Presence – a global media quality metric

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Abstract. In this paper 'presence' (a sense of 'being there' in a mediated environment) is proposed as a global quality metric with which to evaluate advanced multi-modal media systems. The development of a new presence self-report measure, the ITC-Sense of Presence Inventory (ITC-SOPI), is described that comprises four empirically derived scales: Sense of Physical Space, Engagement, Ecological Validity, and Negative Effects. Two applications of the ITC-SOPI are presented. Using both controlled and uncontrolled experimental designs, the sensitivity of the ITC-SOPI scales to degree of physical immersivity (e.g., large vs. small format; monoscopic vs. stereoscopic viewing condition) is demonstrated. These preliminary results suggest that the ITC-SOPI is a valid tool with which to evaluate experiential aspects of immersive technology.

1 Introduction

Evaluation is a critical ongoing process that informs the development of technology for new media systems. In terms of immersive technology evaluation, a number of issues are raised: What (construct) should be evaluated in order to optimise immersive systems? Can we identify a valid construct that is useful to developers of different types of media system? How do we measure this construct? This paper proposes one such global media quality metric and describes the development and an application demonstration of a new questionnaire to measure this construct, the ITC-Sense of Presence Inventory.

1.1 What (construct) should be evaluated in order to optimise immersive systems?

Immersive technology aims to provide mediated multi-modal stimulation, such as visual, auditory, kinaesthetic, and olfactory information. However, it is more typical for only a few of these sensory inputs, commonly visual and auditory, to be represented [1]. The ultimate goal is to render these inputs convincing and sufficiently realistic in order to replace our 'real world' sensory inputs and to fool our sensory system into 'perceiving' a mediated environment as non-mediated. This "perceptual illusion of non-mediation" has been termed 'presence' [2]. Presence has also been defined more generally as a subjective sensation of "being there" in an environment depicted by a medium [3].

1.2 Can we identify a valid construct that is useful to developers of different types of media system?

Presence is arguably a continuous, rather than a dichotomous, construct that is positively associated with physical immersion, and may therefore be evoked by a range of media to varying degrees. Indeed, Freeman and Avons [4] found that stereoscopic television viewers used terms commonly associated with virtual environment (VE) display systems, such as ‘being there’ [cf. 5] to describe their media experiences. For non-entertainment based immersive applications, however, task performance may be at least as important as presence in system evaluation. However, the relationship between presence and task performance is unclear.

According to Sheridan [6] three major properties of a technology (i.e., media form characteristics) can determine presence: (i) the extent of sensory information presented, (ii) the degree of control a participant has over positioning his/her sensors within the environment (e.g., a turn of the head to see or hear more of the environment); and (iii) a user's ability to modify aspects of the environment. Sheridan’s theory predicts that a system which fully supports each of these criteria would elicit high presence. Other studies have empirically demonstrated that specific physical system properties can determine presence. These have included spatial audio [7]; geometric field of view [7]; stereoscopic depth cues [8, 9, 10, 11] head tracking [7]; display update rate [12]; and motion parallax [10].

In addition to media form, media content and user characteristics can also moderate the sense of presence. Media content refers to the overall theme, narrative or story depicted via a display system. Relevant content variables that have been demonstrated to enhance the sense of presence include user representations within a VE [13], life-like/natural/believable contents [14] and VE stacking (i.e., entering a VE within another VE). There is also some evidence that user characteristics such as a user's perceptual, cognitive, motor abilities and personality traits (e.g., a willingness to suspend disbelief [13]) can be important in determining presence. As presence is multiply determined, it is likely that there are trade-offs between the different determinants of presence. For instance, displays high in photorealism may compensate for an absence of control and manipulation input devices (henceforth referred to as ‘interactive’ displays).

1.3 How do we measure this construct?

Involvement and attention are particularly important in the measurement of presence [15, 16] as participants exposed to a media system and unfamiliar with the presence concept are likely to use these terms to describe their experience. For instance, Freeman and Avons [4] found that participants described their involvement in a 3D video presentation as ‘unavoidable’.

Presence involves heightened attention towards the mediated environment (‘arrival’), and conversely, decreased attention towards the unmediated environment (‘departure’) [17]. Thus, concentration and distraction are also key measurement variables.

The measurement of presence to date has primarily consisted of ad hoc subjective rating scales [1, 7, 13, 14] that typically relate to feeling: (a) physically located in a mediated space (b) that the mediated environment is as real as the real world and (c) that the mediated place had been 'visited'. However, these simple measures can be affected by prior experience, and are thus potentially unstable [10]. Furthermore, they offer little insight into the structure (potential multi-dimensionality) of presence that more complex questionnaires subjected to data reduction techniques afford.

There are several criteria to satisfy and issues to consider in the development of structured presence questionnaires [18], attempts at which to date [16, 17, 19], are limited. These issues and criteria include: (i) probing participants about presence-related sensations rather than presence, per se, which is an unfamiliar construct to most non-experts [4, 11]; (ii) taking care to address just one issue per question; (iii) maintaining consistency across response options to produce a user-friendly measure; (iv) tapping all characteristics that have been putatively related to presence to ensure adequate content sampling; (v) phrasing questions carefully to avoid confounds with specific physical properties and limiting generality to a range of media; (vi) ensuring broad utility by piloting the measure on participants of media systems that differ on a variety of physical parameters; and (vii) satisfying the statistical requirement of a high subject to variable ratio when using data reduction techniques such as factor analysis.

2 The ITC-Sense of Presence Inventory (ITC-SOPI)

Our research group has developed a presence questionnaire that aims to have general utility by explicitly probing the experiential qualities of a media presentation. The full development of this measure is reported elsewhere [18]. To summarise, the ITC-SOPI originally consisted of 63 items, each generated to tap one of a number of facets putatively related to presence (sense of physical space, involvement, attention, distraction, control and manipulation [i.e., autonomy], realness, naturalness, perception of time, awareness of behavioural responses, a sense of social interaction, personal relevance, arousal, and negative effects). Items are rated on a 1-5 Likert scale from 'Strongly Disagree' to 'Strongly Agree'.

2.1 Pilot sample

The 63-item measure was piloted on 604 people (51% male, mean age = 29 years; S.D. = 11.24) following their experience of one of six mediated experiences with different levels of physical immersion (IMAX 3D, IMAX 2D, conventional cinema, college film projection [GCSU], Video Short presentation on a 28'' TV, and an interactive computer games console presented on a 28'' widescreen TV housed within a controlled test platform). The content was varied to avoid confounding the results with a specific type of content. In this way, the stability of the relationships between questions, irrespective of content, could be examined. All respondents rated just one presentation.

2.2 Results

Data were entered into a principal axis factoring analysis (Varimax rotation). Four factors were extracted and labelled: Sense of Physical Space (e.g., 'I had a sense of being in the scenes displayed'; 'I felt I was visiting the places in the displayed environment'), Engagement (e.g., 'I felt involved (in the displayed environment)'; 'I felt sad that my experience was over'), Ecological Validity (e.g., 'The displayed environment seemed natural'; 'I felt that the displayed environment was part of the real world') and Negative Effects (e.g., 'I felt I had a headache'; 'I felt tired').

To refine the measure, items were dropped that (a) failed to load above 0.30 on any factor, (b) showed unstable factor loadings when separate analyses were run on a random split of the dataset and/or were deemed of low importance or relevance to their factor, or (c) elevated the internal consistency of their respective factors when deleted in the alpha check. A total of 44 items were consequently retained for the ITC-SOPI.

Preliminary validity

The first factor, Sense of Physical Space, demonstrated sensitivity to media form in an uncontrolled experimental context. Variations in factors such as naturalness of content, type of image (photorealistic vs. animated) and nature of content both within and across the conditions render comparisons for Engagement, Ecological Validity and Negative Effects, less meaningful. As indicated in Figure 1, the pattern of results correspond somewhat to the degree of physical immersivity offered by the presentation media. For instance, large field of view formats (e.g., IMAX) tended to receive higher ratings than smaller field of view formats (video shorts presented on a 28'' colour TV). The exception is the Computer Game format which is likely to have been rated more highly because it is interactive. This supports the notion that there are trade-offs between the different determinants of presence.

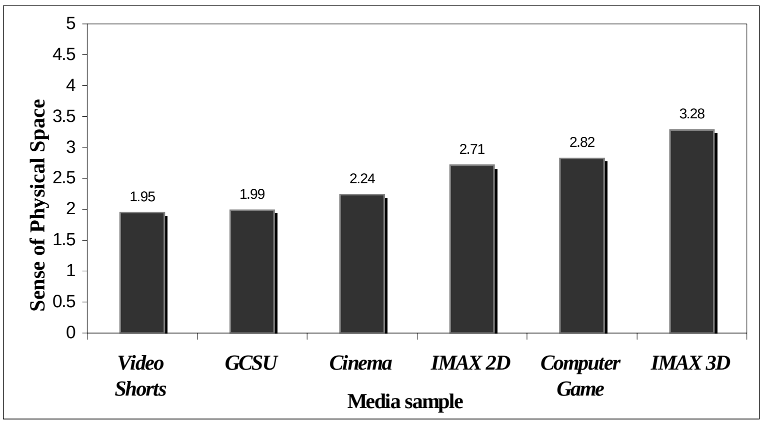

Fig. 1. Mean Sense of Physical Space scores for each of the media samples

3 Controlled experimental application of the ITC-SOPI: Stereoscopic depth cues

Our research group evaluates experiential aspects of Immersive (broadcast) TV - TV that makes the viewer feel present at a live event. By developing appropriate evaluation tools, such as the ITC-SOPI, various display configurations of the immersive system can be tested and recommendations made for its optimisation.

Stereoscopic enhancement of simple presence ratings is a robust finding [8, 9, 10, 11] that we aimed to replicate using our ITC-SOPI. We predicted that 3D presentations would receive higher ITC-SOPI ratings on Sense of Physical Space, Engagement and Ecological Validity than 2D presentations.

3.1 Method

Forty-eight students and staff or affiliates of Goldsmiths College, University of London (24 male, 24 female; aged 18-55 years, $\bar{x}$ = 26.6 years, SD = 8.4) experienced one 3D and one 2D video presentation. This comprised a 120 second piece of continuous stereoscopic video footage of a rally car sequence. The sequence depicts rally car driving shot from the backseat of a car and involves fast driving along a winding dirt track with few objects in view except foliage, traffic cones and isolated buildings. The movement of the car alternates quickly between sharp bends, slow bends and occasional straight stretches of road.

Observers viewed the stimulus video on a 28” Philips 100Hz TV monitor. They viewed the display wearing Crystal-Eyes polarised spectacles. The Crystal Eyes spectacles flicker on and off (switching the visible image between left and right eye) at a rate of 100 Hz, in synchrony with the video output. When separate left and right eye video tapes were placed in the video players, the system displayed stereoscopic video to a viewer wearing the Crystal Eyes glasses. For monoscopic presentations, the left eye view was presented to both eyes. Presentation order was fully counterbalanced across the sample.

The ITC-SOPI was administered immediately following each video presentation. Four scale scores were computed by averaging the constituent items for each of the ITC-SOPI scales: Sense of Physical Space (19 items), Engagement (13 items), Ecological Validity (5 items) and Negative Effects (6 items). Each scale ranged from 1 to 5. Data were collected as part of a larger study but only the data relating to viewing condition will be reported here.

3.2 Results

Repeated measures ANOVAs were run for each of the four ITC-SOPI scales. There was a significant main effect of viewing condition for Sense of Physical Space ($F_{(1,45)} = 20.7$, $p < 0.001$), Engagement ($F_{(1,45)} = 12.2$, $p < 0.01$), and Ecological Validity ($F_{(1,45)} = 7.8$, $p < 0.01$). In each instance, 3D presentations were rated more highly than 2D presentations (see Figure 2). However there was no significant difference between the two viewing conditions for Negative Effects ($F_{(1,45)} < 1.0$, ns). Thus the prediction that 3D compared with 2D presentations would produce higher ratings for ITC-SOPI Sense of Physical Space, Engagement and Ecological Validity was supported.

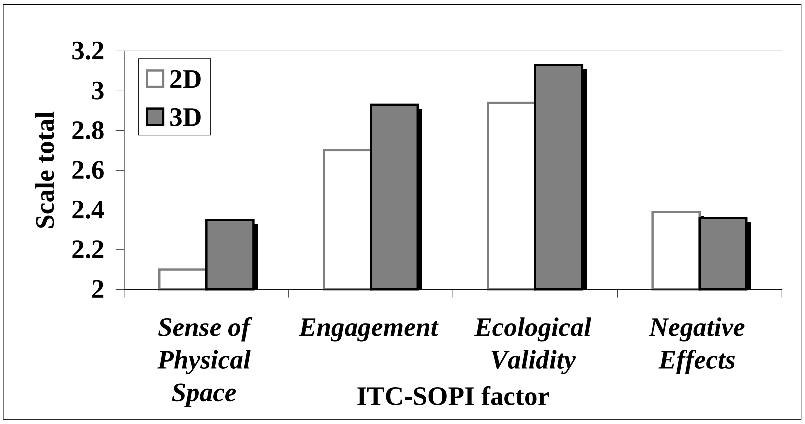

Fig. 2. The effects of viewing condition (2D/3D) on ITC-SOPI scores

4 Discussion

Immersive systems are being developed that provide viewers with an increased number of sensory inputs and enhanced fidelity within each modality. To evaluate a range of these systems a construct is required that (i) represents the goal of immersive systems and, (ii) can be measured using a reliable and valid tool which is sensitive to manipulations of system parameters.

Presence, the subjective sensation of 'being there', is proposed as a global media quality metric with which to evaluate and optimise immersive technology. The ITC-SOPI represents our research group's attempt to develop a presence questionnaire that overcomes some of the limitations faced by existing measures. A rigorous factor analysis of this carefully designed questionnaire suggested that the ITC-SOPI is composed of four scales: Sense of Physical Space, Engagement, Ecological Validity, and Negative Effects, each of which is highly cohesive. Preliminary validation of ITC-SOPI's Sense of Physical Space suggests that even in an experimentally uncontrolled context, it is sensitive to broad variations in media form. Furthermore, in an experimentally controlled context, the ITC-SOPI demonstrated sensitivity to manipulation of stereoscopic depth cues which has previously been shown to covary with simple presence rating scales. These preliminary results suggest that this measure is a promising evaluation tool.

One limitation of the ITC-SOPI is that we have not piloted this questionnaire on a broad range of what we term 'interactive' (i.e. inclusion of a control/manipulation device) displays. Nevertheless, given the high face validity of this measure, VE users should find this measure highly relevant to their experience. The revised ITC-SOPI has now been distributed to a number of VE labs across the world. Confirmatory factor analysis of this new data will enable a test of the stability of both the factor structure and its constituent items. A full exploration of the interrelationships between the factors will be undertaken.

The ITC-SOPI is currently being used in all our controlled laboratory experiments. We have planned studies to investigate, for instance, the impact of audio (number of channels, inclusion of bass, volume etc) and field of view in controlled experimental contexts. We anticipate that the results will further validate the ITC-SOPI, lending support to its use as a global media quality metric.

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