G. Riva, M.T. Anguera, B.K. Wiederhold and *F. Mantovani* (Eds.)
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2 Media Presence and Inner Presence: The Sense of Presence in Virtual Reality Technologies

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Abstract. Presence is widely accepted as the key concept to be considered in any research involving human interaction with Virtual Reality (VR). Since its original description, the concept of presence has developed over the past decade to be considered by many researchers as the essence of any experience in a virtual environment.
The VR generating systems comprise two main parts: a technological component and a psychological experience. The different relevance given to them produced two different but coexisting visions of presence: the rationalist and the psychological/ecological points of view. The rationalist point of view considers a VR system as a collection of specific machines with the necessity of the inclusion of the concept of presence. The researchers agreeing with this approach describe the sense of presence as a function of the experience of a given medium (Media Presence). The main result of this approach is the definition of presence as the perceptual illusion of non-mediation produced by means of the disappearance of the medium from the conscious attention of the subject. At the other extreme, there is the psychological or ecological perspective (Inner Presence). Specifically, this perspective considers presence as a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the control of the human activity.
Given its key role and the rate at which new approaches to understanding and examining presence are appearing, this chapter draws together current research on presence to provide an up to date overview of the most widely accepted approaches to its understanding and measurement.

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2.1 Introduction

Up until the twentieth century, one of the driving forces behind western art was the quest for faithful and compelling reproduction – a virtual rendering of another place, frozen in time. During the twentieth century new technologies such as still cameras and cinematography replaced the canvas and provided a faithful and even dynamic historical record [1]. As the twenty-first century begins a wealth of new technologies have been developed to replace those of cinema and aim to provide an even richer sensory experience. This chapter considers how far technology has come and the potential for new technologies to create not a rendering of a place in time but of that place here and now. The chapter goes on to discuss the means by which one can attempt to quantify the fidelity of a virtual rendering of a real environment as a means of improving current technology and gauging its effectiveness as a training tool.

When it first arrived, image motion was a major leap forward in purveying a sense of virtual realism. Rumour has it that when, in 1895, the Lumière brothers showed the first movie - depicting a train approaching a station - it had people screaming and running for cover. But today's more sophisticated audiences are less unlikely to be convinced by a grainy, black and white, two-dimensional image. Fortunately, technology has improved. One important aspect of this improvement is in the use of man-machine interfaces. Whereas an audience was once restricted to the role of mere passive observer or to the use of an external devices such as a mouse or keyboard, technological developments that have occurred since the 60's have allowed the production of more natural and compelling man-machine interaction systems.

This is nowhere better represented than in the area of haptic control devices. There has been a series of ever more sophisticated devices developed which successfully transmit a feeling of being within the perceptive world created by the machine. Visual display devices have also developed enormously, providing higher resolution, stereoscopy, a larger field of view and devices, which respond almost immediately to the human body's natural movements. For the observer, these developments create a stronger feeling of being a part of the virtual environment. The person while physically located in the real world, through sensory stimulation is manipulated to develop a feeling that the objects surrounding them are actually present in the same environment as the individual [2].

2.2 Origin of the Term "Presence"

The term "*telepresence*" was coined by Marvin Minsky in 1980 and refers to the phenomenon that a human operator develops a sense of being physically present at a remote location through interaction with the system's human interface [1]: through the user's actions and the subsequent perceptual feedback he/she receives via the appropriate teleoperation.

Teleoperations are a specific type of VR that allow the individual to operate in a distant environment (e.g., in space, in the depths of the sea or harmful locations). The user is given the opportunity to command a machine with an anthropomorphic design, which moves according to the user's movements and gives both auditory

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and visual feedback [5]. Such sensory feedback is of sufficient quality and quantity to maintain the operator's feeling of presence in the remote workplace [6]. The operator perceives two separate environments simultaneously: the physical environment where he or she actually is, and the environment, which is being presented via the technology. The term "telepresence" is used when the virtual experience dominates the real world experience. So it describes the feeling of being in the environment generated by the technology, rather than the surrounding physical environment [4].

However, the term "*presenc*e" entered in the wide scientific debate in 1992 when Sheridan and Furness used it in the title of a new journal dedicated to the study of virtual reality systems and teleoperations: *Presence, Teleoperators and Virtual Environments.* In the first issue, Sheridan [3] refers to presence elicited by a virtual environment as "virtual presence", whereas he uses "telepresence"only for the cases involving teleoperations [4].

Nowadays, most new VR devices are not used to operate at a distance. Rather, these systems generate a virtual environment in which the user can participate: not by altering an external real world, but by altering a virtual world generated by the computer. The participant ceases to think of himself as interacting with a computer and starts to interact directly with the three dimensional environment.

2.3 The Two Sides of the Same Coin: Media Presence and Inner Presence

An electronic Forum "Presence-L Listserv" established in July 1999 by the *Information Systems Division* of the *International Communication Association*, hosted a discussion of presence in 2000. A tentative definition of the concept of presence resulted from this: "Presence is a psychological state or a subjective perception in which the participant, although working with an instrument, fails to understand the role of technology in his experience. Although the subject might assert (except in extreme cases) that he is using technology, up to a certain point, or a certain degree, the subject gets involved in the task, in objects, entities and event perception, as if technology was not present"[7]. Although quite comprehensive, this is not the last word on the debate of the term's meaning. Presence entails some emotional involvement and is related to different levels of realism [8]. Many different definitions and descriptions of media presence exist, although it is almost always defined as a feeling of being present in a virtual environment [9]. The objective for most researchers is to develop an operational definition of media presence, with objective measures that may determine adequate levels of presence for the accomplishment of certain tasks. Bearing in mind these aspects, a definition of presence would allow standardization of its evaluation as a valid and reliable measure.

The VR generating systems comprise two main parts: a technological component and a psychological experience. Following this, there will be a dichotomy of the definitions and explanations of the feeling of presence: the rationalist and the psychological point of view.

The rationalist point of view considers a VR system as a collection of specific machines with the necessity of the inclusion of the concept of presence. The researchers agreeing with this approach describe the sense of presence as a function of our experience of a given medium (*Media Presence*). The main result

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of this approach is the definition of presence as the *perceptual illusion of non-mediation* produced by means of the disappearance of the medium from the conscious attention of the subject.

However, the technologic definitions of VR do not deny existence of the psychological component offered by the VR systems, it is simply not included in the definition. At the other extreme there is the psychological or ecological perspective (*Inner Presence*). As we will see in the next two chapters by Riva and by Waterworth *et al*., the feeling of presence is seen as an experience common among different types of human experiences independent of any technology. Specifically, these researchers consider presence as a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the control of the human activity [10-11].

The logical extension of this definition, as discussed in the final chapter of this Section by Moller and Barbera, is that dreams too are virtual experiences involving presence.

2.4 Media Presence in Virtual Reality

VR from a rationalist perspective is typically defined in terms of a collection of technological hardware (computers, helmets and gloves) normally involving a means to communicate [11]. Thus, according to this point of view, a system is VR if it comprises a minimal set of machines. In other words it is a set of diverse technologies placed together. An analogy would be multimedia (MM) applications based on the integration of multiple media like audio, text, video and image. The main difference between VR and MM systems is that the former allows interactive environments.

VR offers a new paradigm in which the users are active participants in a computer generated three-dimensional virtual world [3]. VR is characterized by the illusion of participating in a synthetic world instead of the external observation of that environment through an immersive and multi-sensorial experience [12]. Machover and Tice's [13] definition of presence emphasizes the interactive and immersive components. According to Pimentel and Teixeira: "through visualizing stereoscopic images, hearing binaural sound and manipulating three-dimensional objects in real time in a computer generated world, the subject can overcome the barrier represented by the computer screen and experience new realities" [14]. In functional terms VR is a simulator in which computer-generated graphics respond to the user's command.

Existing sensory stimulation devices allow the users to enter three-dimensional worlds where they can see, hear, touch, move and explore. The virtual space immerses the user and he has an egocentric position similar to the real world. The diversity and quality of these impressions determine the level of immersion, creating a feeling of presence. A technologically ideal system should allow the stimulation of all sensory systems, having trackers for the torso and limbs that would be used to provide precise and instantaneous stimulation feedback to the user [15].

Mazuryk and Gervautz [6] group VR systems according to the different levels of immersion offered to the user. They consider VR immersive systems those which put the user completely inside the world generated by computer, with the help of a

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HMD which supports a stereoscopic vision of the scene according to the positioning of the user and the use of audio and haptic man-machine interfaces. The more VR stimulation and the less external stimulation, the more immersive is the virtual environment.

Some researchers consider immersion as the description of a technology [16, 2, 17]. Total immersion requires, for example, that the participant be able to see 360º, in other words, immersion refers to the physical extent of the sensorial information. To these authors, immersion is purely technological and the feeling of presence is, mostly, determined by the insertion of the subject in the system. This way, immersion depends on technology and the world is presented from the user's point of view such that each time the user moves his head new images are generated according to new viewing geometry. Immersion increases with isolation from the physical environment, inclusion in the virtual situation, the possibility of a natural interaction with the environment and control over it, as well as the existence of stimuli that support the perception of self-motion [18].

According to this perspective, the higher the sensorial immersion, the higher the feeling of non-mediation, offering a feeling of 'being there'. The main purpose of VR is, therefore, to induce the feeling of reality through the development of an immersive synthetic system, in which the subject can interact with computer generated objects and people [19]. It is, therefore, basically, about 'misleading' the senses.

Thus, what differentiates VR from other systems and ways of communicating (e.g., cinema, television) is the bringing together of immersive stimulation (which is the capacity of the system to decrease stimulation due to the real world and increase stimulation from the synthetic world) mostly conveyed by the HMD, and the active participation in the environment, mostly conveyed by the tracker. The sensorial stimulation and the participation in a world generated by a computer seem to be the main factors which lead participants to feel, when immersed in one of these systems, what researchers of this field call presence.

2.5 Inner Presence in Virtual Reality

According to Steuer [6], presence is a component with such importance to VR that it can be seen as part of its definition, and virtual reality should not be defined solely in terms of hardware. He offers an alternative definition for VR as a particular type of experience instead of a technology. Presence can be evoked in writing (e.g, letter, journal), through hearing (e.g., telephone calls, music records) and in a composed process (e.g., movies, videogames). Thus, without referring to any type of hardware, Steuer defines VR as a real or simulated environment in which the participant experiences telepresence [6]. The author does not deny, however, that although many factors contribute to generate the feeling of presence, the quality of the sensorial input and the interactivity of the participant are important in its existence.

According to this point of view, the interaction with the synthetic world offers the subject a feeling of immersion and the world of the computer becomes the world of the user. However this immersion is a result of the interaction between man and environment and not a technological component of VR [6]. Because immersion promotes the feeling of 'being there', in the virtual environment,

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presence is considered a property that emerged from immersion [17], and 'being there' is enhanced by the possibility of 'acting there' [20].

In order to understand this point of view it is useful to contrast it with Loomis' [21]. Loomis considers that the understanding of synthetic experiences should begin by recognizing that its phenomenology is continuous with the normal experience. The perceptual world is created by our senses and nervous system and interaction with the physical world is mediated by such processes. Loomis reminds us of our naïve realism in which we often assume that our vision of the world is equivalent to the world itself. In particular Loomis states that: "The physical world, including our nervous system, is not given to us directly through experience but is inferred through observation and critical reasoning. Given the separation between these two domains, it is useful to recognize the 'normal' division between 'self' or internal phenomenon and 'non self', or external phenomenon". According to these authors and these perspectives, normal experience is therefore mediated. What we experience is a construction, elaborated from our senses and nervous system, as functional as the representation of reality, which makes us act upon the representation as if it was the reality; yet, the real world can merely be inferred [8].

Alternatively, the ecological perceptionist J.J. Gibson believed that the environment can be directly understood, without the need for mediation through cognitive processes [22]. Based on Gibson's ecological theory, Zahorik and Jenison [23] define presence as actions successively afforded by the environment. They maintain that the feeling of presence results from the efficacy of the match between perception and action; in this case, between the user and the virtual environment. The authors suggest that a change in perspective from the rationalist tradition to a Heidggerian vision might be useful for the study of presence (see for more details the next chapter by Riva). The rationalist tradition is the metaphysical position underlying most current theories, and theories regarding VR systems are no exception [23]. Opposed to empiricism, rationalism theorizes that knowledge acquisition is based on reason. This orientation separates the individual world into the mental and physical domains.

Heidegger was a German philosopher who worked mainly on the question of the meaning of 'being'. In order to explore this subject, Heidegger explains we are thrown towards the situations in which we should continuously act and interpret, labelling this 'throwness'. In this way: "…given that we are continuously interpreting, we cannot (in normal circumstances) represent in a detached and analytical way the situation we live in" [23]. Along with Heidegger's proposal of a form of existence, he also argues that when a person is working such as using an object with intention, there is no stable representation of the object, the tool or the equipment [23]. The equipment is conceived according to the use it has to the task. Through action, the equipment becomes transparent to the user and the stable representation of the instrument disappears. Hand gives an interesting example of the power of the use of an instrument to the accomplishment of a task: "When we look at a mirror we are not concerned with the fact that the image presented is not us, but we use it as if it was, because it serves the execution of a task which without the mirror would become much harder"{25].

It seems that Gibson's [24] perspective is quite similar to Heiddeger's in this regard. His theory states that, in perception, the environment is closely related to the observer. Perceptions support successful actions in the environment capturing

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its opportunities, permissions or affordances. For example, the ground permits walking and a hole permits falling, an apple permits being eaten and a tiger permits us getting eaten [26]. Each possibility or permission depends on the environment and the animal. There is, therefore, a perception-action in which the organism understands the environment according to what it allows it to do. Gibson's ontology is one of reciprocity between perceiver and environment. Both reject distinctions between subject and object. The instruments become, according to Heidegger, 'ready-to-hand', unconscious, when the user is not more conscious of the tool itself but only on its use for the task he is performing [26]. Both authors agree that the objects of perception should be understood in terms of possible actions with the perceiver. Given that the VR system is presented in a concrete way, the interaction with it is not accomplished in a symbolic form of textual language, as in books. The user experiences VR through the same perceptive processes with which he interacts with the real world [27].

The fact that the virtual environment allows the perceptive, cognitive and psychomotor capacities of humans to be projected into distant, dangerous or simulated environments [28], allows presence to simply be a consequence of a supported and successful action in the environment. When the response is seen as commensurate with the response that would be given usually in the real world, within the parameters of evolution of the organism and the perceptive system, then it is an action that supports expectations. It can be assumed that the user understands the VR equipment in terms of what can be done with it, resulting in invisibility of the VR (*ready-to-hand*) technology to the user [26]. In fact, when an individual is immersed, his self-perception is inseparable from the perceived environment [17]. The feeling of presence occurs when the subject mentally represents the possibility of acting upon the virtual world. The real cause of the feeling of presence is the interactions [29, 4]. Therefore, presence in a virtual environment is an active suppression process of the real world and the construction of a set of action patterns based on the immediate stimulus.

Following this approach, Riva and Waterworth [10, 11, the next two chapters] defined presence as an evolved neuropsychological process whose goal is the control of the activity of the subject. This is achieved by filtering and organizing the streams of sensory data: the more this process differentiates the self from the external world, the more is the level of presence experienced by the subject. Within this vision, they suggest that the ability to feel "present" in a virtual reality system – an artifact - basically does not differ from the ability to feel "present" in the real world.

A final point expressed by the psychological approach is the link between presence and its evolutionary role [10-11]. Even if presence is a unitary feeling, recent neuropsychological research has shown that, on the process side, it can be divided in three different layers/subprocesses, phylogenetically different, and strictly related to the evolution of self:

- *proto presence* (self vs. non self);
- *core presence* (self vs. present external world);
- and *extended presence* (self relative to present external world).

The existence of three different layers underlying presence suggests that in the real world, the sense of presence is not the same in all the situations but can be different in relation to the characteristics of the social and cultural space the

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subject is in. For instance, if I'm attending a presentation in a conference, my level of presence in it can be lower or higher in relation to the interest I have in the topic discussed. If the presentation is totally boring I may become absent (totally internal). As will by discussed in the fothcoming chapter by Waterworth and Waterwoth, the role of absence is critical for the survival of the subject, because it is in absence that the subject defines plans and organizes future behaviors.

2.6 Variables that Influence the Feeling of Presence

Much research has been devoted to discovering the range of variables, which might contribute to an enhanced sense of presence in VR. In general, two categories of variables can determine a user's presence: (i) user characteristics, and (ii) media characteristics [12]. Moreover, it is possible to divide the characteristics of the medium into media *form* and media *content* variables. The following sections reports how each of these characteristics either support or erode this experience.

2.6.1 User Characteristics

Although the VR technology used will highly influence the level of immersion achieved, the individual user also plays an active part with respect to his interest in the material presented [19]. There are several psychological variables that can impact presence including: concentration, previous experience with VR, previous experience with required tasks, expectations regarding the mediated experience and susceptibility to motion sickness. Although simulator sickness is a form of motion sickness induced by discrepancies between visual and vestibular information in a VE, some individuals can also have an increased predisposition to succumb to the sickness. Each of these variables influence the extent to which the user becomes involved in any task required of them in the VE.
According to Heeter [30], VR can benefit from lessons learned in cinema direction and the resultant capacity to suspend audience disbelief, thereby creating a feeling of presence. Some authors report that users need to be willing to suspend disbelief to participate in a VR environment and experience the feeling of presence [31]. This willingness appears to be related to what is commonly referred to as absorption (the ability to "get lost in the task at hand") and dissociation (disruption in the normally integrated functions of consciousness, memory, identity, or perception of the environment), as defined by Murray, Fox and Pettifer [32]. So, there appears to be a commitment between man and machine in the experience of presence where the machine's task is to mislead man's senses while man himself must allow himself to be misled in order to be immersed in the VE.
Hoffman, Prothero, Wells and Groen [33] demonstrated that chess players experienced increased presence when chess pieces were distributed in significant positions, compared to random positions. The authors also suggested that the more the users focused their attention on virtual environment stimuli, the more they were involved in the experience, resulting in higher degrees of presence [18]. Thus, the feeling of presence also depends on the meaning the user gives to the stimuli that are presented to him. The notion of presence is therefore inseparable from attentional factors [34, 18].

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According to Witmer and Singer [18], involvement is a psychological state resulting from the focus of energy and attention to a coherent group of significantly related stimuli and activities. The level of involvement achieved depends on the degree of importance attached and meaning given to the event by individual users. It is also influenced by the level of intent a user is capable of directing toward the virtual environment. The participant's ability and will to focus on the task can increase their feeling of presence since it requires the individual to not only concentrate on the task and virtual environment but also to ignore external distractions [18].

VR seems to facilitate, through technological immersion, selective attention regarding the mediated environment. Selective attention is the tendency to focus on significant information of particular interest to the individual [18]. Usually, attention is divided among one or more components of the physical and mental world of memories and planned activities. Darken, Bernatovich, Lawson and Peterson [35] consider that in order to be present in an alternative world, it is necessary to be focused on that world and not the real one. Thus, the extension of presence might depend not only on the quality and extension of the sensorial information, but also in the interest evoked by the presented scene. If the user is worried about personal issues or focused on activities that are occurring outside the virtual environment they will naturally be distracted and therefore less involved [18].

Due to the range of influential user variables a VR experience is ultimately a personal one. It is an experience that becomes inexplicably tied to personal aspects of the user and how they construct an explanation of their experience. Even with the identical technology in use, therefore, it is unlikely any two users would experience the identical level of presence. As discussed in a later section on presence measurement this becomes highly problematic for self-report measures.

2.6.2 Media Characteristics: Media Form

Technological or system characteristics can play an important role in the experience of presence. Although systematic research regarding the causes of presence is ongoing, a considerable number of variables have been identified. Several causal factors have been investigated and a growing number of possible determinants of presence have been empirically tested. The majority of these studies have tried through manipulation of system characteristics to increase the user immersion in the VR system and thereby increase the feeling of being present in the virtual world [36]. Among the topics studied are latency of response [37]; audio system [35]; stereoscopic presentation [38]; head tracker [39]; visual field [40] and the control process [29, 42].

For further discussion the findings of this research have been grouped under the following variables of influence: sensorial channels; pictorial realism; media content; system response time; control; vision field; isolation; body representation and the presence of other subjects in the VR environment.

2.6.2.1 Number of Sensorial Channels

According to Steuer [4], the sensorial input quality refers to the capacity of the technology to produce an environment of sensorial richness, with information for

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all the senses. This potential depends on the variety of sensorial stimulation achievable and the level of 'resolution' for each of these types of stimuli.

In a study with 322 subjects, Dinh; Walker; Song, Kobayashi and Hodges, [43] assessed the impact of a variety of sensorial inputs upon the feeling of presence and object memory. Results indicated that when enhancing the sensorial input modes in the virtual environment, there was an increase not only in the feeling of presence but also on object memory in that environment. Data indicates that it is particularly useful adding tactile clues (e.g., heat from a lamp when the subject approaches the balcony); olfactory clues (e.g., coffee aroma near a coffee machine) and auditory clues (e.g., volume variations when approaching a copy machine).

Several authors report that any stimulation increase that creates sensorial redundancy (e.g., seeing and touching an object) contributes to the feeling of presence [30; 3; 18], for instance, the inclusion of dynamic shadows [44]. It is however important that there is consistency among different presentations [45]; if not, both the absence of redundant cues and the conflict between cues can have a negative effect on the experiment [15]. Therefore, the quantity of sensorial information must be presented in a way that is consistent with the user's senses.

It has also been asserted that the introduction of sound is very useful for the induction of feelings of presence [35; 46]. One study tested participants divided into groups of different audio conditions: no sound, low fidelity sound (typical AM quality) and high fidelity sound (typical CD quality). Each virtual location was allocated a distinct sound. Results revealed a higher feeling of presence and capacity to recall objects among participants who were exposed to sound, independent of its quality [46]. Additionally, adults who have become suddenly deaf frequently complain of feeling disconnected from the surrounding environment [15]. Auditory cues can be incorporated in lower-end technology, allowing an increase in presence without introducing computational delays in the system that pictorial realism can generate (see below) [42].

2.6.2.2 Pictorial Realism

Pictorial realism increases presence in a virtual environment [42, 18]. Part and parcel of the issue of pictorial realism is the rendering of visual depth. Several authors have found a positive relation between sense of depth and presence. Indeed, the use of stereoscopic clues has been described as an important factor in enhancing presence [38, 39, 48]. However, such glasses have previously been linked with an increase in simulator or 'cybersickness' – a form of motion sickness [26].

2.6.2.3 System Response Time

System response time is the time adjustment between the user's actions and the perceived effects of those actions on the environment [49]. Response time becomes a crucial issue when wearing an HMD for example, since it affects the responsiveness of the HMD to head movements. The latency of visual feedback, in other words, the time existent between the user's action and the system's response, was seen as responsible for the degradation of presence when it generated significant time intervals between action and its results [37, 45, 42]. In order to

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preserve the illusion of interactive instantaneous control, the intervals should be no longer than 0.1s [50].

According to Durlach & Mavor [50], there should be a display of more than 8 to 10 images per second in order to offer a continuous illusion of movement, although this figure will vary to some extent with the speed of head movements. It has been shown that presence decreases abruptly under 15-20 images a second [51]. It is therefore suggested that response velocity of the system increases the feeling of control from the user upon his actions in VR, increasing presence [3, 18].

2.6.2.4 Control

According to some authors, presence occurs when the subject mentally represents the possibility of acting upon the virtual world [29]. Presence can be increased, for example, if the participant perceives his own movement inside the virtual environment [18], or when the subject has more capacity to change the environment he is in. One study reports presence was higher in users that had control over their actions in VR, as opposed to passive observers [43]. It is likely then that subjects would experience more presence if they were capable of anticipating what would happen next [45].

2.6.2.5 Field of vision

Field of vision is important in two different ways. First, a large field of view provides larger and more compelling visual motion cues. Second, by restricting vision of the real-world environmental, less distraction/conflict occurs with images from the virtual world. In other words, devices which isolate users from their physical environment can increase presence in VR environments, facilitating immersion. Use of a mask, in order to limit the field of vision close to the eyes, has been shown to reduce the referred quantity of presence [41]. Additionally, a HMD, which isolates the participant from the real world, might increase presence in the virtual environment compared with a regular screen [52, 53, 18]. HMDs, however, cause cybersickness which can be experienced by up to 95% of HMD users [54]. Cybersickness has been shown to reduce one's sense of presence by diverting attention away from the VE and there is a negative correlation between simulator sickness and presence measured by the Presence Questionnaire [18].

2.6.3 Media Characteristics: Media Content

Irrespective of whether the system uses is a high-end or low-end VR interface, the content of media experienced by the user has been reported to influence the level of presence. A study by Banos, Botella, Alcaniz, Liano, Guerrero and Rey [55] compared three immersive systems (a PC monitor, a rear projected video wall, and a head-mounted display). Their aim was to test the role of immersion and media content on the sense of presence and to determine if presence could be enhanced in less immersive VEs by using emotional content. They found that presence could be enhanced in less immersive virtual environments by using emotional content.

This result is coherent with the cultural approach to presence [12]. As suggested by Riva and colleagues, to be "present" in the context offered by a symbolic

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system, the user has to be aware of its meaning. Only "making sense there", the user really experiences a full sense of presence.

According to this vision, researchers have to study presence by analyzing the user/s interaction with and within the media experience, including all the different aspects that converge on it: the relevance of the content, the social relationships established, the physical and symbolic resources exploited and the cultural competence used.

2.6.3.1 Body Representation

The participant's body representation in the virtual space is important to the sense of presence [15]. Other researchers agree with the key role of possible interactions, however, they stress that action is essentially social. Thus, the presence experience will depend on the accordance between the virtual environment and our cultural expectations. Slater and Usoh [15] emphasize the body and the way it can be perceived and represented in the virtual environment. The body works as an interaction, communication and self identification system. Thus, in order for the VR system to function ideally, it is necessary to offer proprioceptive information which will offer a mental model of our body and of the disposition of its limbs [17].

2.6.3.2 Presence of Others

There is a growing interest in presence generated by the existence of virtual actors in VR systems [4; 30]. The differentiation and experience of the self can be enhanced if other people exist in the virtual world and seem to recognize the existence of the participant [30]. One might choose to refer to this sensation as *social presence* (see also the next chapters of the book). This concept has its basis on the premise that if other people are in a virtual world it is more likely that it exists. In this way it justifies a sub-type of presence called social presence [42]. The hypothesis is that presence can increase with the existence of other individuals in the virtual environment and with the number of interactions between the participant and the virtual actors. Heeter [30] also takes into consideration environmental presence where the environment seems to 'know' we are there and reacts to our presence, e.g., lights turning on when the subject enters a room.

Recently, Biocca and colleagues [56] analyzed in a comprehensive review the concept of social presence. In the paper they indicated different factors influencing the experience of "being together with another" (pp. 462-465):

- *Sensory awareness of the embodied other*: The representation of the other triggers a sensory impression of the other that exists of a continuum from the minimal to the intense.
- *Mutual awareness*: The user is aware of the mediated other, and the other is aware of the user.
- *Sense of access to intelligence*: Social presence is activated when the user believes that an entity in the environment displays some minimal intelligence in its reactions to the environment and the user.
- *Salience of the interpersonal relationship:* It affects the "apparent distance" of the other and the level of social presence.

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- *Intimacy and immediacy:* They describe a cognitive state in which individuals feel more or less directly "present" in the interaction and in the process by which relationships are being created.
- *Mutual understanding:* The definition of social presence emphasizes the ability to project a sense of self through the limitations of a medium.
- *Behavioral engagement*: Social presence implies the effective negotiation of a relationship through an interdependent, multi-channel exchange of behaviors.

These variables suggest that the *continual awareness* of others in a shared media is required to flexibly adapt the behavior in social situations (e.g., a user heading across the room towards another, probably indicates an interest in beginning an interaction). This implies, for example, that the virtual environment has to allow changes in the way in which both the user is represented and he/she monitors what is going on in the environment.

2.7 Presence Measurement

As a consequence of the casual relationship evident between presence and the perceived realism of VR, much research has also undertaken the task of determining possibilities for reliable measurement of the concept. While many questionnaires and surveys are available to attempt to measure presence via underlying causal factors and determining variables such as those identified in earlier sections of the chapter, only a small number of these have gained widespread use.
Presence measurements must be reliable. They can achieve this through designs which are dependent only on the considered characteristics, and ensuring validity through measuring only what they are intended to measure [18]. Approaching the concept from different perspectives researchers have as a consequence developed different methods of measuring presence. These attempts are discussed here under the two major types: subjective self-reports, and objective measures.

2.7.1 Subjective Measurements of Presence

As described earlier, under considerations of user characteristics, even if users have the same experience in a VE it is unlikely they would report the identical experience. It is for this reason that Slater [57] claims self-report is not appropriate for measuring presence. Subjective self-reports are by nature inexplicably tied to personal aspects of the user. For example, Nisbett and Wilson [58] argue that introspective reports do not function as memories of mental process, but rather, that they are a process of the subject constructing an explanation of their behaviour based on personal theories of behaviour.

Subjective measurements of presence, however, are essential in order to collect the user's personal opinion [2, 3]. In addition, the majority of methods developed to measure presence to date have relied on subjective measurements using self-report [26, 59]. Subjective measures of presence include distinct forms of evaluation: scales (e.g., from 1 to 10, what level of being there did this virtual environment offer?); paired comparative method (e.g., which system offered more

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presence?); and comparative method by similarities among distinct modes (e.g., put this light as bright as the strength of presence you have experimented in this VR system). In utilizing any self-report measure of presence, however, it must be borne in mind that results can be tied to the personal aspects of the user.

2.7.1.1 Scales

Subjective evaluation scales have been used extensively to assess presence in virtual environments [63]. As data collection during the exposure could influence negatively the experience of presence it is recommended it be done immediately after the exposure [2]. Commencing with a theoretical body of work, essentially based on Sheridan [3], Held and Durlach's [45] work, and on a number of empirical studies, Witmer, Jerome and Singer [60] developed and validated the *Presence Questionnaire* (PQ), including 32 items measured through a 7 point Likert scale, that measures presence after using a VR system via causal factors. The questionnaire has gained a significant level of acceptance and has been tested across a number of studies [61; 62]. The PQ has four sub-scales: a) involvement; b) sensory fidelity; c) adaptation/immersion and d) interface quality. All four sub-scales measure user's perception of display system features.

Another well-known scale is the ITC-Sense of Presence Inventory (ITC-SOPI). It is a state questionnaire measure that focuses on users' experiences of media, with no reference to objective system parameters [64]. It has been translated in many languages and used in studies covering a wide range of media.

The ITC-SOPI, including 44 items measured through a 5 point Likert scale, has four factors:

- *Sense of Physical Space*, 19 items: a sense of being located in a physical space depicted by the media system
- *Engagement,* 13 items: a sense of involvement with the narrative/content of the mediated environment
- *Ecological Validity*, 5 items: a sense of naturalness and believability of the depiction of the environment itself and events within the environment;
- *Negative Effects*, 6 items: the negative experiences associated to an immersive media, such as eye-strain, headache, sickness.

Other widely used questionnaires are (for the full list of the available questionnaires see the Presence Research web site: http://www.presence-research.org): the UCL Presence [65] questionnaire (3 items), the Reality Judgement Presence [66] questionnaire (18 items) and the Igroup Presence [67] questionnaire (14 items).

However, it must be considered that by measuring presence using subjective self-report, a conflict is created between a user's feelings or emotions and their knowledge. For example, the user knows he is in a virtual world and remembers how he entered this new situation yet the investigator is asking him to respond to questions relating to the extent to which he feels present in this artificially entered situation [59].

2.7.1.2 Comparative

Presence has been divided into subjective and objective aspects [68]. The first is the likelihood of the person perceiving himself as being physically present in the virtual environment; the second, the feasibility of a task being completed

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successfully. We would suggest that the subjects be asked to compare the virtual environment with reality in order to measure presence. Because it is still very unlikely that someone would mistake the real world for the virtual presentation, Schloerb [68] suggests a degradation of the real scene through the use of filters, in order to confuse the real and virtual environments. However, this measure might become an assessment of the discrimination ability between two images, instead of the evaluation of presence [1], and "in similarity limit, the answers between the systems would be equivalent" [59].
With current technology it is hard for the participant to confuse the two worlds, and the level of degradation needed can be used as a measure of presence. It is natural that the subject is more sensitive to the degradation of a particular stimulus (e.g., frame rate of image presentation) than another (e.g., sound). It will also be difficult to deteriorate aspects of the real scene in order to fit the virtual scene. One of the advantages of this method would be the lack of need to question the participants about presence directly.

A variant of this method is the "Break in Presence" approach [69]. This approach is based on the idea that a participant experiencing virtual reality technology interprets the stimuli coming from the environment as belonging either to the virtual or to the real world. Slater & Steed suggested that the participant switches between the two interpretations throughout the experience, and that a measure of presence could be obtained if the amount of time that the participant spent interpreting the stimuli as coming from the virtual could be estimated. They proposed to do this estimation by looking for "breaks" those times when the participant realised they were in the real world. The main limitation of this approach is its oversimplification: it does not address the full complexity of mediated experience. For example, it does not account for mixed perceptions where the participant simultaneously holds and even partially responds to both (real and virtual) interpretations, as noted by Spagnolli and Gamberini [70, 71].

2.7.1.3 Similarities between Distinct Modes

In order to assess presence, one can also ask the participant to compare magnitudes in different modes. Pressure and luminance are sometimes used as an example. In this case, the participant presses a button with the strength he believes is correspondent to the level of brilliance of the light. Another possibility is sound and presence: the subject elevates the amplitude of a sound to the level of presence he felt in the VR environment. Although this method has many methodological difficulties it is considered to be an adequate quantitative measure of presence [72].

In order to continuously evaluate presence, Ijsselsteijn and collaborators [1] used an instrument to continuously evaluate image quality in television screens. It consisted of a small sliding part (*hand-held slider)*, that the subject moved forward or backwards, according to the degree of presence they felt. A possible criticism of this measure is that the participant will be dividing his attention between the virtual task and the measure of presence. These authors defend their method by stating that the participants are aware of being in a laboratory, making it unlikely that they would believe they were in fact in the scene presented on screen. Instead, according to the authors, they refer to a feeling of being in the environment similar to the one they would feel if they actually were there.

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2.7.2 Objective Presence Measurements

Objective performance measures have the advantage of not interfering with the task. However, presence has no physical manifestation objectively measurable [2]. The objective methods to measure presence have mostly used neurophysiologic measures, performance evaluation and postural response evaluation. Each of these forms of evaluation will now be briefly considered.

2.7.2.1 Physiological Measures

The use of a high number of neurophysiologic responses like cardiac frequency, skin's electric conductance (GSR), reflex motor behaviours and VR event evoked cortical responses were suggested as objective measures corroborative of presence. However, available research is still scarce [1]. Authors consider that physiologic reactions should be similar to those observed in a real environment. In a study by Dillon, Keogh, Freeman and Davidoff [38], it was observed that cardiac frequency was higher during the presentation of rally sequences as compared with calm boat sequences.
However, a critical issue for using neurophysiologic responses for presence measurement is the understanding of the link between emotion and presence. In particular its critical to identify what is an emotional response and what is a presence response. As noted by Baños and colleagues [55] within the activity of the "EMMA" European funded research project (http://alemania.did.upv.es/~juansoler/emma/), there are significant differences between emotional and neutral environments in presence measurements. On one side, the emotional environment seems to be more engaging, natural, believable and real to users than the neutral environment. On the other side, the influence of immersion on presence was higher in non-emotional environments than in emotional ones.

Recently "PRESENCIA" (http://www.cs.ucl.ac.uk/presencia), another European funded research project, has tried to identify a neural and physiological characterization of presence. Specifically the project is carrying out different psycho-physiological and brain imaging studies to identify the physiological and neuronal signatures associated with switches between different presence states. The key goal is to implement fMRI experiments, using event-related designs, where the presence state (or switches in state of presence) is indexed by (i) phenomenological report from subjects (ii) a change in bodily state indexed by independent psycho-physiological markers.

2.7.2.2 Performance Measures

It is frequently suggested that increased presence will produce better task performance and better skill transfer to the real world [72]. In order for these constructs to have validity, they should first allow the empirical establishment of equivalent classes [73]. This demonstration asks for a registration of performance variation when the factors which influence the construct vary. This also requires that a variation which does not change the construct also does not influence the performance the construct it is supposed to explain. Thus, equivalent classes are of use for the evaluation of change in presence. However, the relationship between

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presence and performance is unclear, given that performance can actually improve with a decrease in presence [73].

2.7.2.3 Postural Responses

According to Steuer [4], immersion is a function of system and user. However it seems likely that one can be physically immersed in a VR system but not 'be there', that is, feel presence. In other words, participation in a VR system does not guarantee presence. Immersion is created for a user when they give their attention and commitment to their closest physical environment [4]. Thus, it is the level of commitment to the environment which determines the level of immersion.

According to Usoh, Alberto and Slater [17], an increase in presence raises the similarity between behaviour in virtual environment and usual behaviour in a real environment. The measure of these differences should therefore provide a means of measuring presence. The adjustment of the observer's posture as a possible corroborative measure of presence has also been explored. It is a distinct and promising measure of presence assessment that consists of postural response evaluation to stimuli presented. Referred to as *behavioural realism,* the basic principle of this form of assessment is that the more similar the virtual environment is to the one it mimics, the more similar the observer's response to the virtual presentation will be [59].

These measures are potentially useful for two reasons. First, the observers are not normally conscious of their postural responses, and so their responses are less likely to be affected by subjective assessments [30]. Second, because postural measures have the capacity of producing different levels of responses, they do not simply generate binary results such as yes and no. Instead, it is possible to assess degrees of response and relate them to different degrees of presence [59]. The implicit theory in this form of assessment is that postural changes only occur if the subject is extremely present in the virtual environment. The advantage of this approach is in the evaluation of observable phenomena. Its weakness is lies in a lack of sensitivity to and exclusion of subtle aspects of presence [74].

2.8 Conclusions

The rationalist (*Media Presence*) and psychological/ecological (*Inner Presence*) points of view of presence reflect a remarkable epistemological difference between them. It seems evident, however, that the use of multiple sensory channels (particularly vision, hearing and feeling); immersion (through the exclusion of external stimuli to the ones offered by the virtual environment); egocentric location (offered specially by the HMD which provides images in accordance with the head's location) and the possibility of action in the environment (provided by an environment's response to our movements), seem to be the main determinant factors in presence.

Other systems and means of communication offer similar feelings, but VR ameliorates that feeling in a way never before achieved. In the case of VR, instead of the device being unconsciously used as a function of its operation in a task, it is the environment that becomes 'invisible' by turning into and becoming part of the task. While reading a book, watching television or talking on the phone might

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create a certain level of presence because VR is capable of high levels of immersion and interaction, these effects are multiplied.

The division existent among researchers regarding the definition of presence seems to mirror their adherence to the rationalist or ecological perspective of presence. The rationalist point of view does not consider presence necessary in order to define a VR system but rather presence is considered an epiphenomenon of the immersive stimulation allowed by VR, in other words its physical properties. In contrast, the psychological point of view defines presence as a possible experience outside a VR system. In the next chapters of this Section this position will be discussed in depth by Riva, Waterworth and Waterworth, and Moller and Barbera.

Despite the controversy regarding its definition, there is greater consensus on the variables which influence presence. Technological variables are numerous. The number of sensorial channels stimulated increases not only presence but also the memory of objects in that environment. Sound is a particularly important cue because of its large impact without costly investment demands. However, when adding cues, it should be taken into account that consistency is needed between different presentations, given that the conflict among different cues can have a negative effect on the overall experience. Consistency between the user's movements and the system's feedback presentation should also be preserved. In terms of measuring presence much work still needs to be done, but a combined strategy based on objective and subjective measures seems preferable since each brings with it specific advantages and disadvantages.

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