

# P-15: Presence as an experiential metric for 3-D display evaluation

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## Abstract

*In this paper, we argue that the experience of presence, i.e. the sense of "being there" in a mediated environment, provides us with a useful criterion to assess the global experiential impact of immersive and perceptually realistic display and communication media in general, and 3-D displays in particular. Measuring presence in a reliable, valid and robust manner is a considerable challenge to media research and methodology development. We present an experiment in which we attempt to measure presence both through subjective ratings, and through measuring postural responses, i.e. automatic postural adjustments in response to moving video, which are hypothesized to corroborate subjective presence ratings.*

## 1. Introduction

"It's hard to beat the thrills of 'Grand Canyon: The Hidden Secrets,' the IMAX film that rides the Colorado River rapids slicing through nature's most majestic chasm....So effective are the film's you-are-there perspectives that you wipe away imagined white-water from your brow when you're not holding on to your armrest for dear life". (C. Rickey, *Philadelphia Inquirer*, June 10, 1994).

With the rapid developments in the area of 3-D, immersive, multisensory displays, and the increased availability of transmission bandwidth, computing power and digital resources, we are able to create and experience reproductions and simulations of reality with an unprecedented sensory quality, blurring the distinction between reality and its representation. Particularly in the area of broadcast displays, recent technological advances have been aimed at improving the reproduction and scope for both sound and vision, including wide-screen, high-definition displays, immersive television, stereoscopic television, and directional audio formats [1-5]. With the increased perceptual realism and impact of these media, additional evaluation concepts and tools are needed that go beyond evaluating image or sound quality alone and are sensitive to the overall psychological impact a display has on the viewer.

Stereoscopic (3-D) displays contribute significantly to the perception of egocentric distance and exocentric depth. For performance-oriented applications (e.g., medical teleoperation,

remote inspections of hazardous environments, etc.) the capacity of 3-D displays to provide an accurate representation of structured layout, distance and shape can be utilized for precise perception and manipulation of objects. For entertainment purposes, stereoscopic displays are used in cinema, broadcasting and virtual reality gaming for their ability to generate a compelling sense of physical space, allowing a scene to extend in depth, and objects or actors within it to appear in front or behind the screen pane.

Producers of 3-D movies are well aware of the enhanced psychological impact stereoscopic films can have on the viewing public. This is illustrated by the catch phrases used on publicity ads for 3-D movies, particularly in the 1950s, such as: "The flat screen is gone! You – not a camera – but you are there" (*Bwana Devil*, 1952), "It happens to YOU in three dimensions" (*Man in the Dark*, 1953), or the slightly ambiguous "Puts the action right in your lap" (*The Starlets*, 1976), which was used for an X-rated movie. These phrases underline the *first person* nature of the experience – the audience is not simply observing, but actively participating. The viewer is made to feel *part of* the movie or, as Slater and Wilbur [6] put it, with reference to virtual environments, the "discontinuity between the place of our current reality and the reality showing through the display" is collapsing.

When aiming to evaluate the overall viewing experience, i.e. moving beyond the assessment of modality-specific quality attributes, a particularly relevant user experience is that of *presence*. When users are exposed to immersive and perceptually realistic media, they report a sense of "being there" in the scene - of becoming "part of the action". In addition to such subjective judgements, behavioral and psychophysiological responses may be provoked that are similar to those in nonmediated environments. Such responses could potentially serve as objective indicators of presence, corroborating the results of subjective assessments [7].

Systematic research into presence has only started since the early 1990's, mainly in relation to virtual environments. There is consensus that the experience of presence is a complex, multidimensional perception, formed through an interplay of raw (multi)sensory data, perceptual-motor activity, and various cognitive and emotional processes – an experience in which attentional factors play a crucial role as well. Figure 1 depicts a common framework of media experience in general, and presence in particular.

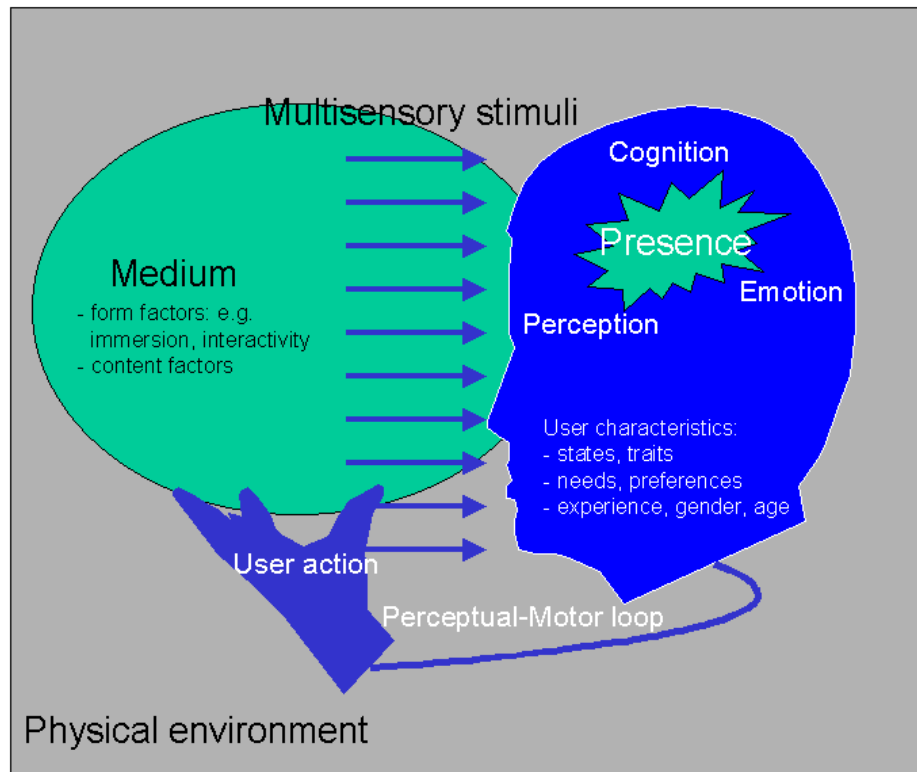


Figure 1. A general framework of presence in relation to media

## 2. Measuring Presence

A measure of presence that is reliable, valid and robust is an essential tool in designing and evaluating media from a user-centred perspective. It will allow engineers and media developers to identify the factors (and trade-offs between them) needed to optimise the level of presence for the media user. Moreover, a good presence measure will allow the research community to further develop its understanding and systematic investigation of the construct, which will in turn enable further refinement of measurement methodologies, and so on.

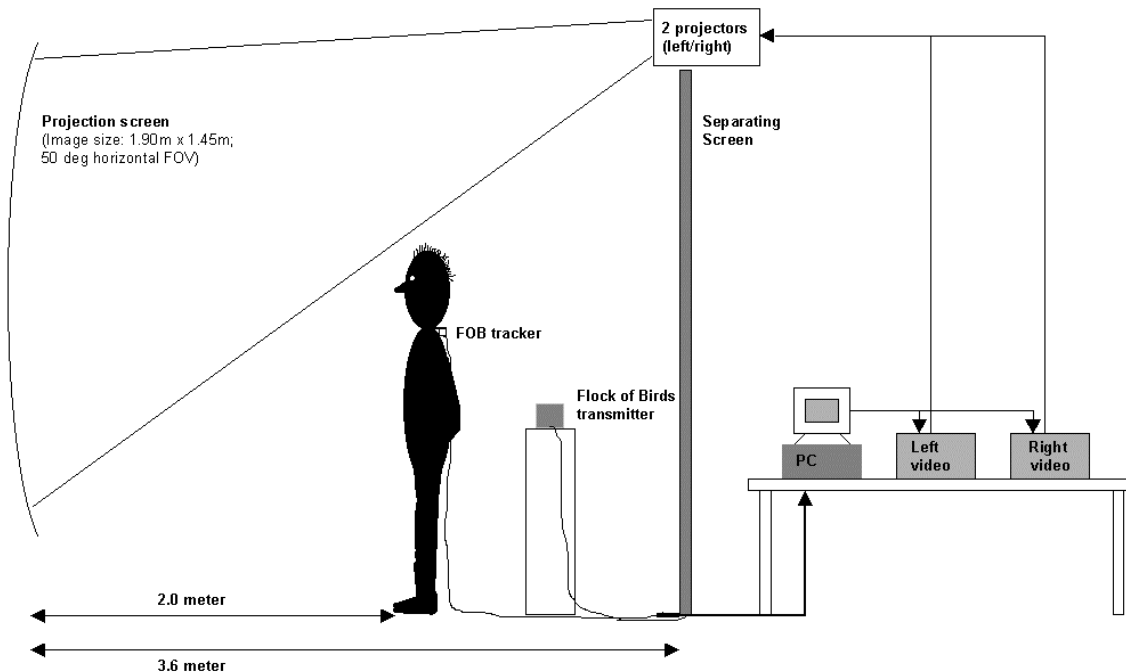
To date, a variety of presence measures have either been proposed or used which can generally be classified into subjective and objective corroborative approaches. The former is by far the most common approach taken and is usually questionnaire-based. The latter approach may involve the measurement of various behavioural and psychophysiological responses, which are thought to be sensibly related to the medium manipulation under study. Importantly, both approaches present complementary ways of measuring presence, and should ideally be used together to overcome limitations of either approach alone (for review and discussion see [7]). Despite considerable progress in investigating several candidate measurement methodologies, measuring presence in a reliable, valid and robust way still remains one of the main research challenges of the field [8, 9].

## 3. Experiment

We performed a 3-D display evaluation experiment in which we employed presence as an evaluation metric for assessing the subjective impact of the display. In addition, the experiment was aimed to investigate the utility of postural responses as a potential objective corroborative measure of presence. The reason for selecting this measure was three-fold. First, postural responses have been shown to be sensitive to various types of display manipulations, such as screen size or stereoscopic presentation [10], which have also independently been shown to be related to presence [11-13]. Secondly, postural responses occur automatically without conscious reflection and are thus unlikely to influence concurrent subjective evaluations. Thirdly, they have the capacity to produce differential levels of response, making them potentially sensitive to various levels of display manipulations and enabling comparison with differential levels of subjective response to presence [14].

### 3.1 Method

Left-right postural sway was measured in response to a stimulus containing substantial lateral movement (i.e. a rally car traversing a curved track at speed), which was displayed on a large stereoscopic projection display (50 deg. horizontal field of view). In addition, subjective measures of presence, involvement and vection (i.e. feeling of self-motion) were taken. Stereoscopic presentation (mono/ stereo) and image motion (motion/ still) were manipulated as independent, within-subject variables.



**Figure 2.** Schematic diagram of the laboratory set-up illustrating the observer's position in relation to the display.

Figure 2 schematically illustrates the laboratory set-up, with the observer standing in front of the stereoscopic projection display where his/her postural responses were measured via a Flock of Birds © magnetic position tracker.

### 3.2 Results

Results demonstrated a noisy yet positive effect of stereoscopic presentation on the lateral postural responses. Post-test subjective ratings revealed a significant effect of stereoscopic presentation on the subjective judgements of presence, but not on those of vection or involvement. Image motion had a large and significant effect on the subjective judgements of presence, vection and involvement. The effect of image motion was considerably larger than that of stereoscopic viewing. Figure 3 illustrates the effects of image motion and stereoscopic presentation on the group mean lateral postural responses ( $n=16$ ).

Comparison of the results of the current study with the results of a previous, similar study employing a smaller screen size (28 deg. horizontal field of view) [14] showed a large significant effect of screen size on subjective presence and vection ratings, but no significant difference on the postural response measure.

### 3.3 Discussion

The significant effects of stereoscopic presentation, image motion and screen size on subjective presence ratings are line with the hypotheses based on presence theory, anecdotal evidence and previous experimental work [12-14]. The postural response measure yielded mixed results. On the one hand, the significant effect of stereoscopic presentation was in the hypothesized direction. On the other hand, the absence of a significant effect of screen size between the current study and our previous postural response study [14] does not bode well for the sensitivity of the

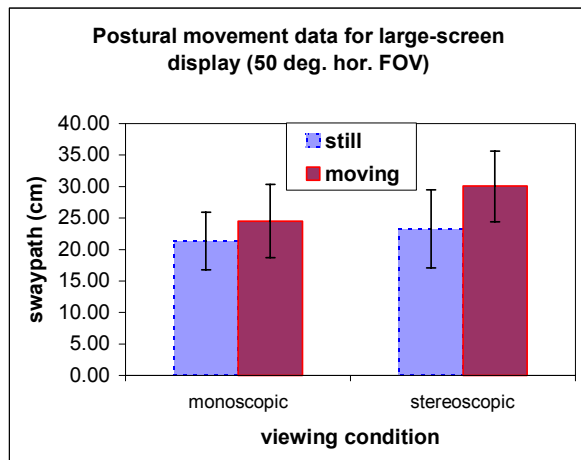
postural response measure as a measure of presence. This lack of effect may be due to an artefact in the experimental set-up, i.e. more ambient field illumination in the large-screen case, which will be addressed in future research. Postural responses may be useful as a behavioral measurement tool in assessing the overall psychological impact of media displaying motion content, either stereoscopically or monoscopically. However, the measure clearly needs to be refined in order to be practical in its application as a corroborative measure of presence.

## 4. Conclusions

We argued that presence, or the experience of 'being there', provides us with a promising experiential construct for evaluating 3-D displays. Supporting this statement, the results of our experiment showed that stereoscopic presentation of a video stimulus enhances the subjective experience of presence. In addition, we investigated lateral postural responses to the medium as an objective behavioral measure of presence that can corroborate subjective presence ratings. Our results showed a positive effect of stereoscopic image presentation on the postural response measure, yet we found this measure to be limited in its sensitivity to screen size manipulations.

Given the wide variety of media experiences, ranging significantly in both media form and media content, it becomes evident that measures of presence will either need to be media-independent, or specifically tailored to a very limited subset of media. In fact, both approaches are presently emerging. Media-independent (i.e. purely experiential and not technology-based) presence questionnaires are being developed using factor analysis, and are carefully piloted across a range of media and media-users with promising results (see e.g. [15]). Behavioral and psychophysiological measures of presence on the other hand are intrinsically bound to the specific type of behavioral or

physiological response the media form and/or content is able to elicit. In other words, objective measures need to be selected and tailored such that they are appropriate and sensitive to the specific experience the medium is aimed to elicit. For example, media aimed at eliciting fear responses (e.g. therapeutic virtual environments aimed at treating various kinds of phobias through systematic desensitisation) can be assessed using psychophysiological measures (see e.g. [16]), whereas for evaluating a communication medium (e.g. a videoconferencing set-up) socially conditioned responses would be more appropriate.



**Figure 3.** Group mean lateral postural responses. Bars indicate standard errors.

By combining both subjective and objective approaches we may arrive at a set of *aggregate* measures of presence that can avoid the limitations of either approach alone. The necessity of developing such a global experiential measure is clear as we witness the expansion of the media universe from traditional television, film and radio to home theater, simulation arcades, IMAX, virtual reality, HDTV, and more. We need measures that are sensitive to the overall quality of the experience, such as the one of watching IMAX 3-D, as described by Janet Murray [17]:

“When the movie starts, the sensation is not of size or gadgetry but of magical apparition, for the 3-D movies that are shown in this new Alhambra make conventional movies look like daguerrotypes. The world that is displayed through those lightweight and soon forgotten goggles has the depth and dimension of the actual world., where you can see around things, look left and right, and shift your focus from back to front within the same image. The size of the film means an increase in information, offering a richer and therefore more persuasive visual illusion. It is not merely a larger image but a more present reality.” (p. 45)

## 6. Acknowledgements

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