

Presence: Concept, determinants and measurement

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ABSTRACT

The concept of presence, i.e. the sensation of ‘being there’ in a mediated environment, has received substantial attention from the virtual reality community, and is becoming increasingly relevant both to broadcasters and display developers. Although research into presence is still at an early stage of development, there is a consensus that presence has multiple determinants. To identify and test which parameters affect presence, a reliable, robust and valid means of measuring presence is required. In this paper, we describe the categories of factors thought to have an impact on presence. Furthermore, we present an overview of various approaches taken to measuring presence, which can be divided into two general categories: subjective measures and objective corroborative measures. Since presence is a subjective experience, the most direct way of assessment is through users’ subjective report. This approach has serious limitations however, and should be used judiciously. Objective measures, such as postural, physiological or social responses to media, can be used to corroborate subjective measures, thereby overcoming some of their limitations. At present, the most promising direction for presence measurement is to develop and use an aggregate measure of presence that is comprised of *both* subjective and objective components, tailored to the specific medium under study.

Keywords: presence, telepresence, determinants, measurement, subjective measures, objective corroborative measures

1. INTRODUCTION

“When the curtain swept up to reveal the now-legendary wide-screen roller coaster ride, I realized that the film’s creators were no longer content to have me look *at* the roller coaster but were trying to put me physically *on* the ride. The audience no longer surrounded the work of art; the work of art surrounded the audience – just as reality surrounds us. The spectator was invited to plunge into another world. We no longer needed the device of identifying with a character on the other side of the ‘window.’ We could step through it and be a part of the action!” – Morton Heilig commenting on his experience with Cinerama in New York, 1952.

1.1 The concept of presence

As Heilig’s quote illustrates, there has long been a tendency to reproduce reality with increasing levels of fidelity, especially in the arts and in cinema. The psychological effect that Heilig described is nowadays more commonly known as *presence*, i.e. the sense of ‘being there’ in a mediated environment. This user experience is of particular interest to us today, since the current pace of technological development in networks, computing power and displays, as well as improvements in human-computer interfaces, increasingly enable the creation of services that are capable of eliciting a sense of presence in the user. The concept of presence has potential relevance for the design and evaluation of a broad range of interactive and non-interactive media, and applications in areas such as training and education, telecommunications, medicine, and entertainment.

The term *telepresence* was coined by Marvin Minsky in 1980¹, 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, i.e. through the user’s actions and the subsequent perceptual feedback he/she receives via the appropriate teleoperation

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technology. Even earlier, Johnson and Corliss² (cited in³), discussed the importance of designing displays and controls that will “help the operator project his presence” into a remote work space. Since the early 1990’s onwards, the subjective sensation of being there in a remote or mediated environment has been studied in relation to various media, most notably virtual environments (VEs). Sheridan⁴ refers to presence elicited by a VE as ‘virtual presence’, whereas he uses ‘telepresence’ for the case of teleoperation that Minsky¹ was referring to. However, from the point of view of psychological analysis, this distinction based on enabling technologies is unnecessary, and for the purpose of this paper we will regard the two terms as essentially synonymous.

1.2 Two types of presence: Physical and social

In an attempt to unify a set of six different conceptualizations of presence found in the literature, Lombard & Ditton⁵ elegantly define presence as the ‘perceptual illusion of non-mediation’, i.e. the extent to which a person fails to perceive or acknowledge the existence of a medium during a technologically mediated experience. The conceptualizations Lombard and Ditton identified can be grouped into two broad categories - physical and social⁶. The physical category refers to the sense of being physically located somewhere, whereas the social category refers to the feeling of being together (and communicating) with someone. The question may be raised whether it is fruitful to group these two distinct categories under one unifying definition, since a number of aspects of communication that are central to social presence, are unnecessary to establish a sense of physical presence. Indeed, a medium can provide a high degree of physical presence without having the capacity for transmitting reciprocal communicative signals at all. Conversely, one can experience a certain amount of social presence, or the ‘nearness’ of communicative partners, using applications that supply only a minimal physical representation, as is the case, for example, with telephone or internet chatrooms. This indicates that social and physical presence can be meaningfully distinguished. This is not to say, however, that the two are unrelated. There are likely to be a number of common determinants, such as the immediacy of the interaction, that are relevant to both social and physical presence. In fact, applications such as videoconferencing or shared virtual environments are based on providing a mix of both the physical and social components*. The extent to which shared space adds to the social component is an empirical question, but it seems likely that as technology increasingly conveys non-verbal communicative cues, such as gaze direction or posture, social presence will increase. There is evidence suggesting that this indeed may be the case^{7,8}.

2. DETERMINANTS OF PRESENCE

Systematic research into the causes and effects of presence has only recently started, but a large number of factors that may potentially influence the sense of presence have already been suggested in the literature. Although the terminology used tends to vary across authors, there appears to be a broad agreement on the major concepts. Based on various theoretical analyses^{4,9-13}, the factors thought to underlie presence include:

- i) The *extent and fidelity of sensory information* - this is the amount of useful and salient sensory information presented in a consistent manner to the appropriate senses of the user. This includes Steuer’s¹² notion of ‘vividness’, i.e. the ability of a technology to produce a sensorially rich mediated environment. Note that this category can apply to both interactive and non-interactive media. Examples from this category are monocular and binocular cues to spatial layout, resolution, field of view, or spatialized audio.
- ii) The *match between sensors and the display* - this refers to the sensory-motor contingencies, i.e. the mapping between the user’s actions and the perceptible spatio-temporal effects of those actions. For example, using head tracking, a turn of the user’s head should result in a corresponding real-time update of the visual and auditory display.
- iii) *Content factors* – this is a very broad category including the objects, actors, and events represented by the medium. Our ability to interact with the content and to modify it, as identified by Sheridan⁴, is also likely to be important for presence. Other content factors include the user’s representation or virtual body in the VE¹⁴, and the autonomy of the environment, i.e. the extent to which objects and actors (e.g. agents) exhibit a range of autonomous behaviours¹⁰. Social elements, such as the acknowledgement of the user through the reactions of other actors, virtual or real, will be important for establishing a sense of social presence¹⁵. The nature of the potential task or activity, as well as the meaningfulness of the content have been suggested to play a role as well.
- iv) *User characteristics* are likely to play a significant role as well, but have received little attention thus far. Such characteristics include the user’s perceptual, cognitive and motor abilities (e.g. stereoscopic acuity, susceptibility to

* Although the terminology used by various authors tends to vary, the term ‘co-presence’ has been suggested to refer to the mix of social and physical presence, i.e. a sense of ‘being there together’.

motion sickness, concentration), prior experience with and expectations towards mediated experiences, and a willingness to suspend disbelief. Allocating sufficient attentional resources to the mediated environment has also been proposed as an important component of presence^{3, 16, 17}. Relevant individual characteristics will probably vary with the age and possibly with the sex of the user. Huang and Alessi¹⁸ point out that various mental health conditions, like depression, anxiety, or psychotic disorders, are also likely to affect an individual's sense of presence, since they are known to have a clear effect on how people experience the world around them.

Factors i) and ii) may be regarded as *media form* variables that are aimed at making the medium as transparent as possible, thereby creating the illusion of non-mediation⁵. To create and sustain this illusion, distractions and negative cues to presence should be avoided. An awkward interface will stress the mediated nature of the experience and may diminish the sense of presence. Examples of such negative cues include: bad stereoscopic alignment (causing eye strain), coding distortions in the image (e.g. visible blockiness or noise), weight of a head-mounted display, process interruptions (e.g. 'new mail has arrived', malfunctions, error notices), noticeable tracking lags, low update rates, stereo/occlusion conflicts, etc. Furthermore, distractions that draw the user's attention from the mediated environment to the real world (e.g. a telephone ringing) are likely to diminish the user's sense of presence as well (as would be predicted by Draper *et al.*'s attentional resource model of presence³). Certain common media conventions, such as an identification logo appearing in the corner of the screen, may also diminish the illusion of non-mediation⁵. Generally speaking, a seamless continuity between the real and the mediated environment is likely to add to a more convincing illusion of non-mediation. An example of such a continuity is presented in the KidsRoom¹⁹, a room where real-world items such as posters and windows are combined with large back-projection walls, in order to create an interactive narrative playspace for children.

An increasing number of the suggested determinants have been empirically tested. Among these are medium-related factors such as user-initiated control of the simulation²⁰, stereoscopic presentation²¹⁻²³, head tracking²¹, motion parallax^{22,23}, field of view^{24,25}, spatialized audio²⁶, response latency²⁷, and meaningfulness of the simulation²⁸. Slater and colleagues^{14, 29} have performed some initial studies on user characteristics, such as the extent to which a person's field dominance (e.g., visual, auditory) affects their sense of presence. Further study is required however to investigate the potential impact of individual characteristics on presence.

3. MEASURING PRESENCE

Scientific research into presence is still at a relatively early stage of development. At present, there is no generally accepted theory of presence. Technological advances have only recently been developed to a level that enables and motivates the systematic exploration of presence measures. At this moment, a single, accepted paradigm for the assessment of presence is still lacking and, perhaps as a consequence, a variety of presence measures have been proposed.

A reliable, robust and useful measure of presence will provide display, interface and content developers with a tool to evaluate media within a user-centered design approach, by allowing them to identify and test those factors that may produce an optimal level of presence for the user. As Ellis³⁰ has argued, a valid and stable presence measure will allow for equivalence classes to be established, i.e. maintaining the same level of measured presence, whilst trading off contributing factors against each other. In addition, a good measure of presence will aid human factors specialists in investigating the relationship between presence and task performance, and may aid our general understanding of the experience of presence in the real world.

The different approaches taken to measuring presence can be divided into two general categories of presence measures: subjective measures and objective corroborative measures.

4. SUBJECTIVE MEASURES OF PRESENCE

4.1 Post-test rating scales

Since presence is primarily a subjective sensation, it has been argued that 'subjective report is the essential basic measurement'⁴. Indeed, the majority of studies measure presence through post-test questionnaires and rating scales, which have the advantage that they do not disrupt the media experience and are easy to administer. For instance, Slater *et al.*²⁹ asked participants, after exposing them to a VE, to answer three questions on Likert scales (1-7) that served as an indication of presence: (a) their sense of 'being there' in the computer-generated world, (b) the extent to which there were times when the experience of the computer-generated world became the dominant reality for the participants, thereby forgetting about

the 'real world' outside, and (c) whether they remembered the computer-generated world as 'something they had seen' or as 'somewhere they had visited'. According to Slater³¹, the 'experiencing-as-a-place' is central to understanding presence in VEs: people are there, they respond to what is there and they remember it as a place.

Witmer and Singer¹⁷ developed a presence questionnaire (PQ), with questions on four major categories of theoretical presence determinants: control factors, sensory factors, distraction factors and realism factors. A cluster analysis on the combined data of four experiments revealed a measure of presence along three subscales: (a) involvement/ control, (b) naturalness, and (c) interface quality. Items on the first subscale referred to the perceived control over and responsiveness of the VE as well the participant's involvement in it. Naturalness items referred to the extent to which the interaction and the participant's movement within the VE felt natural as well as the extent to which the VE was consistent with reality. Interface quality items addressed whether control and display devices interfered with or distracted from task performance. As Slater³¹ notes, a problem with Witmer and Singer's PQ is that the questions intrinsically confound individual characteristics and properties of the VE, with no way of separating them out.

Although generally speaking rating scales are effective, they need to be used with great care as results obtained through subjective report can be potentially unstable^{23, 30}. Several research groups are currently using factor analysis to construct reliable and valid presence questionnaires, applicable to both interactive and non-interactive media.

4.2 Continuous presence assessment

One important limitation of discrete post-test subjective ratings is that they do not provide any measure of temporal variations in presence. Such variations are likely to occur through changes in the stimulus (i.e. both in form and content) or the participant (e.g. prolonged exposure may have an impact on presence through perceptual-motor adaptation, boredom, fatigue, etc.) and would be lost in an overall post-test presence rating. In addition, discrete subjective measures are potentially subject to inaccurate recall and anchoring effects.

To overcome these limitations, the method of *continuous presence assessment* has been applied^{22, 23, 32-34}. This method, originally developed to measure TV picture quality^{35,36} requires subjects to make an on-line judgement of presence using a hand-held slider. A computer subsequently samples the position of the slider at a constant rate (see fig. 1). When applied to non-interactive stereoscopic media, it was found that presence ratings were subject to considerable temporal variation depending on the extent of sensory information present in the stimulus material²².

A potential criticism that may be raised against continuous presence assessment is that subjects are in fact required to divide their attention between both the display and the on-line rating they are asked to provide, thereby possibly disrupting the presence experience. However, observers are unlikely to report on a *belief* of being in the displayed scene, since they are usually well aware of actually being in a media laboratory. Rather, they report on a *sensation* of being there that approximates what they would experience if they were really there⁶. This does not necessarily conflict with providing a continuous rating – especially given the fact that the measurement device requires very little attention or effort to operate. The need to consciously reflect on the amount of presence experienced in order to give a reliable rating is of course intrinsic to both continuous *and* discrete subjective measures of presence^{*}.

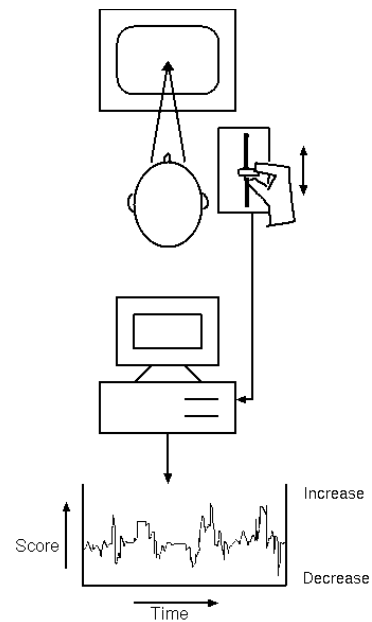


Figure 1. A schematic representation of continuous presence assessment (from IJsselsteijn *et al.*²²).

* Taking only one measurement with a post-test technique using independent groups may avoid participants reflecting on their presence during the media experience. However, such a between-subjects design typically requires more subjects than a within-subject design to obtain a similar level of sensitivity.

This criticism underlines the need for objective measures to corroborate subjective presence measures, as discussed later in this paper. At this moment, continuous presence assessment is mainly applicable to non-interactive media since using a measurement device, such as a hand-held slider, may interfere with operating an interaction device. An alternative option for measuring temporal variations in such a case would be to use continuous verbal reporting.

4.3 Psychophysical methods

Various psychophysical methods for measuring presence have been proposed to date^{13, 37}, but very little empirical research is currently available that employs this well-established approach. Snow and Williges³⁸ used free-modulus *magnitude estimation* to investigate the effects of a wide variety of VE system parameters on presence. With this method, originally proposed by Stevens³⁹, participants are presented with a series of stimuli and asked to assign a number for each stimulus corresponding to the strength of their subjective sensation. In *free-modulus* magnitude estimation, the observer is asked to assign any value to the first stimulus and subsequently assign values accordingly.

Cross-modality matching can be regarded as a variation on magnitude estimation that has special applicability to constructs that do not lend themselves easily to verbal scaling. This method requires a participant to express a judgement of a subjective sensation in one modality by responding through adjusting a parameter in a different modality - e.g. 'Make this sound as intense as the strength of presence you experienced in this VE'⁴⁰.

A final psychophysical method we would like to mention here is the method of *paired comparisons*, which, in the context of VEs, has sometimes been referred to as the 'virtual reality Turing test'. Here the user is asked to distinguish between a virtual (or remote) and a real scene. Schloerb⁴¹ suggested that the probability that a human operator perceives that he or she is physically present in a given remote environment can serve as a subjective measure of presence. Since subjects are unlikely to confuse the real environment with the virtual one, Schloerb proposed a number of perceptual limitations (or filters) to be imposed on the subject during the test. For example, both the real and virtual environments have to be viewed with a limited visual field, with reduced contrast or color, not using sound, etc. Following Schloerb's proposal, Sheridan⁴² suggested to take the amount of degradation of the real scene that is necessary to make it indistinguishable from the virtual one as a measure of presence. A potential criticism that can be raised against this methodology is that it becomes a test of participants' ability to discriminate between two degraded images rather than a measure of presence⁶.

5. OBJECTIVE CORROBORATIVE MEASURES

The search for objective measures to corroborate subjective presence measures is motivated by a number of reasons. First of all, subjective measures require users to have a fair understanding of what is meant by the term 'presence'. Possibly as a consequence of the fact that, at present, most naïve users are relatively unfamiliar with the concept of presence, subjective measures have been shown to be potentially unstable, with inconsistencies across different raters and rating situations³⁰. A varying intrinsic subjective interest in the represented content will likely add to the variability across raters. Relatedly, as Freeman *et al.*²³ have shown, subjective ratings of presence can be biased by previous experience, e.g. rating a different attribute in a previous session. Secondly, objective measures relate to user responses that are, in general, produced automatically and without much conscious deliberation. This will thus diminish the likelihood that the subject is responding to the demand characteristics of the experiment. In addition, it circumvents the conflict between sensation ('I am in a VE') versus knowledge ('I am in a psychology lab wearing an HMD'), that seems intrinsic to subjective measures of presence⁴³.

In an attempt to develop objective corroborative measures of presence, the *behavioral realism* approach was proposed, which is based on the premise that as a display better approximates the environment it represents, an observer's responses to stimuli within the display will tend to approximate those which he/ she would exhibit in response to the environment itself⁴³. Based on this principle, a variety of objective corroborative measures can be formulated. Several authors have suggested the use of reflexive responses (e.g. ducking in response to a looming virtual object) and socially conditioned responses (e.g. smiling) as objective approaches to measuring presence^{4, 11, 44}. Generally speaking, the objective measure that is being used as a presence measure should be tailored to the media experience the user is intended to have.

Some authors have suggested *task performance* as an objective measure of presence^{41, 45}. Although such measures may be very useful for the assessment of training efficiency in VEs, the relationship between presence and performance measures remains unclear. Although there seems to be some tentative evidence suggesting a positive correlation between presence and task performance¹⁷, Ellis³⁰ reported that removing redundant information from air traffic control displays elevated performance, whereas such a manipulation would also tend to decrease presence. However, one needs to be aware of the

possibility that reducing realism (through removing redundant information) may in fact enable participants to better select a useful viewpoint. This implies that the overall level of presence need not necessarily diminish, in line with Ellis' notion of iso-presence equivalence classes⁴³. There is general agreement in the field however with Ellis' assertion that there need not necessarily be a causal relationship between presence and performance⁴⁴. In addition, task performance measures usually require the completion of a task within a VE. In this respect, their application to non-interactive media is problematic.

5.1 Postural responses

Within the behavioral realism paradigm, Freeman *et al.*⁴³ investigated observers' postural adjustments as a potential objective corroborative measure of presence. Both Prothero⁴⁶ and Ohmi⁴⁷ proposed that measures of vection (i.e. feeling of self-movement) and presence should be related, basing their arguments on the premise that it is likely that an observer will feel present in an environment that causes him/her to experience vection. In the Freeman *et al.* experiment, observers were instructed to stand as still as possible in front of a display that showed a moving video of a rally car circling a track, using monoscopic and stereoscopic presentation in counterbalanced sessions. The observers' automatic postural adjustments were measured via a magnetic tracking device. The results demonstrated a positive effect of stereoscopic presentation on the magnitude of postural responses elicited. Post-test subjective ratings of presence, vection and involvement were also higher for the stereoscopically presented stimuli. However, the postural responses cannot be taken as a direct substitute for subjective presence ratings as the two measures were not correlated across subjects. They can, however, corroborate *group* subjective ratings of presence.

5.2 Physiological measures

A number of physiological indicators, such as heart rate and skin conductance response (SCR), have been suggested as objective corroborative measures of presence, but at present there is little empirical research available that is specifically aimed at relating physiological measures to presence. Galvanic skin response is known to be sensitive to arousal, whereas heart rate is sensitive to hedonic valence (pleasant stimuli cause heart rate acceleration, whereas unpleasant ones cause a slowing of the heart rate). Both arousal and hedonic valence are viewed as two primary components of emotion⁴⁸. Within the behavioral realism paradigm, these measures would likely be most useful when applied to media experiences that could potentially elicit an emotional response.

Wiederhold, Davis and Wiederhold⁴⁹ reported a study in which they investigated the effects of varying levels of immersion in a flight simulation, comparing a computer screen to a head-mounted display, on participants' subjective presence ratings as well as measures of heart rate, respiration rate, peripheral skin temperature and SCR. They found that SCR was the single measure that reflected a change in arousal across all participants, however with no significant effect of immersion. When asked in which condition subjects felt more present, they chose the HMD condition. Although this study yielded some interesting insights into the psychophysiological measurement of presence, it lacks generalizability due to the limited number of subjects.

Sallnäs⁵⁰ investigated the effect of haptic feedback on co-presence, using both questionnaires and galvanic skin response as measures of presence. Fourteen pairs of participants (each comprised of one male and one female) performed four collaborative tasks. A between-group design was used. Half of the pairs were able to feel the forces exerted by the other person through force-feedback whereas the other half received no force-feedback. All pairs had audio channels with which to communicate. The results showed that haptic feedback significantly improved task performance and significantly enhanced presence, but not co-presence. The galvanic skin response measure didn't show a significant effect in this study (Sallnäs, personal communication). One potential explanation of these results may be that the audio feedback that was presented across conditions already supported a sufficient level of co-presence, thereby saturating any effect of haptic feedback on co-presence.

More extensive studies are needed to investigate whether SCR, heart rate or other potential physiological correlates of presence provide a reliable corroborative measure. Such studies would need to include a reliable, sensitive subjective measure of presence.

5.3 Dual task measures

Consistent with the view that the allocation of attentional resources plays an important role in presence^{3, 16, 17}, *secondary reaction time measures* could potentially be used as a corroborative measure to subjective report. The fundamental assumption is that as more effort is dedicated to the primary task, fewer resources remain for the secondary task. Typical results in this line of research show that, when attending to the primary task, people make more errors in responding to the

secondary task or take longer to respond to a cue (often a tone or a light)⁵¹. It may thus be hypothesized that as presence increases, more attention will be allocated to the mediated environment, which would mean an increase in secondary reaction times and errors. This hypothesis has yet to be empirically investigated.

A slightly different approach would be to look at the extent to which information from a secondary source (real or mediated) is processed, either through a shadowing task during the medium experience or a memory task afterwards. As more attentional resources are allocated to the secondary source, less attention can be directed towards the primary source, thereby, in theory, diminishing presence.

The extent to which signals from the real world get integrated into the experience of the virtual world could also potentially serve as a corroborative presence measure⁵², although such signals would presumably need to have some ecological validity in the virtual world – e.g. a telephone ringing in an underwater diving simulation would not be very convincing as part of the mediated experience. This also illustrates the point made earlier about avoiding distractions and providing a seamless continuity between the real and the virtual.

5.4 Social responses

In order to obtain an objective corroborative measure of social presence, socially conditioned responses are likely to yield relevant results. In social encounters we interact with other people through a rich repertoire of social behaviours, both verbal and nonverbal, most of which occur automatically and without conscious reflection. Such behaviours are also likely to occur in mediated interactions of a social nature. Observable social behaviours with potential relevance to social presence include facial expressions (e.g. smiling), gestures (e.g. reaching out to shake someone's hand), body and head movements (e.g. nodding), eye contact, vocal cues (e.g. tone of voice), turn-taking behaviour in dialogues (e.g. frequency of interruptions), the use of space (e.g. moving towards someone) and verbal expressions directly acknowledging the communicative partner (e.g. 'How did you do that?' or 'I see what you mean').

In an attempt to develop a virtual reality therapy for fear of public speaking, Slater⁵³ recently reported on a study investigating participants' responses when giving a 5 minute talk in front of a virtual audience. The virtual audience's behaviour varied from enthusiastic, interested responses, like nodding and applauding, to disinterested, even rude, responses, such as frowning or walking out of the virtual lecture theater. The results showed that a participant's self-rating of speaking performance was correlated with the reaction of the virtual audience, in that a positive audience response led to a positive self-evaluation. Although this study was aimed at investigating the effects that positive audience feedback may have in overcoming fear of public speaking, useful social (e.g. gestures or facial expressions) and psychophysiological (e.g. SCR or heart rate) measures of presence may potentially be derived from such a scenario, provided that independent manipulations ensure different levels of presence and that sensitive and reliable subjective measures of presence are used.

6. CONCLUDING REMARKS

"If, as it is said to be not unlikely in the near future, the principle of sight is applied to the telephone as well as that of sound, earth will be in truth a paradise, and distance will lose its enchantment by being abolished altogether." – Arthur Mee, 1898, cited in Slater & Wilbur⁴⁴.

6.1 Maximal vs. optimal presence

It is likely to be quite some time before we are able to convincingly reproduce all aspects of physical and social presence through advanced communication and display media. Although intentions in this direction are clear^{54, 55}, eliciting a complete experience of presence is not within the means of the technology available at present. However, current technology is able to generate and communicate a greater sense of presence than ever before. This leads us to the question of whether maximal presence can be equated to optimal presence. The answer to this question will depend on the application area for which the high-presence technology is being used. It may be argued that for most *entertainment* applications creating a compelling sense of presence is a desirable goal. However, for other application areas this may be less straightforward – e.g. for the performance of certain tasks, changes that may diminish presence may could in fact enhance performance.

With respect to communication media, an issue of particular importance is the issue of *privacy*. Just adding sensory channels to a telecommunication medium may maximize presence, but may also lead to some unwanted or irritating interactions. Think, for instance, about feeling present in the company of an annoying salesperson. There is already evidence suggesting that users may not desire transmission of (parts of) their home environment. In a study evaluating a

videophone for elderly users, Bouwhuis⁵⁶ reports that the perceived disadvantages of the system centered on the intrusion of privacy. Subjects mentioned that other people could see their possessions, emotions or appearance, and calls would no longer be anonymous. As with any telecommunication service, the starting point for telepresence services should be the consumer's desire for contact. One option that should be offered along with a high-presence telecommunications medium is a *presence-regulator*, such as a dial or slider that will determine the level of presence at which one person experiences the other(s). As communication systems become capable of mimicking face-to-face communications, social or technological conventions are likely to emerge for establishing the 'access level' each person will have when communicating with others⁵⁷.

6.2 Towards an aggregate measure of presence

Given the relatively recent advent of presence research, substantial progress has been made in developing measures of presence. It seems reasonable to assume that not *one* overall presence measure will be developed, but rather an aggregate measure of presence that is comprised of *both* subjective and objective components, in order to avoid the limitations of either alone. It will thus likely consist of different but complementary types of measures, and the extent to which each measure is used may vary with the characteristics of the application.

Subjective measures are expected to become more stable as more reliable questionnaires are developed and a better insight is gained into the structure of presence. It is important to note, however, that presence research to date has used a wide range of content for its investigations. For results to be comparable across studies, content standards need to be developed when measuring presence in different situations and across different display media. In conjunction with subjective measures, potential objective corroborative measures need to be further developed and investigated, so that appropriate and sensitive objective measures can be selected and tailored to the specific medium under study.

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