of narrative immersion, so did Ryan (2003). She called temporal immersion the involvement brought about by the individual's desire to learn what will happen next. In other words, temporal immersion may be defined as "the reader's involvement in the process by which the progression of narrative time distills the field of potential, selecting one branch as the actual, confining the others to the realm of forever virtual" (Ryan, 2003, p. 141). Spatial immersion refers to the form of immersion brought about by the individual's response to the depicted location or scenery (Ryan 2003). It involves having a sense of place as well as the pleasure experienced when one is exploring the virtual space (Ryan, 2008). When discussing spatial immersion in relation to textual narratives, Ryan stated that, in its most complete form, "the reader's private landscapes blend with the textual geography. In those moments of sheer delight, the reader develops an intimate relation to the setting as well as a sense of being present on the scene of the represented events" (Ryan 2003, p. 122). Lastly, emotional immersion refers to the experience of immersion resulting from the reader's emotional investment in the fate of the protagonists or antagonists of the narrative (Ryan 2003). Ryan argued that this form of immersion is achievable because of the mind's capacity for simulating incredibly vivid emotions even when their causes are not real.

Following the outlined definitions of immersion, it would appear that narrative immersion and its subcategories (temporal, spatial, and emotional) are characterized by a degree of mental absorption or intense preoccupation with the story, the diegetic space, and the characters inhabiting this space. Thus, narrative immersion is largely the product of the mediated content. Furthermore, when discussing spatial immersion, Ryan (2003) suggested that the media form also may be influential. According to Ryan (2003), pictorial media are able to instantaneously transport the viewer into the diegetic space. Textual media, on the other hand, involve a more gradual transition into the story world. This implies that the experience of spatial immersion accompanying exposure to high-fidelity displays resembles perceptual immersion (McMahan, 2003) and sensory immersion (Ermi & Mäyrä, 2005). Thus, spatial immersion may be influenced by both form and contents (i.e., system immersion may contribute to the sensation of spatial immersion). Table 3 summarizes the definitions of immersion pertaining to the experience of immersion brought about by exposure to narratives.

Immersion as a Response to Challenges

In addition to viewing immersion as the outcome of exposure to narratives, Ryan (2008) also acknowledged that immersion may arise from the experience of VRs devoid of explicit narrative contents. She referred to this form of immersion as *ludic immersion* and described it as an intense focus on the performance of a given task, akin to the intensity exhibited by some professional classical musicians. McMahan described immersion on a nondiegetic level as the player's love for the game and the strategy it requires to play it (McMahan, 2003, p. 68). Ermi and Mäyrä referred to this form of immersion as *challenge-based immersion* and described it as "the feeling of immersion that is at its most powerful when one is able to achieve a satisfying balance of challenges and abilities" (Ermi & Mäyrä, 2005, p. 43). Notably, they argued that this feeling of immersion may be brought about by challenges to both sensorimotor and mental skills.

Table 3. Immersion as a Reaction to Narratives in Terms of Form, Content, and User Response.

Terms	Form	Content	User response
Narrative immersion (Adams & Rollings, 2006; Ryan 2003), *imaginative immersion* (Ermi & Mäyrä, 2005) and *fictional immersion* (Arsenault, 2005)	May be experienced across different types of media	May result from exposure to the events, characters, and world of an unfolding narrative	Characterized by a mental absorption with the mediated narrative
Temporal immersion (Ryan, 2003)	May be experienced across different types of media	Results from expose to the unfolding events, i.e., the plot	Characterized by an intense preoccupation with the narrative due to a strong desire to know what will happen next
Spatial immersion (Ryan, 2003)	May be experienced across different types of media, but pictorial media is particularly effective at eliciting this form of immersion	Results from exposure to the depiction of the narrative space	Characterized by an intense preoccupation with the narrative accompanied by a strong sense of place and the pleasure of exploring the environment
Emotional immersion (Ryan, 2003)	May be experienced across different types of media	Results from the experience of the depicted characters	Characterized by an intense preoccupation with the narrative due to a strong emotional investment in the fate of the protagonists or antagonists of the narrative

However, the two authors are of the belief that the challenges more often than not will pertain to both conditions to some degree. Whereas the simultaneous occurrence of both types of challenges is possible, one may argue that one of two conditions has to be met in order for the challenges to be experienced as immersive. Either the simultaneous occurrence of the challenges has to be brief enough to avoid attentional overload, or the user needs to be so proficient at tackling one of the two skills that he or she has the attentional surplus necessary to face the second one. That is, either task switching must be possible, or one of the two competing tasks has to be automated (Saariluoma, 2005). With these arguments in mind, it seems reasonable to distinguish between the immersion engendered by challenges to the user's motor or his/her mental skills.

Adams and Rollings (2006) made exactly this distinction when describing the two forms of immersion: *strategic immersion* and *tactical immersion*. The former refers to the experience of being intensely preoccupied with trying to win the game. In other words, when strategically immersed, the player is almost entirely preoccupied with the optimization of choices and therefore ignores elements such as the story and characters (Adams & Rollings, 2006, p. 30). Thus, strategic immersion results from a player's intense preoccupation with observation, calculation, and planning. Tactical immersion refers to the form of immersion experienced when playing hectic action games where continuous demands for reactions to occurring obstacles give rise to complete attentional surrender. Particularly, repeated confrontation with relatively small and similar challenges requires the player's undivided attention, leaving no time for focusing on other elements of the game, such as the general strategy or story (Adams & Rollings, 2006, p. 30). Notably, these definitions of immersion greatly resemble the experience of *flow* (Csikszentmihalyi, 1990), which also describes the experience of playing video games (Chen, 2007). Flow arises when an individual performs an activity of interest in which the perceived challenges correspond to the perceived skills. The state of flow is characterized by intense and

focused attention, the merging of action and awareness, the loss of self-consciousness, a sense of control, a distortion in temporal experience, and the experience of the activity as being intrinsically rewarding (Nakamura & Csikszentmihalyi, 2005). Considering that challenge-based immersion is most intense when the balance between challenges and skills is maintained, both strategic and tactical immersion may be accompanied by a subjective response similar to the state of flow.

Thus, the types of immersion outlined in this subsection may be characterized by intense focus and attention brought about by the need for physical reactions to occurring obstacles or cognitive demands. Moreover, this implies that these types of immersion are influenced to a large extent by the mediated content because the challenges themselves are shaped by the subject matter. Even though the cited authors do not explicitly address the role of media form, it does seem likely that it also influences challenge-based immersion. For example, the display's field of view—the vertical and horizontal angles subtended by the visual display (Steinicke et al., 2011)—is believed to influence a variety of aspects of human performance and perception, including, but not limited to, navigation performance in real and virtual environments (Hassan, Hicks, Lei, & Turano, 2007; Jansen, Toet, & Delleman, 2010; Toet, Jansen, & Delleman, 2007), self-motion perception (Nilsson, Serafin, & Nordahl, 2014), postural stability (Duh, Lin, Kenyon, Parker, & Furness, 2001), reaching distance estimation (Watt, Bradshaw, & Rushton, 2000), as well as simulator sickness (Lin, Duh, Parker, Abi-Rached, & Furness, 2002). Therefore, media form may influence the user's performance in relation to both sensorimotor and intellectual challenges that, in turn, help determine whether challenge-based immersion is experienced. Alternately, this implies that system immersion may influence the experience of challenge-based immersion. Table 4 summarizes the definitions of immersion pertaining to a user's mental absorption brought about by the experience of challenges requiring mental or sensorimotor skills.

Table 4. Immersion as a Reaction to Challenges in Terms of Form, Content, and User Response.

Terms	Form	Content	User response
Challenge-based immersion (Ermi & Mäyrä, 2005)	While the effects of form are not explicitly addressed by the authors, it seems likely that it may be influential (e.g., whether practice is necessary in order to use the controls or displays).	Results from confrontations with nontrivial challenges that lie within one's capacity for action.	Intense and focused attention on the challenge at hand.
Strategic immersion (Adams & Rollings, 2006)	It is possible that form may be influential (e.g., the type of visual display may influence challenges involving spatial perception, such as navigation tasks).	Results from challenges demanding use of one's intellect.	Intense and focused attention on an intellectual challenge.
Tactical immersion (Adams & Rollings, 2006)	It is possible that form may be influential (e.g., the precision and complexity of the peripherals may influence performance).	Results from challenges demanding use of one's sensorimotor skills.	Intense and focused attention on evaluation of occurring obstacles and responding with appropriate actions.

A Taxonomy of Existing Conceptualizations of Immersion

We propose that the conceptualizations of immersion presented throughout the preceding subsections may be organized into a taxonomy with three dimensions. The presented definitions may be divided broadly into three categories based on whether they relate to immersion as a property of the system (system immersion), a subjective response to narrative (narrative immersion) or a subjective response to challenges (challenge-based immersion). Thus, the proposed taxonomy bears resemblance with the SCI-model proposed by Ermi and Mäyrä's (2005) that distinguished between the previously described notions of sensory, challenge-based, and imaginative immersion. An important difference is that the current taxonomy does not include immersion as a response to being enveloped by technology, that is, sensory immersion (Ermi & Mäyrä, 2005) or perceptual immersion (McMahan, 2003). The reason for this perspective is twofold. First, the intensity of this form of immersion increases proportionally with an increase in system immersion. Therefore, its inclusion does not add any significant descriptive power. Second, this view of immersion considerably overlaps with at least one existing view of presence, which is addressed in the Immersion and Illusions of Place and Plausibility subsection below. Moreover, the proposed taxonomy somewhat resembles the previously outlined categories of immersion proposed by Adams and Rollings (2006), that is, narrative, tactile, and strategic immersion. Specifically, we consider challenges to both one's intellect (strategic immersion) and sensorimotor skills (tactical immersion) to be subcategories of challenge-based immersion. Finally, we use the term narrative immersion in a manner similar to Ryan (2003) and Arsenault (2005) in that this type of immersion can be subdivided into spatial, temporal and emotional immersion.

It is possible to represent the three dimensions of the proposed taxonomy as axes in a coordinate system (Figure 1) in a manner similar to how Zeltzer (1992) visualized the relationship between autonomy, interaction, and presence. The three subcategories of narrative immersion (spatial, temporal, and emotional) are collapsed into one axis because an intense preoccupation with the unfolding narrative may be caused by more than one of the three subcategories simultaneously. The same is true for the axis challenge-based immersion, which may be influenced by both intellectual and sensorimotor challenges. The xz-plane represents variations in the subjective experience of immersion, while the y-axis represents changes to the system that may influence the subject experience. By considering the cube subtended by the three axes, we are able to provide an account of the experiences generated from combinations of the three types of immersion.

- The origin 0,0,0 corresponds to a unmediated experience, or one relying on a very low fidelity system, devoid of both interesting narrative contents and obstacles posing a noteworthy challenge (e.g., waiting for someone in an empty parking lot).
- The corner 0,1,0 represents a scenario that is equally trivial, despite the user being technologically immersed (e.g., waiting for someone on an empty *virtual* parking lot). It is possible that a novice VE user will experience some degree of preoccupation with the virtual world due to the sheer novelty of the simulated parking lot. However, such an instance of mental absorption can be attributed to the experience of some degree of spatial immersion.
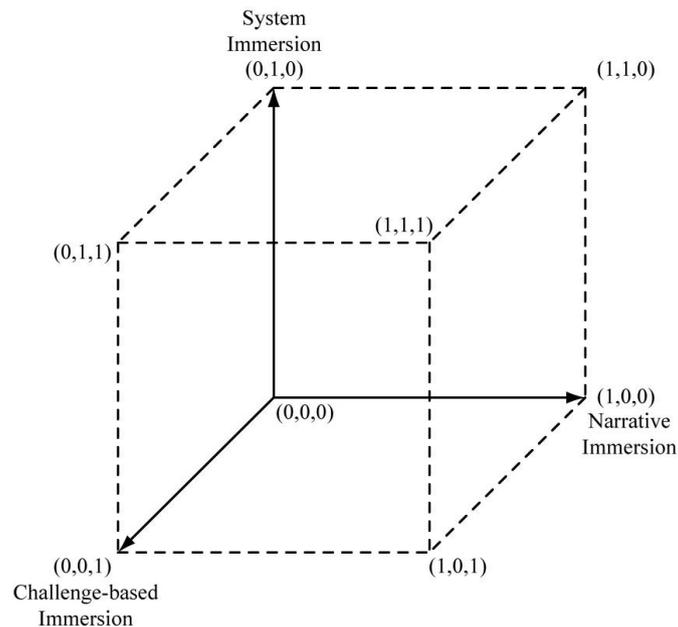
117

Figure 1. Illustration of the proposed taxonomy of existing conceptualizations of immersion. The three axes represent the extent to which interaction with a system involves system immersion (vertical), narrative immersion (horizontal), and challenge-based immersion (depth). The degree to which each type of immersion is presented is represented on a scale from 0 to 1, where 0 represent absence and 1 represents the highest possible level of immersion.

- The points 0,0,1 and 1,0,0 both represent situations involving close-to-no technological immersion but a high degree of narrative immersion (e.g., a great work of literary fiction) or challenge-based immersion (e.g., a Sudoku puzzle or a game of foosball).

- Fantasy roleplaying games, such as Dungeons and Dragons, may be used to illustrate the experience corresponding to the coordinate set 1,0,1. Such games need not involve explicit use of technology; players may experience narrative immersion when they assume the role of a character in an unfolding story or in challenge-based immersion due to the mental skills required to tackle the fictional challenges.

- The points 0,1,1 and 1,1,0 correspond both to video games running on technologically immersive systems capable of delivering high-fidelity tracking and sensor stimuli in several modalities. In the case of point 0,1,1, the game would involve an ideal balance between intellectual or sensorimotor challenges and the player's capacity for action. In the case of point 1,1,0, the game would present the player with an interactive narrative that strongly appeals to the player's curiosity to know more about the ongoing events, the fate of the virtual characters, or the virtual space itself.

- Finally, the corner 1,1,1 might correspond to a video game running on a technologically immersive system but involving both obstacles posing a suitable challenge and an interesting story.

IMMERSION AND VARIETIES OF PRESENCE

A defining feature of VEs is arguably the ability to elicit a compelling sensation of presence inside the computer-generated environment. However, like immersion, the concept presence becomes synonymous with a variety of different experiences, and the two terms often are used interchangeably. In this section, we introduce the concept of presence and discuss how four views of presence may relate to system immersion, narrative immersion, and challenge-based immersion.

Presence at a Glance

Many credit Minsky (1980) for coining the term *telepresence,* describing the sensation of "being there" in some remote location while perceiving and acting vicariously through a robot. According to Riva (2009), the term *presence* first entered the broad scientific debate when Sheridan and Furness founded the journal *Presence: Teleoperators and Virtual Environments*. In the second issue of the journal, Sheridan (1992) presented a comparable definition of telepresence and added that an individual similarly may experience a sensation of being physically present during exposure to multisensory stimuli generated by a computer. Since then, the term has been used within a variety of academic domains (e.g., communication, cognitive science, computer science, engineering, philosophy, psychology), to describe a variety of experiential phenomena. This is perhaps best exemplified by Lombard and Ditton's (1997) seminal taxonomy of presence, which outlined six different, yet interrelated, forms of presence: presence as social richness, presence as realism, presence as transportation, presence as immersion, presence as social actor within medium, and presence as medium as social actor. Based on the writings of fellow scholars, Lombard and Ditton (1997) proposed a definition of presence they believed to be broad enough to include the various existing conceptualizations of presence. They defined presence as "the perceptual illusion of nonmediation" (Lombard & Ditton, 1997, "Presence Explicated," para. 1). The failure of the individual to acknowledge the mediated nature of an experience is similarly reflected in the definition of presence endorsed by the International Society for Presence Research (ISPR). In their explication statement, ISPR presented the following definition of presence:

> Presence (a shortened version of the term "telepresence") is a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. (ISPR, 2000, "The Concept of Presence: Explication Statement," Point 1).

Notably, the technology needs not comprise only high-fidelity displays and tracking, but also may refer to representational media, such as television, photographs, paintings, sculptures, and traditional print media (ISPR, 2000). In line with the conceptualization of system immersion, these technologies are not equally immersive because they vary in terms of the extent to which they deliver multisensory displays and are able translate the movements of the individual into virtual actions. Indeed, the question of whether presence is influenced by system immersion and factors such as mental imagery space and attention have spurred various theories of presence. In the balance of this section, four theories of presence will be introduced and their relation to our taxonomy of existing views of immersion will be discussed. The four theories are (a) Biocca's

(2003) three-pole model of presence shifts that, among other things, attempted to explain why textual media such as books can elicit a sensation of presence; (b) E. L. Waterworth and Waterworth's (2001) three-dimensional model of attention during virtual experience, which introduced the notion of absence so as to explain experiences devoid of presence; (c) Riva, Waterworth, and Waterworth's (2004) account of how the presence may be described as a three-layered bio-cultural mechanism that helps the self in making sense of sensory stimulation; and (d) Slater's (2009) conceptual framework for describing how the combination of system immersion, virtual body-ownership, and illusions of place and plausibility make individuals respond realistically to virtual worlds.

Immersion, Presence, and Mental Imagery Spaces

Biocca (2003) proposed the so-called three-pole model of presence shifts. Biocca believed two central assumptions in the existing presence theories to be flawed, namely, the two-pole assumption and the sensorimotor immersion assumption. The former relates to the belief that an individual's sensation of presence can alternate between two states. Either one feels present within the physical environment or one feels present within the virtual (or remote) environment. The sensorimotor assumption stipulates that the main causes of presence are the immersive properties of the technology, that is, system immersion. Biocca (2003) found that the two-pole assumption was unable to explain how presence can occur during everyday encounters with the world and while dreaming because these experiences do not involve system immersion. Additionally, the sensorimotor assumption made it difficult to explain why individuals seemingly can experience presence while exposed to low-fidelity, noniconic media such as books.

In order to alleviate these problems, Biocca added a third pole, dubbed *mental imagery space*. Biocca's argument for doing so was that the spatial models produced by mental imagery possess analog properties similar to those of sensorimotor spaces and may rely on neural mechanisms related to spatial perception (Kosslyn, 1983, 1996; Kosslyn & Koenig, 1992). Assuming that the sensation of presence is defined by a mental model of space, then presence may gradually shift between the physical and virtual environment as well as the mental imagery space, depending on which of the three supplies the mental model with spatial cues (Biocca, 2003). Finally, Biocca proposed that shifts between imagery space and stimulus-driven spaces (virtual and physical environments) are governed largely by spatial attention. Shifts between the physical and virtual environments are attributed to spatial updating, that is, primarily sensory-driven cognitive processes responsible for updating the mental model of positions of objects relative to the perceiver during movement (Biocca, 2003).

Despite the emphasis of mental imagery space, Biocca's (2003) view does not appear to contradict the claim that system immersion may be conducive to the sensation of presence (the circle labeled A in Figure 2). Biocca theorized that spaces generated from mental imagery are inferior to VEs in terms of sensory resolution, the salience of memory, and intersubjective consistency. However, it would seem that the focus of spatial attention needs to be leveled at the mediated environment in order for the user to feel present within the VE. Thus, the sensation of presence within a VE devoid of an interesting narrative or challenging obstacles may be fragile because shifts in spatial attention are more likely to occur. In turn, this implies that the combination of system immersion and the mental absorption characterizing narrative immersion is likely to elicit a sensation of presence (Circle B in Figure 2). A defining characteristic of Biocca's
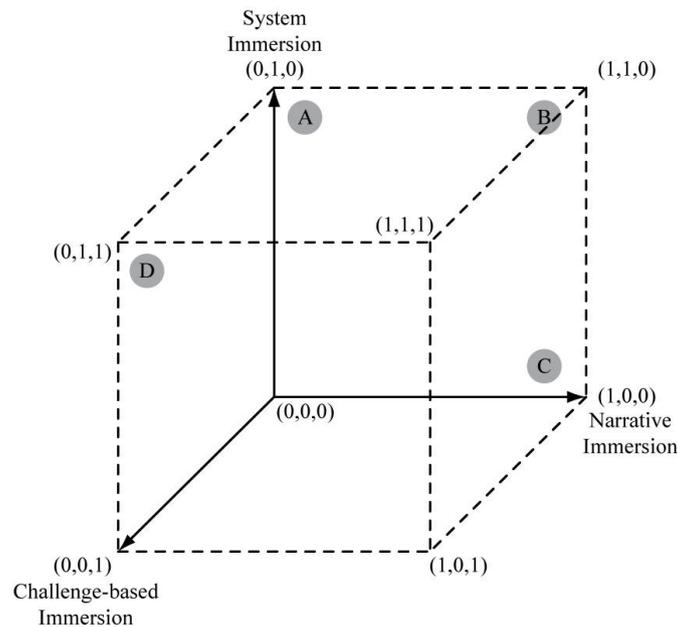
Figure 2. Illustration of how the different types of immersion may elicit a sensation of presence following Biocca's (2003) three-pole model of presence shifts. The grey circles represent instances believed to elicit presence. The three axes represent the extent to which interaction with a system involves system immersion (vertical), narrative immersion (horizontal), and challenge-based immersion (depth). The degree of each type of immersion is represented on a scale from 0 to 1, where 0 represents absence and 1 represents the highest possible level of immersion.

view of presence is that textual media such as books can elicit a sensation of presence. Thus, narrative immersion and its subcategories (temporal, spatial and emotional) may be particularly important to the sensation of being there in the diegetic space (Circle C in Figure 2). While Biocca (2003) did not explicitly describe the role emotions play in relation to presence, the model indirectly suggests that emotions may contribute to the sensation of being there in VR. To elaborate, it is a widely held belief that affect may bias both perception and attention and that individuals generally assign greater importance to emotionally salient stimuli (Fox, 2008). Thus, it seems likely that narrative events, characters, or locations capable of eliciting emotional responses might reduce the risk of shifts in presence from the VR to the external environment. Moreover, it is worth recalling that Ryan (2003, p. 122) stated that, when experiencing intense spatial immersion, "the reader develops an intimate relation to the setting as well as a sense of being present on the scene of the represented events." Thus, spatial immersion resulting from textual narratives appears largely identical to Biocca's description of the experience of presence arising from spatial cues originating within one's mental imagery space. Moreover, Biocca (2003, p. 7) described that when "action in space involves high spatial attention to sensory stimuli (e.g., learning a new motor task or during fight–or–flight), spatial presence is focused and undivided on one consistent spatial model driven by physical or virtual space." This suggests that challenge-based immersion also may contribute to the sensation of presence during exposure to technologically immersive VEs (Circle D in Figure 2).

Immersion and the Focus, Locus and Sensus of Attention

E. L. Waterworth and Waterworth (2001) generally conform to the view that presence is tantamount to the sensation of being there within an environment. They characterized presence as "a conscious emphasis on direct perception of currently present stimuli rather than on conceptual processing" (p. 211). While these authors acknowledged that system immersion may increase the sensation of presence, they raised the question of whether a high degree of technological envelopment always will yield a strong sensation of being in the VE. In order to approach an answer to this question, Waterworth and Waterworth (2001) proposed a model describing virtual experiences in terms of three dimensions pertaining to the individual's allocation of attentional resources. The three dimensions are *focus of attention*, *locus of attention* and *sensus of attention*. The first dimension pertains directly to presence in that presence is believed to arise when an individual primarily attends to the immediate real or virtual environment within and around the body. The amount of attentional resources allocated to the immediate environment depends on the extent to which the given situation requires conceptual processing, that is, abstract reasoning. If the situation demands a low degree of conceptual processing, the individual can focus on direct perceptual processing of the environment. On the other hand, if the situation requires a high degree of abstract reasoning, the resources allocated for perceptual processing are low and the individual enters a state of absence rather than presence. Thus, presence constitutes one extreme of the dimension of focus and absence forms the other extreme. The second dimension, locus of attention, relates to whether the individual currently allocates attention to the virtual or the external environment. Finally, the dimension sensus of attention relates to the degree of conscious arousal experienced by the individual. Waterworth and Waterworth (2001) described conscious arousal as a basic physiological response to significant external stimulus and use the state of dreamless sleep as an example of low very low-conscious arousal.

J. A. Waterworth and Waterworth (2003) noted that the dimension focus of attention implies that presence is a function of media form. A technologically immersive system provides concrete information that can be processed directly by the perceptual–motor systems, unlike abstract information, which is realized mentally (e.g., an imagined world is contingent upon abstract information). Thus, their view of presence supports the assertion that some degree of system immersion is a prerequisite for the sensation of presence within VR (the circle labeled A in Figure 3). However, because mental acts involving conceptual processing, such as daydreaming, are believed to hamper the direct perceptual processing necessary for presence, it seems plausible that narrative- and challenge-based immersion might contribute positively to the sensation of presence within the VE. Narrative immersion may be influential insofar as it involves explicit assignment of attention to the ongoing events, rather than contemplating the nature of these (Circle B, Figure 3). Waterworth and Waterworth (2003) explicitly stated that presence should not be confused with emotionality or level of interest. However, it does seem plausible that emotionally salient stimuli originating within the VE might entail allocation of resources to direct perceptual processing, thereby indirectly influencing the sensation of presence. Finally, it also seems plausible that challenge-based immersion may be of influence. The immersion accompanying intellectual challenges are likely to give rise to conceptual processing, which thereby results in absence. However, sensorimotor challenges might have the reverse effect. Such challenges will require the individual to focus
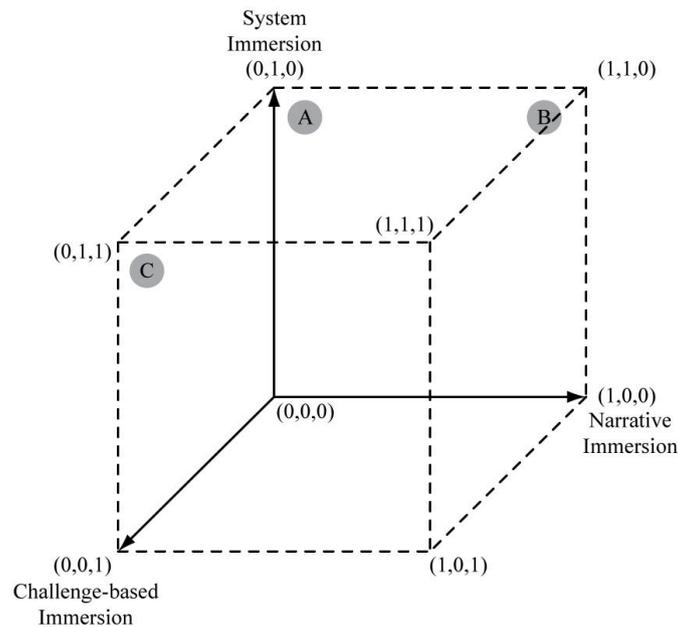
Figure 3. Illustration of how the different types of immersion may elicit a sensation of presence following E. L Waterworth and Waterworth's (2003) three dimensions of virtual experience. The grey circles represent instances believed to elicit presence. The three axes represent the extent to which interaction with a system involves system immersion (vertical), narrative immersion (horizontal), and challenge-based immersion (depth). The degree to which each type of immersion is presented is represented on a scale from 0 to 1, where 0 represent absence and 1 represents the highest possible level of immersion.

entirely on reacting to obstacles represented within the environment, which implies that the attentional resources are almost entirely devoted to direct perceptual processing (Circle C, Figure 3).

Layers of Presence

Riva and colleagues have proposed that the sensation of presence within real and virtual environments can be described in terms of layers of presence (Riva, 2009; Riva et al., 2004; Riva, Waterworth, Waterworth, & Mantovani, 2011). This proposition can be viewed in some capacity as an extension of E. L. Waterworth and Waterworth's (2001) description of virtual experiences in terms of the focus, locus, and sensus of attention. To be exact, it helps explain how focus might shift to produce a state of either presence or absence (Riva et al., 2004).

Riva et al. (2004) described presence as a bio-cultural mechanism that has evolved to help the self-making sense of perceived sensory data. Thus, presence may be the feeling that makes it possible for an individual to separate external percepts from internal mental constructions composed of imagined events and situations (Riva et al., 2004). The authors argued that, despite being experienced as a unitary feeling, it is possible to distinguish between three separate layers of presence associated with each of the three levels of the self, as proposed by Damasio (1999). In addition to drawing on the work of Damasio (1999), the

notions *core consciousness* and *extended consciousness* are central to Riva et al.'s (2004) description of how the three layers of presence impact one's experience of the surrounding environment. Core consciousness essentially refers to the basic integrated representation of the current environment. This level of consciousness may be shared across many species and be independent of language, reasoning, and memory (Riva et al., 2004). Extended consciousness is believed to rely largely on working memory and enables the individual to form and attend to internal worlds. Also, it makes it possible for the individual to consider possibilities extending beyond the current external situation (Riva et al., 2004).

The three layers of presence proposed by Riva et al. (2004) are *proto presence*, *core presence*, and *extended presence*. Proto presence is viewed as a mostly unconscious embodied presence that helps distinguish the self from the nonself through the coupling of perception and action. Thus, proto presence relies heavily on kinesthetic information about the relative position of the body in space. A high level of coupling between performed movements and perceptions will result in a large degree of differentiation between the self and the surrounding environment. The second layer, core presence, is described as the process of selective attention performed by the self on perceptions. When a large degree of attention is assigned to sensorial experiences, other neural processes are left in the background, leaving room for identification of the present moment and the tasks at hand. Finally, extended presence helps establish the significance of external events with respect to the self and thereby helps ensure that the self is present in significant experiences. When the three layers are integrated and leveled at a particular situation, this may give rise to what Riva et al. (2004) refer to as *proto consciousness*. When the contents of proto, core, and extended consciousness are aligned, then maximal presence is experienced, that is, the outermost extreme of the focus dimension described by E. L. Waterworth and Waterworth (2001). Contrarily, the other extreme of focus (i.e., absence) may arise when the current environment occupies a very small part of extended consciousness (Riva et al., 2004).

Riva et al.'s (2004) theory may, as suggested, be considered an elaboration on E. L. Waterworth and Waterworth's (2001) description of how the focus, locus, and sensus of attention influence virtual experiences. Therefore, it does not come as a surprise that the relation between the two theories and the new taxonomy is similar (see Figure 3). Riva et al. (2004) argued that print media and verbal accounts primarily engage extended consciousness and are unable to produce core or proto presence. For that reason, the integration of the three layers of presence is limited. Media forms relying more heavily on visual imagery, such as photographs or film, may to a larger extent elicit core presence. However, given their inability to support action–perception coupling, proto presence will be low. Indeed, it would seem that Riva et al.'s (2004) theory of presence suggested that a relatively high degree of system immersion may be a prerequisite for a maximal experience of presence within VR. In order for all three layers to be integrated, it is necessary to elicit proto presence, which is said to function on the level of proprioception, and spatial and internal monitoring (Riva et al., 2004). Considering that high levels of system immersion will enable the user to naturally perceive and interact within a computer-generated environment, such systems should support proto presence. However, it would seem that system immersion will not always suffice because the integration of all three layers is important for maximal presence. To elaborate, extended presence requires content that is either emotionally or intellectually significant. Thus, a virtual environment devoid of significant contents will be less likely to elicit a strong sensation of presence. Both narrative

immersion and challenge-based immersion are arguably accompanied by extended presence because an individual experiencing these types of immersion, by definition, is mentally absorbed by the unfolding narrative or the obstacles within the environment. As it happens, Riva et al. (2004) highlighted that narratives may be crucial when one wishes to design for optimal presence. However, they stressed that, in order for narratives to positively influence the sensation of presence, the user will have to assume the role of a character and inhabit the story. Similarly, the authors suggested that maximal presence bears semblance to the concept of flow. The characteristics of a flow state include intense and focused attention and a merging of action and awareness. Similarly, maximal presence may be experienced when proto, core, and extended consciousness are leveled at the same external event. Because challenge-based immersion in many regards corresponds to the state of flow, it seems likely that this form of immersion also would be conductive to presence as it is described by Riva et al. (2004).

Immersion and Illusions of Place and Plausibility

Slater and colleagues described presence as the phenomena occurring when individuals respond to virtual stimuli in the same way as they would when exposed to equivalent unmediated stimuli (Sanchez-Vives & Slater, 2005; Slater, Lotto, Arnold, & Sánchez-Vives, 2009). More specifically, this response should be similar on every level, "from unconscious physiological behaviors, through automatic reactions, conscious volitional behaviors, through to cognitive processing—including the sensation of being there" (Sanchez-Vives & Slater, 2005, p. 338). Thus, the sensation of presence makes up the subjective experience of a realistic response to virtually generated stimuli, that is, a response that would be identical if the stimuli were unmediated. Notably, Slater refined this theory of users' responses to VEs by suggesting that the sensation of being there is not the sole factor in determining whether an individual responds realistically to virtual stimuli (Rovira, Swapp, Spanlang, & Slater, 2009; Slater, 2009). Slater (2009) presented the hypothesis that this response-as-if-real can be ascribed to the simultaneous occurrence of not one but two perceptual illusions: the place illusion—the illusion that you are really there despite the sure knowledge that you are not—and the plausibility illusion—the illusion that the unfolding events are really happening in spite of the knowledge that they are not. Combined with notions of immersion and a virtual body, the place and plausibility illusions make up a conceptual framework for explaining how VEs potentially can transform our experience of space and ourselves (Slater, 2009).

Slater (2009) reserves the term place illusion for the type of presence that refers to the qualia of being there despite knowing that one really is not. Qualia can simply be understood as "the way things seem to us" (Dennett, 1988, p. 381). Slater (2003) eloquently used the relationship between the wavelength distribution of light and color perception as a metaphor to describe the connection between immersion and presence. Just as a color can be objectively described based on its wavelength distribution, so can immersion be described based on objective properties, such as frame rate, fidelity of tracking, or the size of the field of view. Even though wavelength distribution and immersion are objectively describable, they both lead to subjective experiences, namely, perceived color and illusions of place. Slater (2009) argued that one may characterize an immersive system by the sensorimotor contingencies it supports. Sensorimotor contingencies correspond to the actions that the user knows how to perform when attempting to perceive, such as, turning one's head in order to change the gaze direction or

taking a step forwards in order to more closely inspect an object. Slater (2009) went on to describe that the place illusion occurs as a function of the range of normal sensorimotor contingencies facilitated by the system. While system immersion is an objectively measurable quantity, presence is not. Thus, it is entirely possible for two individuals to experience different levels of presence despite being exposed to the same immersive system. The difference in experienced presence need not be caused by individual differences. Instead, a difference in the actions performed by the two individuals might be responsible for the variations in the sensations of presence. One person might explore the environment to a larger extent than the other: for example, by picking up and inspecting objects and thereby testing the limits of the system (Slater 2009). Notably, there is a considerable overlap between Slater's place illusion and existing definitions of immersion (e.g., general definition of immersion, Witmer & Singer, 1998; perceptual immersion, McMahan, 2003; and sensory immersion, Ermi & Mäyrä, 2005). In other words, these definitions hold that immersion corresponds to the subjective sensation of being enveloped by and included in the VE's mediated via high-fidelity tracking and displays. For that reason, it may not be particularly fruitful to rely on these definitions of immersion following this view of presence (Slater 1999).

Unlike place illusion, plausibility illusion is not the direct result of an individual's ability to perceive the VE. Instead, this perceptual illusion arises as a result of what the individual perceives within the environment. Specifically, the plausibility illusion occurs when the unfolding events are experienced as actually occurring, despite the certain knowledge that they are not (Slater, 2009). Rovira et al. (2009) indicated that the plausibility illusion depends on the VE meeting at least three conditions: (a) The actions performed by the user must produce correlated reactions within the VE (e.g., a virtual character might avoid eye contact and step aside if the user stares or exhibits aggressive body language); (b) The environment should respond directly to the user, even when the user is not performing an instigating action (e.g., a virtual character might react to the presence of the user without the user initially approaching or addressing this character); and (c) The environment and the events occurring within it should be credible, that is, they should conform to the user's knowledge and expectations accrued through a lifetime of unmediated interactions.

Slater's (2009) distinction between the place and plausibility illusion bears resemblance with Lombard and Ditton's conceptualization of presence as realism. Lombard and Ditton (1997) distinguished between two forms of realism that may contribute to the experience of presence, whether perceived in isolation or in concert, namely *social realism* and *perceptual realism*. Perceptual realism refers to the extent to which mediated artifacts appear like their real-world counterparts; social realism refers to "the extent to which a media portrayal is plausible or true to life, as it reflects events that do or could occur in the nonmediated world" (Lombard & Ditton, 1997, "Presence as Realism," para. 1). While place illusion need not be contingent upon visual realism (Sanchez-Vives & Slater, 2005), plausibility illusion shares some commonalities with social realism.

Slater (2009) described the body as the focal point where the illusions of place and plausibility are fused. During everyday interactions within unmediated environments, we humans continuously receive sensory information about our bodies. Slater (2009) argued that this ability to perceive ourselves serves as a strong confirmation of the place illusion. That is to say, if we are able to perceive our body then we must be there. The ability to provide users of VEs with a credible virtual body is therefore central to eliciting illusions of place.

On the topic of the relationship between Slater's conceptual framework and the taxonomy outlined earlier in this paper, it is evident that system immersion is viewed as the principal determinant for compelling place illusions (the circle labeled A in Figure 4). That is, the place illusion should increase as the range of natural sensorimotor contingencies supported by the system increases. Consequently, it may seem puzzling that individuals report experiencing a sense of being there after engaging with lower order immersive systems, such as a first-person video game played on a desktop system. When attempting to explain this predicament, Slater (2009) hypothesized that the types of presence brought about by lower and higher order immersive systems are qualitatively different. The illusion of being there elicited by systems providing a high level of system immersion happens as a consequence of exposure to the sensory stimuli. Contrarily, Slater (2009) provided the following account of the experience accompanying desktop systems:

> In the case of a desktop system the situation is quite different; the feeling reported as "being there" if it comes at all is after much greater exposure, requires deliberate attention and is not automatic—it is not simply a function of how the perceptual system normally works, but is something that essentially needs to be learned, and may be regarded as more complex. (Slater, 2009, p. 3552).

Some of Slater and colleagues' early work on walking-in-place locomotion arguably lend some credence to this claim. Slater, Usoh, and Steed (1995) found that the subjective sensation of presence was higher on behalf of subjects walking in place rather than pressing a button to
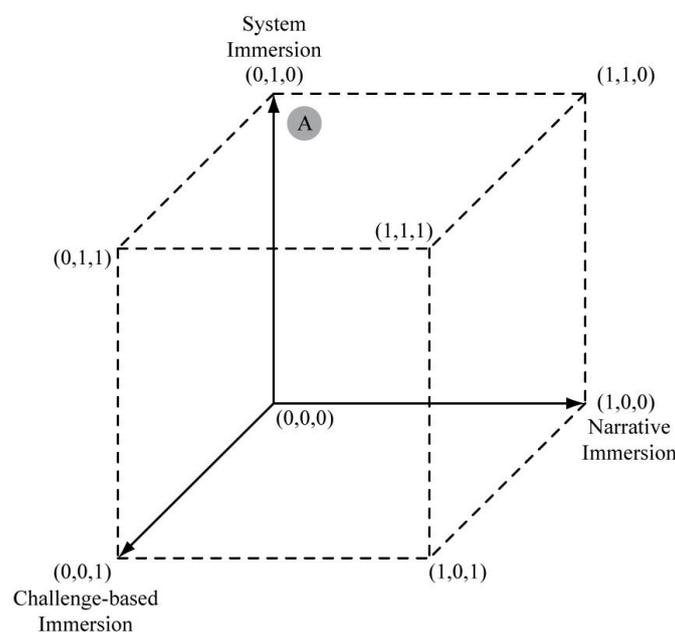

Figure 4. Illustration of how the different types of immersion may elicit a sensation of presence following Slater's (2009) framework. The grey circle represents instances believed to elicit presence. The three axes represent the extent to which interaction with a system involves system immersion (vertical), narrative immersion (horizontal), and challenge-based immersion (depth). The degree to which each type of immersion is presented is represented on a scale from 0 to 1, where 0 represent absence and 1 represents the highest possible level of immersion.

generate virtual movement. Usoh et al. (1999) confirmed these findings and also found that real walking is better than the two other input methods in terms of simplicity, straightforwardness, and naturalness. Even though locomotion methods allowing users' to rely on natural gestures may elicit stronger illusions of place than lower order systems, it would seem that players may exhibit emotional responses similar to those experienced in real life when interacting with lower order immersive systems. One example is the emotions experienced by phobic patients who play video games as treatment for their phobias (Bouchard, Côté, St-Jacques, Robillard, & Renaud, 2006).

Following this view of users' responses to VEs, narrative immersion and its three subcategories (temporal, spatial, and emotional) appear to have no effect on the place illusion. These forms of immersion are characterized by the user becoming mentally absorbed by the unfolding narrative, the diegetic space, and the characters inhabiting this space. The user's attraction toward, or aversion to, the sight, sound, and feeling of the virtual world is obviously relevant to the study of user experiences of VEs. However, these are matters of content rather than form, and they are therefore deemed inconsequential for the experience of presence following this view. To borrow an example from Slater (2003), imagine listening to a live recording of Bach's *Toccata and Fugue* in D minor on a high-end surround system. You do not need to be a classical music aficionado to experience the sensation of being in the concert hall. However, if you favor heavy metal, it is unlikely that you will find a similar situational experience enjoyable or involving. Thus, it would seem that narrative immersion should not be considered a factor contributing to illusions of place as described by Slater (2009). Finally, it is unlikely that challenge-based immersion is a factor influencing the place illusion, as introduced by Slater (2009). While the experience of challenge-based immersion will entail allocation of attention to the virtual obstacles, this does not mean that presence is experienced. As in real life, one may find a particular virtual task boring, enjoyable, or aggravating due to its difficulty level, but that has nothing to do with whether one feels present or not. This being said, one may argue that there might be one way in which narratives and challenges indirectly can influence the place illusion. Because the extent to which users probe the bounds of the immersive system might influence presence, it seems possible that the risk of too close inspection can be reduced by means of narrative contents and challenges explicitly designed to discourage users from performing undesired actions.

IMPLICATIONS FOR RESEARCH OR APPLICATION

The general aim of our research has been to explicate the different meanings associated with the term immersion and to clarify how these relate to varying views of presence. A better understanding of the similarities and differences between theories of presence and immersion may have implications for how scholars and researchers approach the study of these areas and for developers who seek to elicit and evaluate such experiences.

The current ambiguous and interchangeable use of terminology related to immersion and presence in the literature often results in a mismatch between the phenomena scholars wish to study and the methods they end up employing. For example, one theory of immersion or presence is taken as a point of departure but, in the data collection and/or analysis, the employed metrics are devised based on a different view of the concepts. Thus, clarified

knowledge of the theories pertaining to immersion and presence will help students, researchers, and developers to make well-informed decisions when consulting the literature, and thereby ensure correspondence between the theoretical underpinnings of a given project, design decisions, and the employed evaluation method. Specifically, the proposed taxonomy offers a useful starting point for both individuals who are entirely new to the concepts immersion and presence, and individuals that are just familiar with how the terms are used in a specific domain (e.g., video game studies or VE research). This is particularly relevant considering that technologically immersive virtual reality is becoming increasingly widespread and video games are a primary application area of such technology. Thus, game researchers are increasingly likely to need an understanding of the theory familiar to researchers working with VEs and vice versa. Moreover, immersive technologies are also being adopted by researchers and developers working within a variety of different fields, including health care and education, and the work documented in the current paper will serve as a valuable introduction to such individuals. Finally, because we propose that the different views on the concepts immersion and presence each have their merits, our work may help inform potential future research questions on behalf of scholars studying both video games and VEs: For instance, how does system immersion influence challenge-based and narrative immersion, and how can narrative elements and challenges be used to subtly prevent the user from probing the bounds of the system in a manner that disrupts the sensation of presence.

CONCLUSIONS

Through the research documented in the current paper, we sought to address two primary questions: What meanings are associated with the term immersion and how do these meanings map onto existing views of presence? In order to address these questions, we presented a review of existing definitions of immersion related to VEs, video games, and literary works of fiction and, based on this review, a taxonomy of different conceptualizations of immersion was proposed. Specifically, this taxonomy organizes existing definitions of immersion along three orthogonal dimensions: (a) immersion as a property of the system, (b) immersion as a response to an unfolding narrative, the diegetic space, or virtual characters, and (c) immersion as a response to challenges demanding use of one's intellect or sensorimotor skills. The first is an objectively measurable property of the system whereas the last two are characterized by an experience of intense and focused attention on events in the virtual world. Most existing categorizations of immersion are aligned with one of these two descriptions; that is, immersion is either an objective property of the system or a subjective state of the user. The proposed taxonomy illustrates that such dissimilar views need not be a source of ambiguity, but rather these can be used to describe various features of users' interactions with VEs. However, it is exactly because most existing views of immersion have their merits that researchers and developers need to clearly specify what they mean when using the term immersion. Taxonomies such as the one proposed in this paper should make this task easier.

The four theories of presence outlined in the current paper all relate to the sensation of being in a given virtual (or unmediated) environment. However, they differ in terms of the factors believed to influence presence. Particularly, the theories differ in regard to the importance assigned to mental imagery and the degree of explicit attention assigned to the sensory stimuli

depicting the environment. Biocca (2003) did not view system immersion to be a prerequisite for the illusion of being there because presence is dependent on a mental model of space that can receive spatial cues from sources other than sensory perception. Thus, following this view, narrative immersion should positively influence the sensation of presence. Moreover, challenge-based immersion may positively influence presence on behalf of users exposed to higher levels of system immersion insofar as the challenges help steer the user's attention towards events in the virtual world. The theories proposed by E. L. Waterworth and Waterworth (2001) and Riva et al. (2004) assigned greater importance to system immersion because the sensation of presence is thought to be contingent upon information being processed directly by the perceptual–motor systems. Notably, it would seem that narrative immersion may positively influence the sensation of presence as described by both E. L. Waterworth and Waterworth (2001) and Riva et al. (2004). Narrative immersion entails intense and focused attention on the unfolding narrative events. Such attention should reduce the risk that users will engage in mental acts involving conceptual processing that takes away resources from the direct perceptual processing necessary for presence (J. A. Waterworth & Waterworth, 2003). Similarly, narrative immersion may influence presence as described by Riva et al. (2004) because emotionally or intellectually significant events may induce extended presence. Challenge-based immersion brought about by sensorimotor challenges may also indirectly influence the sensation of presence following the theories of Waterworth and Waterworth (2001) and Riva et al. (2004) because it involves allocation of attention to the events occurring within the environment. Finally, Slater (2009) argued that the sensation of being there within a VE (i.e., the place illusion) occurs as a function of the range of normal actions the user knows how to perform when attempting to perceive. Based on this account, it is apparent that system immersion is viewed as the principal factor determining whether presence is experienced. Nevertheless, this does not mean that the place illusion is viewed as being the same as system immersion. One user may perform actions that the system does not support, thus experiencing a different degree of the illusion than a user who does not probe the bounds of the system. Moreover, the narrative contents or the posed challenges may indirectly influence the place illusion by encouraging the user only to perform actions permitted by the system. Neither narrative immersion nor challenge-based immersion should be influential. Following this view, the illusion of place appears to be divorced from the individual's interest in the activity being performed. A realistic response to virtual stimuli may be characterized equally well by indifference and excitement. Just as in real life, a user may find virtual events irrelevant, fascinating, challenging, or trivial, but that has nothing to do with whether the place illusion is experienced.

In this paper, we have attempted to highlight the relatively large differences between existing views of what characterizes and causes presence. We believe it to be crucial that researchers and developers are mindful of these differences when interpreting the findings of others and when selecting what measures of presence to employ. Furthermore, because the terms presence and immersion have been used to refer to similar phenomena, a number of the methods developed to study some conceptualizations of presence may be applicable when studying psychological immersion and vice versa. In particular, both narrative and challenge-based immersion are characterized by an experience of intense and focused attention on events in the virtual world. Similarly, some views of presence hold that the sense of being in the virtual space requires the user's attention to be leveled at the virtual world. Thus, measures assessing presences in terms of allocation of attentional resources should also be applicable

when attempting to assess the degree to which narratives or challenges fully capture the user's attention. To exemplify, IJsselsteijn, de Ridder, Freeman, and Avons (2000) described that the so-called secondary reaction time measure has been used to measure presence. The underlying assumption is that the user will react slower and produce more errors on a given secondary task, as compared to the primary task, if presence is experienced. Because such methods essentially operationalize presence in terms of allocation of attentional resources, they may also be used to assess the intensity of narrative and challenge-based immersion. Thus, knowledge of the differences and similarities between varying views of immersion and presence will enable students, researchers, and developers to make well-informed decisions when consulting the literature in search for design guidelines and evaluations methods.

Even though the current paper does provide an overview of existing views of immersion and their relation to four theories of presence, it is possible to point to certain limitations of the work and propose potential directions for future research. Most notably, the literature review is not exhaustive, and therefore we cannot claim that all conceptualizations of immersion and presence have been covered. For that reason it would be meaningful for future work to adopt an approach similar to the one employed when performing critical reviews (Cook et al., 1997). That is, such a review should involve a comprehensive search of all potentially relevant work based on reproducible criteria. Other than providing a more complete picture, a critical review would also enable researchers to comment on the prevalence of various definitions of the terms across different domains and allow for the work to include a systematic review of the design principles and evaluation methods associated with different conceptualizations of immersion and presence. Moreover, it would be meaningful for future work to more explicitly include related terms such as engagement, absorption and involvement. Nevertheless, it is hard to argue why the term immersion is better suited to describe certain notions rather than others. Thus, we hope that the current review and the accompanying the taxonomy may offer clarity by making explicit the different conceptions of the term immersion and their relation to different theories of presence.

REFERENCES

Adams E., & Rollings A. (2006). *Fundamentals of game design*. Upper Saddle River, NJ, USA: Prentice Hall, Upper Saddle.

Argyle, M., & Dean, J. (1965). Eye-contact, distance and affiliation. *Sociometry*, *28*(3), 289–304.

Arsenault, D. (2005). Dark waters: Spotlight on immersion. In proceedings of the *Game-On North America 2005 Conference* (pp. 50–52). Ghent, Belgium: Eurosis.

Biocca, F. (2003, May). *Can we resolve the book, the physical reality, and the dream state problems? From the two-pole to a three-pole model of shifts in presence*. Paper presented at the EU Future and Emerging Technologies, Presence Initiative Meeting, Venice, Italy. Retrieved June 17, 2016, from http://www.mindlab.org/images/d/DOC705.pdf

Blascovich, J., & Bailenson, J. (2011). *Infinite reality: Avatars, eternal life, new worlds, and the dawn of the virtual revolution*. New York, NY, USA: HarperCollins Publishers.

Bouchard, S., Côté, S., St-Jacques, J., Robillard, G., & Renaud, P. (2006). Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games. *Technology and Health Care*, *14*(1), 19–27.

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion. In *CHI'04 extended abstracts on human factors in computing systems* (pp. 1297–1300). New York, NY, USA: ACM.

Chen, J. (2007). Flow in games (and everything else). *Communications of the ACM*, *50*(4), 31–34.

Cook, D. J., Mulrow, C. D., & Haynes, R. B. (1997). Systematic reviews: Synthesis of best evidence for clinical decisions. *Annals of Internal Medicine*, *126*(5), 376–380.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York, NY, USA: Harper & Row.

Damasio, A. (1999). *The feeling of what happens: Body, emotion and the making of consciousness.* San Diego, CA, USA: Harcourt Incorporated.

Dennett, D. C. (1988). Quining qualia. In A. Marcel & E. Bisiach (Eds.), *Consciousness in modern science*. Oxford, UK: Oxford University Press.

Duh, H. B. L., Lin, J. J., Kenyon, R. V., Parker, D. E., & Furness, T. A. (2001, March). *Effects of field of view on balance in an immersive environment*. Paper presented at the 2001 IEEE Virtual Reality Conference, Yokohama, Japan.

Dura, M. T. (2006). The phenomenology of the music-listening experience. *Arts Education Policy Review*, *107*(3), 25–32.

Ermi, L., & Mäyrä, F. (2005). Fundamental components of the gameplay experience: Analysing immersion. In S. D. de Castell & J. Jenson (Eds.), *Worlds in play: International perspectives on digital games research* (pp. 15–27). New York, NY, USA: Peter Lang Publishing.

Fox, E. (2008). *Emotion science cognitive and neuroscientific approaches to understanding human emotions*. Basingstoke, UK: Palgrave Macmillan.

Hassan, S. E., Hicks, J. C., Lei, H., & Turano, K. A. (2007). What is the minimum field of view required for efficient navigation? *Vision research*, *47*(16), 2115–2123.

Ihde, D. (2007). *Listening and voice: A phenomenology of sound* (2nd ed.). New York, NY, USA: State University of New York Press.

IJsselsteijn, W. A., de Ridder, H., Freeman, J., & Avons, S. E. (2000, June). *Presence: concept, determinants, and measurement*. Paper presented at Human Vision and Electronic Imaging V conference, San Jose, CA, USA.

International Society for Presence Research (ISPR). (2000). *The concept of presence: Explication statement*. Retrieved June 17, 2016, from https://ispr.info/about-presence-2/about-presence/

Jansen, S., Toet, A., & Delleman, N. (2010). Restricting the vertical and horizontal extent of the field-of-view: Effects on manoeuvring performance. *The Ergonomics Open Journal*, *3*, 19–24.

Kosslyn, S. M. (1983). *Ghosts in the mind's machine: Creating & using images in the brain*. New York, NY, USA: W. W. Norton.

Kosslyn, S. M. (1996). *Image and brain: The resolution of the imagery debate*. Cambridge, MA, USA: MIT Press.

Kosslyn, S. M., & Koenig, O. (1992). *Wet mind: The new cognitive neuroscience*. New York, NY, USA: Free Press.

Lin, J. J. W., Duh, H. B., Parker, D. E., Abi-Rached, H., & Furness, T. A. (2002, March). *Effects of field of view on presence, enjoyment, memory, and simulator sickness in a virtual environment*. Paper presented at the 2002 IEEE Virtual Reality Conference, Orlando, Florida, USA.

Lombard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer–Mediated Communication*, *3*(2), unpaginated. doi: 10.1111/j.1083-6101.1997.tb00072.x/

McMahan, A. (2003). Immersion, engagement, and presence: A method for analyzing 3-D video games. In W. Mark & B. Perron (Eds.), *The video game theory reader* (pp. 67–86), New York, NY, USA: Routledge.

Minsky, M. (1980). Telepresence. *Omni*, *2*, 45–51.

Murray, J. B. (1997). *Hamlet on the holodeck: The future of narrative in cyberspace*. New York, NY, USA: Free Press.

Nakamura, J., & Csikszentmihalyi, M. (2005). The concept of flow. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of positive psychology* (pp. 89–105). Oxford, UK: Oxford University Press.

Nilsson, N. C., Serafin, S., & Nordahl, R. (2014). Establishing the range of perceptually natural visual walking speeds for virtual walking-in-place locomotion. *IEEE Transactions on Visualization and Computer Graphics*, *20*(4), 569–578.

Prince, G. (2003). *A dictionary of narratology*. Lincoln, NE, USA: University of Nebraska Press.

Riva, G. (2009). Is presence a technology issue? Some insights from cognitive sciences. *Virtual Reality*, *13*(3), 159–169.

Riva, G., Waterworth, J. A., & Waterworth, E. L. (2004). The layers of presence: A bio-cultural approach to understanding presence in natural and mediated environments. *CyberPsychology & Behavior*, *7*(4), 402–416.

Riva, G., Waterworth, J. A., Waterworth, E. L., & Mantovani, F. (2011). From intention to action: The role of presence. *New Ideas in Psychology*, *29*(1), 24–37.

Rooney, B., Benson, C., & Hennessy, E. (2012). The apparent reality of movies and emotional arousal: A study using physiological and self-report measures. *Poetics*, *40*(5), 405–422.

Rovira, A., Swapp, D., Spanlang, B., & Slater, M. (2009). The use of virtual reality in the study of people's responses to violent incidents. *Frontiers in Behavioral Neuroscience*, *3*, Art 59. doi: 10.3389/neuro.08.059.2009

Ryan, M. L. (2003). *Narrative as virtual reality: Immersion and interactivity in literature and electronic media*. Baltimore, MD, USA: The Johns Hopkins University Press.

Ryan, M. L. (2008). Interactive narrative, plot types, and interpersonal relations. In U. Spierling & N. Szilas (Eds.), *Interactive storytelling* (pp. 6–13). Berlin, Germany: Springer-Verlag**.**

Saariluoma, P. (2005). Explanatory frameworks for interaction design. In A. Pirhonen (Ed.), *Future interaction design* (pp. 69–83). London, UK: Springer.

Sanchez-Vives, M. V., & Slater, M. (2005). From presence to consciousness through virtual reality. *Nature Reviews Neuroscience*, *6*(4), 332–339.

Sheridan, T. B. (1992). Defining our terms. *Presence: Teleoperators and Virtual Environments*, *1*(2), 272–274.

Slater, M. (1999). Measuring presence: A response to the Witmer and Singer presence questionnaire. *Presence: Teleoperators and Virtual Environments*, *8*(5), 560–565.

Slater, M. (2003). A note on presence terminology. *Presence-Connect*, *3*(3), unpaginated. Retrieved November 8, 2016, from http://s3.amazonaws.com/publicationslist.org/data/melslater/ref-201/a%20note%20on%20presence%20terminology.pdf

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1535), 3549–3557.

Slater, M., Lotto, B., Arnold, M. M., & Sánchez-Vives, M. V. (2009). How we experience immersive virtual environments: The concept of presence and its measurement. *Anuario de Psicología*, 2009, *40*, 193–210.

Slater, M., Usoh, M., & Steed, A. (1995). Taking steps: The influence of a walking technique on presence in virtual reality. *ACM Transactions on Computer–Human Interaction*, *2*(3), 201–219.

Steinicke, F., Bruder, G., Kuhl, S., Willemsen, P., Lappe, M., & Hinrichs, K. (2011). Natural perspective projections for head-mounted displays. *IEEE Transactions on Visualization and Computer Graphics*, *17*(7), 888–899.

Toet, A., Jansen, S. E., & Delleman, N. J. (2007). Effects of field-of-view restrictions on speed and accuracy of manoeuvring. *Perceptual and motor skills*, *105*(3f), 1245–1256.

Usoh, M., Arthur, K., Whitton, M. C., Bastos, R., Steed, A., Slater, M., & Brooks Jr, F. P. (1999, July). Walking> walking-in-place> flying, in virtual environments. In *Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Ttechniques* (pp. 359–364). New York, NY, USA: ACM Press/Addison-Wesley Publishing Co.

Visch, V. T., Tan, E. S., & Molenaar, D. (2010). The emotional and cognitive effect of immersion in film viewing. *Cognition and Emotion*, *24*(8), 1439–1445.

Waterworth, E. L., & Waterworth, J. A. (2001). Focus, locus, and sensus: The three dimensions of virtual experience. *CyberPsychology & Behavior*, *4*(2), 203–213.

Waterworth, J. A., & Waterworth, E. L. (2003). The meaning of presence. *Presence-Connect 3*(2), unpaginated. Retrieved 8 November 2016 from http://www8.informatik.umu.se/~jwworth/PRESENCE-meaning.htm

Watt, S. J., Bradshaw, M. F., & Rushton, S. K. (2000). Field of view affects reaching, not grasping. *Experimental Brain Research*, *135*(3), 411–416.

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, *7*(3), 225–240.

Zahorik, P., & Jenison, R. L. (1998). Presence as being-in-the-world. *Presence: Teleoperators and Virtual environments*, *7*(1), 78–89.

Zeltzer, D. (1992). Autonomy, interaction, and presence. *Presence: Teleoperators and Virtual Environments*, *1*(1), 127–132.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *38*(9), 25–32.

Authors' Note

All correspondence should be addressed to
Niels Christian Nilsson
Aalborg University Copenhagen
A.C. Meyers Vænge 15
2450 København SV, Denmark
ncn@create.aau.dk