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The Place Probe: Exploring a Sense of Place in Real and Virtual Environments

Abstract

This paper describes the design, application, and refinement of a qualitative tool designed to study sense of place. The Place Probe incorporates a range of stimuli and techniques aimed at articulating a person's sense of place. It has been developed, used, and undergone three revisions. The paper describes the background to the choice of measures that were included in the Place Probe and describes its application in both a physical place and a virtual representation of that place. This enables a comparison of the experiences. An analysis of the results reveals a similarity of reported experience, however the extremes experienced in the physical place were less pronounced in the virtual representation. The Place Probe has been refined in light of the results of the empirical work and now incorporates both qualitative and quantitative data on the experience of place.

1 Introduction

BENOGO (BEing there, NO need to GO) was a research project funded under the European Union's €20m Future and Emerging Technologies theme of the Fifth Framework Programme, Presence, 2002–2005. The aim of the project was to develop a novel technology based on real-time image-based rendering (IBR) for representing places in virtual environments (VE). This technology would be used in empirical and theoretical studies of presence. As real places with manmade and/or organic objects like trees, foliage, and so on are hard to represent in a graphically constructed VE, IBR technology offers an alternative. IBR does not require a reconstructed geometrical model of the scene (Buehler, Bosse, & McMillan, 2001; Shum & Kang, 2000). However, large amounts of image data need to be stored and retrieved for real-time visualization if an egocentric viewpoint is to be maintained as the viewer's head position is tracked. Fundamental research in the project has been concerned with identifying how a relatively few photographic images of a scene can be captured, processed by algorithms and rendered to provide a realistic representation of the scene that includes stereoscopic effects (Feldman, Padjla, & Weinshall, 2003). Another objective of the project, then, is to find ways in which the key aspects of the place can be captured and communicated to the designers and engineers, so that technological constraints do not undermine the subjective feeling of presence and place.

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This paper reports the experience of conducting empirical work into understanding and representing a sense of place. This work has taken place over a period of thirty-six months and has involved over 190 participants in eight separate studies. In between the studies much analysis, reflection, and discussion has been undertaken. This paper focuses on the development of a method for representing a sense of place for the purpose of designing for a VE of that place. The method for communicating this information to designers and engineers is described in Smyth, Benyon, McCall, O'Neill, and Carroll (2006). The paper is organized as follows. Section 2 provides a brief introduction to the philosophical issues that underpin the work. Section 3 discusses the different studies that have informed the production of a Place Probe. This instrument is described in Section 4. Section 5 presents data from the use of the probe by thirty people at a viewpoint in the city of Prague and by thirty people in a photorealistic VE of the viewpoint rendered through a head mounted display (HMD). Section 6 provides some discussion of further developments and conclusions as to the success of this approach.

2 From Presence to Place

At the outset the project we adopted a conceptual framework based on the concept of embodied interaction (or embodiment). Embodiment is a development of the phenomenological school of philosophy developed by Edmund Husserl (1917) and later by Heidegger (originally Heidegger, 1927, now Heidegger, Macquarrie, & Robinson, 1978). Phenomenology aims to describe the experience or awareness of things in a manner which does not reduce them to objective scientific data. For Husserl, an individual's experience was the experience of some phenomena; *something*. By focusing attention on the act of this "experiencing of" rather than on the thing being experienced or the person who was having the experience, he aimed to focus on knowledge that could account for things beyond the reach of science. Heidegger, a student of Husserl, further developed ideas of phenomenology. He started with the common-sense observation that the world exists; a condition he dubbed Being. Beings are those entities that exist in the world and are able to reason about Being. The focus of the use of a phenomenological approach should be *average-everydayness*.

Continuing in the phenomenologist tradition, Merleau-Ponty's account of being-in-the-world emphasizes the importance of the body (Merleau-Ponty, 1962). He places the body at the center of people's relation with the world and argues that it is only through having bodies that people can truly experience space. In the context of perception Merleau-Ponty formulated a sense of sight as an embodied vision: "our body is both an object among objects and that which sees and touches them." In art and architecture many argue that this central role of the body is disappearing. The emphasis on the visual sense in Western culture has resulted in "designs which housed the intellect and the eye, but that have left the body and the senses, as well as our memories and dreams, homeless" (Pallasmaa, 1996). The sense of "aura," the authority of presence, that Walter Benjamin (1997) regards as a necessary quality of an authentic piece of art, has been lost. The philosophy of embodied interaction continues with works such as *Where the Action Is* (Dourish, 2001).

It is contended that this philosophical background has two important consequences for research into presence and place. Firstly, the sense of presence requires a body; it is not just a mental construct. A body is clearly missing from the experience of many virtual environments (such as those rendered using an HMD) and we suspect that this will result in an impoverished sense of presence. Secondly, psychophysical measures of presence such as arousal, fMRI, or EEG will not capture this rich qualitative nature of presence.

The thrust of the BENOGO project was, to be there no need to go; that is, to provide people with a realistic sense of being somewhere else. Accordingly the research has focused our attention on capturing the essential features of places and finding ways in which to communicate these to the designers and engineers of virtual environments. Some of the wider philosophical issues of trying to do this are described in Turner and Turner (2006). The focus here is on finding a method,

grounded in the embodied interaction tradition, that captures a sense of place in a form that is useful to designers.

The interaction between people who populate a space, and the objects in a space can result in a variety of interpretations of that place. For example, the design of city center parks may provide convenient lunchtime seating for office workers but as night falls may also provide unforeseen challenges for the city's skateboarders. While the found space (Borden, 2001) remains the same for each group it is contended that the sense of place is quite different.

The sense of place has been considered extensively in environmental psychology, sociology, geography, literary, and media theory. Relph's (1976) monograph takes an explicitly phenomenological and holistic stance towards appreciating places. He defines three components of place identity:

- physical setting
- activities afforded by the place
- meanings and affect attributed to the place.

Relph's model of place provides us with the basic framework within which we developed the Place Probe. However we also explored the idea of place from the perspective of Gustafson's conceptualization (2001). He draws on empirical work in the form of an interview survey and builds on a review of earlier conceptualizations of place to identify three poles that can be used to understand places. Self concerns the individual's lifepath, emotions, activities, and identification. Environment concerns the physical environment, distinctive features and events, the type of place, and its localization. The characteristics of other people in the place characterize the third pole.

There are other accounts of space and place, notably the work of Edward Casey (1997), Y.-F. Tuan (1977), and Jorgensen and Stedman (2001) that are related, but which have not directly informed our work. Turner and Turner (2006) provide a good review. We have evolved our view of place through undertaking empirical studies, discussing results within the project team and exploring the data through the frameworks of Relph and Gustafson.

3 Contributing Studies

Techniques for understanding and measuring presence fall broadly into two approaches. Measurements of arousal take physiological measures of things such as skin conductivity and use this as a measure of presence. The other approach is to measure people's responses using questionnaires. The Immersive Tendencies Questionnaire (ITO; Witmer & Singer, 1998) was developed to identify real world tendencies (e.g., using computer games) that may affect a person's sense of presence. The ITC-SOPI (Lessiter, Freeman, Keogh, & Davidoff, 2000) questionnaire was developed for the UK's Independent Television Commission. This Sense of Presence Inventory is a cross media questionnaire that explores spatial presence, levels of engagement, sense of naturalness, and negative aspects that affect presence. The MEC spatial presence questionnaire (Vorderer et al., 2004) is a recently developed questionnaire of spatial presence.

In addition to asking people how they rate themselves, there are a number of techniques that are used to enable researchers to elicit people's feelings. The Talk Aloud technique invites people to talk about their feelings and thoughts while immersed in an environment. Sometimes people are given free rein to talk about what they want. On other occasions they are given prompts to address issues of object identification or the meanings and significances that they attribute to the space (O'Neill & Benyon, 2003). A version of the technique using video in a real world setting has also been used. Structured Interviews can be used after people have been immersed in a VE. Participants were asked to describe the environment and asked a series of specific questions about how they feel. Repertory Grids are a means of gaining access to the meaning a person has attached to their experience (Kelly, 1955). People are asked to describe their experiences according to a number of dimensions supplied either by the people themselves or by the experimenter. Relationships between

these dimensions are used to arrive at key concepts that describe a domain. A related method is to ask people to rate an experience using key differential scales that have been developed to describe the experience (Osgood, Suci, & Tannenbaum, 1957).

A third approach to gathering data about experiences is to ask people to express their feelings in a more free-form fashion. Sketch maps are a technique used to elicit people's understanding of spaces, key landmarks, and relationships between salient features of an environment. Written descriptions of places can also be used. An instruction such as "please write a 150 word description as if you were describing this place to other people" (Turner, Turner, & Carroll, 2005) has been used. Undirected descriptions in the form of analyzing entries in a holiday home visitors book (Turner & Turner, 2003) is another form. A variation on this is to get people to select a few key words that capture their experiences concisely. Selecting a photograph is a method that offers a nonverbal medium for people to express their views. People are asked to select a photograph from a set of images.

The data gathered using these data gathering techniques can be subjected to a variety of data analysis techniques such as grounded analysis (Glaser, 1998), peer reviewing, semiotic analyses (O'Neill & Benyon, 2003) and various forms of coding. The questionnaires provide a quantitative measure that can be used to compare across individuals and can also be used to arrive at a consensus view of how immersive and effective a VE is. Written descriptions, verbal reports, and sketch maps require a qualitative approach to the analysis, which can be time consuming. Typically two researchers will analyze some of the same data and discuss their findings to arrive at an appropriate interpretation. Later a workshop may be held where different analyses are compared and discussed until consensus is reached.

In developing the Place Probe this whole range of techniques has been used, reviewed, and discussed. They have been used in a variety of settings such as a real environmental architecture (Smyth, 2005), a real botanical garden (O'Neill & Benyon, 2003), a virtual environment representation of a botanical garden in an HMD (Turner et al., 2003), a university stairwell rendered in an HMD, a city view of Prague rendered in an HMD (McCall, O'Neill, Benyon, & Smyth, 2004), a virtual environment of the Technical Museum in Prague in both a fully immersive, six sided CAVE and HMD (McCall, O'Neill, Carroll, Benyon, & Smyth, 2005). The main contributing studies to the development of the Place Probe are summarized in Table 1.

One of the motivations underpinning the research is to compare virtual representations against real places. Such comparisons can be made at many different levels of abstraction. Thus the comparison, undertaken in Demonstrator 1, of the Prague botanical gardens and the Edinburgh botanical gardens was considered to be valid at the level of general characteristics. The virtual gardens did not feel hot and humid which was a key characteristic of the real gardens; however, many of the plants were of similar shapes and sizes. They were not the same plants, but they provided an overall feel for being in a botanical garden.

The virtual stairwell used in Demonstrator 2 provided interesting insight. When the researchers who had only experienced the virtual environment visited the real stairwell they expressed a real sense of having been there before. The visual fidelity and the sense of scale provided by the virtual representation had caught something.

Demonstrators 3 and 4 were smaller studies focusing more on a functional perspective rather than a presence point of view. They were concerned with measuring a series of specific technical aspects which seem to have an impact upon participants' feeling of realism within an IBR virtual environment.

Demonstrator 5 provided the best opportunity to benchmark a place and to enable the comparison between a real place and a virtual representation of that place. The place chosen was a city viewpoint in Prague and the subsequent study will be summarized in the next section. But even here, the real and the virtual are experienced at different times of day, with different weather conditions and so on. This impossibility of making a detailed and exact comparison must be born in mind when considering benchmarking data. The final experiment compared an IBR environment with a

Table 1. *Summary of the Methods Utilized within the BENOGO Project*

Location	Date	Mediating technology	Participants	Data analysis methods
Demo 1. Real study: Edinburgh Botanical Gardens	February 2003	Video camera (subjects talked whilst videoing the scene).	4 male	Quantitative analysis of ITQ and SOPI questionnaires.
				Qualitative analysis and identification of reoccurring themes of talk aloud and structured interview data.
Demo 1. Virtual study: Prague Botanical Gardens	February 2003	Head mounted display	29: 22 male, 7 female	Quantitative analysis of ITQ and SOPI questionnaires.
				Qualitative analysis and identification of reoccurring themes through video talk aloud and structured interviews.
Demo 2. Virtual study: stairway at CTU in Prague	April 2003	Head mounted display	32: 20 male, 12 female	Quantitative analysis of ITQ and SOPI questionnaires.
				Qualitative analysis of talk aloud, structured interviews, and repertory grids.
Demo 5. Real study: viewpoint in Prague	November/ December 2003	None	30: 17 male, 13 female	Qualitative analysis and identification of reoccurring themes based on Gustafson's Place model, based on Place Probe version 1.
Demo 5. Virtual study: viewpoint in Prague	March 2004	Head mounted display	30: 17 male, 13 female	Qualitative analysis and identification of reoccurring themes based on Gustafson's Place model based on Place Probe version 1.
Demo 6. Technical Museum, Prague	December 2004	Head mounted display and CAVE	28: 17 male, 11 female	Quantitative analysis of distance estimates, and MEC questionnaire data.
				Qualitative analysis of Place Probe version 2.
Comparative Study. image-based rendering versus modeled scene	August 2005	Head mounted display	40: 22 male, 18 female	Quantitative analysis based on Place Probe version 3 (including MEC questionnaire).

graphical model of the same place both rendered in an HMD.

4 The Place Probe Version 1

The experience of using a variety of data capture techniques indicated that no single questionnaire, or set of questions or other unitary method was going to provide the rich variety of data required to understand the key features of a place. To address this lack it was proposed to utilize a variety of data capture methods used in conjunction with a range of data analysis methods. Accordingly the Place Probe was created.

Probes have been used recently in two main contexts. Cultural probes (Gaver, Dunne, & Pacenti, 1999) consisted of a number of stimuli such as postcards, cameras, diaries, and so on and were developed to inform the design of new technologies. They were not intended simply to elicit some objective data, they were intended to provoke responses. In a similar vein Technology probes (Westerlund, Lindquist, & Sundblad, 2001) have been used particularly in the domestic setting to explore new uses of technologies. Other probes have been used by Eggen, Hollemans, and van de Sluis (2003) and by Baillie, Benyon, Macaulay, and Petersen (2003) both in the setting of technologies in the home.

A key feature of probology (Gaver, 2004) is to assemble a collection of stimuli that elicit responses from people using a variety of media and forms of expression that enable researchers to become sensitized to the key issues in some domain. Probes encourage designers and evaluators to engage in subjective interpretation and to maintain a degree of uncertainty about results. Probes are meant to help designers in their work, not to gather objective data. The Place Probe was designed with this philosophy. The aim was to represent people's experiences of place at a specific point in time and to inform the design of virtual environments. The Place Probe has gone through three iterations during which time it has incorporated more objective data. The Place Probe version 3 is included in Appendix 1. Drawing on the experiences of the previous empirical studies it was decided to include the following instruments within the probe.

4.1 The Visitors Book

Research undertaken by Turner and Turner (2003) has highlighted the written reports contained in visitor's books as a source of rich data about place. Indeed such reports have the advantage that they are often ask open-ended questions, for example, "Please tell us about your experience" rather than "Tell us about the lighting," hence they do not prompt people to provide answers on specific topics.

4.2 Sketch Maps

Sketch maps provide information on the layout and key features of a location. In this case accuracy of the map is not of prime concern, rather it is the depiction of those aspects of the place that people remember; for example a tree, building, or seating area. They can also be used to provide additional information such as where people are standing or their paths through the environment.

4.3 Salient Features

This section of the probe asks for participants to rate the three most salient features of the environment. The aim of this is to establish the most important characteristics of the place in order to help advise the designers of a virtual place and to evaluate how effective the virtual scene is. The Probe asks, "Pick 3 features of the environment that you remember and rank them in order of importance."

4.4 Semantic Differentials

In this instrument participants were asked to rate various features of the environment (see Table 2). This part of the probe combined Osgood's semantic differentials (Osgood et al., 1957) and Relph's (1976) three aspects of place (physical features, activities afforded, and affect engendered). Participants were asked to rate the environment on the scale shown in Table 2. It is a technique that has also been used by Lawson (2001).

Table 2. *Semantic Differentials*

	Very	Quite	Neither	Quite	Very	
Attractive						Ugly
Big						Small
Colorful						Colorless
Noisy						Quiet
Temporary						Permanent
Available						Unavailable
Versatile						Limited
Interactive						Passive
Pleasant						Unpleasant
Interesting						Boring
Stressful						Relaxing

4.5 Select a Photograph

A set of photographs is taken of the real world location. These were then given to the participants in the study who were asked to select the one that best represented their experience of the location they had visited or were visiting.

4.6 Six Words

The final part of the probe asked people to write down six words that best described their experience of being in a particular place.

The Place Probe is given to participants of the studies directly following their experience of the place to be assessed, whether that is a real place or a VE. Each source of data (except for the semantic differentials) is analyzed using a (semi) grounded theory approach (Glaser, 1998), the objective being to allow themes to emerge from the data rather than to force the data to fit into any preconceived model. However, we include the caveat "semi" because we are looking for issues of place and we do have some theory of place that is underlying the analysis. Typically three evaluators will analyze the data. Each source of data is thoroughly analyzed by one evaluator and a random sample from each source is given to other evaluators. This ensures inter-rater reliability.

After analyzing each source of data a workshop is held. This is a forum where all evaluators gather to discuss the themes that emerged within the data with a view to agreeing on a common set of themes. Various theoretical models have been used to assist in the analysis of the data. For example on one occasion the data was arranged using the model of place developed by Gustafson (2001). The themes were then checked against the samples chosen from each data type to ensure that similar items are being identified and to discuss any discrepancies.

During the next stage of the analysis the evaluators begin to explore which themes appear across the range of data sources, with a view to retaining those that appear in more than one data source and possibly eliminating those that appear in only one source. They also look for links between themes in different data sources so that any that refer to the same feature or phenomenon can be grouped together.

The ultimate objective of developing the themes is to provide designers and evaluators with a series of templates, or patterns, that can be used to describe a given place. This is similar to the idea of architectural design patterns developed by Alexander (1979). Alexander's architectural patterns are sets of high-level common descriptions of architectural features such as parking lots, galleries, openings, and cafés. He identified 286 pat-

terns for the development of cities. Our work has investigated whether such standard descriptions—for example, "outdoor scene," "city view," and so on—are feasible in the context of virtual environments (Smyth, Benyon, McCall, O'Neill, & Carroll, 2006).

The analysis of the semantic differentials is much quicker and this is one reason why their use has been expanded in later versions of the Probe. The analyst can count the number of responses to each point within the differential scale and various statistical analyses can be done. In Place Probe version 3, the semantic differentials have been expanded to reflect the Relph model of place. Thus there are semantic differentials covering physical characteristics, activities, meanings, and affective characteristics of the place. A technology differential has also been introduced to deal with characteristics of VEs. We return to this discussion in Section 6.

5 Using the Place Probe Version 1

The first use of the probe was in Prague in December 2003. Places in Prague dominate the locations for exploring places because the engineers responsible for collecting the photographs that formed the basis of the VEs were located there. The objective of this study was to find a number of locations that could then be recreated in photorealistic environments. A number of technical and physical constraints were placed upon the selection process. For example the requirement to find locations that had adequate lighting, sound, and where it was possible to take photographs without interference from any people moving around.

As a precursor to the study, a variety of travel guides were obtained with the objective of prioritizing a number of possible sites in Prague. This list formed the basis of initial discussions with the engineers who would ultimately be photographing the locations. Following on from discussions with the development and photographic teams a place suitability checklist was devised which examined each location and rated it for how suitable it was given any constraints or desirable attributes (see Table 3).

The most promising locations were visited and data was recorded using the checklist, notes, photographs, diaries, and a variety of other rich, contextual data collection methods (collages, drawings, etc.). Based on this four locations were selected: the Botanic Gardens, the Church of St. Nikalas, the Czech Technical Museum, and a hilltop with a view of Prague. In this paper we use the empirical study of the Prague viewpoint to illustrate the process. More detail is provided in O'Neill et al. (2004).

The viewpoint is one of Prague's largest single green spaces (with many trees) and it is ideal for quiet walks and breathtaking views over the city of Prague (Figure 1). The viewing platform (where the study took place) is situated on the top of this hillside and is accessible from the road by climbing up a number of very steep steps. It is an open circular space which is partially surrounded by a hedge, a few benches, and a sheer drop to the front of the platform. There is a statue of the Virgin Mary to the rear of the platform, a plaque to the front, and a monastery and house in the surrounding local background. The view is spectacular and it looks out over the entire of Prague city, exposing some of the city's most famous landmarks. It is, as one of the participants described, "like being on top of the world."

5.1 Study of the Real Environment

A total of 30 people (17 male/13 female) took part in the study at the viewpoint in Prague, with ages ranging from 15 to 58. The group contained a range of nationalities including Czech, English, Swedish, and German. At the hilltop view of Prague, members of the public who were visiting the area were asked to complete the Place Probe. Each person was told it would take around 15 minutes and they would be paid 150CZK (around $5 or €5). Participants were informed that the study was interested in their experience of the place.

A typical example of the data gathered from the description section of the probe is as follows:

> *A gray mist is covering Prague, my fingers are bitterly cold but still the magnificence of Prague cannot be covered. I was standing on the hill, which the castle is*

Table 3. *Place Suitability Checklist*

	1. St. Vitus Cathedral	2. Prague Castle	3. Technical Museum	4. St. Nikalas Church	5. Library	6. Viewpoint	7. Loreto	8. Botanical Garden	9. Train station	10. Post Office
Natural scene	—	—	—	—	—	1	—	1	—	—
Clear vertical lines	1	1	.5	1	1	—	1	1	1	1
Complex geometry	1	1	.5	1	1	1	1	1	1	1
Horizontal occlusion	1	.5	1	1	1	1	1	1	1	1
Range of colors	1	.5	1	1	1	1	1	1	1	1
Constant light source	.5	—	—	.5	1	.5	.5	1	1	1
Low light conditions	1	—	—	1	1	.5	1	—	1	—
Constrained movement	—	—	—	—	1	1	—	1	1	—
No people/accessible after hours	.5	.5	.5	.5	—	.5	—	1	—	.5
Constrained interaction	1	1	1	1	1	1	1	1	1	1
Possible augmentation	1	1	1	1	1	1	1	1	1	1
Range of interesting sounds	.5	.5	—		.5	1	.5	.5	1	1
Total	8.5	6	5.5	8	9.5	9.5	8	10.5	10	9

on, and it was facing the new town, the Volta River and the old town in the distance. All the most beautiful landmarks are visible and I felt totally happy and contented to be there.

(22, female, Singaporean, First time at the viewpoint)

Figure 2 is an example of the kind of sketch maps that were drawn by the participants.

The participants seemed to rank the view, St. Vitus Cathedral, and their feelings/impressions of the place (i.e., quiet, peaceful) as the features of most importance. Overall, the cathedral featured more dominantly than any other feature (though some people called it a castle). The view was mentioned on ten occasions with references to it ranging from a "fantastic" view to a "wide" view to a "good" view. The platform, river, nature, and trees were also frequently mentioned. Feelings and expressions of openness and niceness were noted throughout the responses and the overall impression was quiet, peaceful and clean with noted sounds of dogs and birds.

A number of themes began to emerge from the words used by participants to articulate their experience of being at the viewpoint, such as Peaceful, Relaxing, Interesting, Beautiful, Enjoyment, and so on.

5.2 The BENOGO Virtual Viewpoint

The BENOGO VE (Figure 3) environment was a representation of the viewpoint in Prague rendered using BENOGO's real-time IBR software. The system in itself comprised six networked computers running as a cluster, a head mounted display (HMD) and eight speakers providing surround sound. The scene is captured as a set of photographs taken in a circle from a static location. This allows the scene to be rendered in

Figure 1. *View of Prague from the hillside viewpoint.*

the HMD so that the viewer can rotate the displays through 360° through head movement. Unlike other photorealistic technologies, the BENOGO system lets people move freely within a specified area and provides vertical occlusion cues. However the level of movement is limited. For example, in the system used in this study people can only walk within a 60 cm radius (in the *X* and *Z* planes). Moreover, when looking at the top and bottom (of the world or sphere) there are some graphical distortions.

The HMD had a resolution of 640 × 480 pixels, 14 pixels per degree of view and a field of view of 60°. Head tracking with six degrees of freedom was used within the HMD in order to calculate the position of

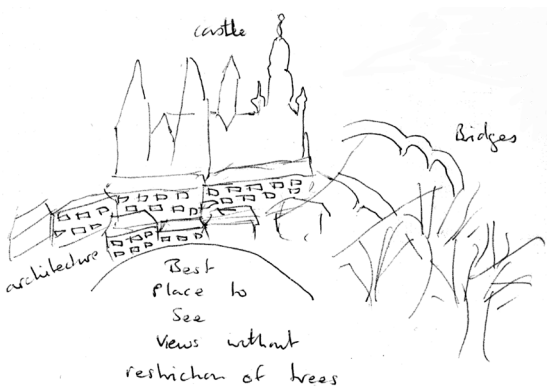

Figure 2. *A typical sketch map from the Prague study.*

Figure 3. *Viewpoint Mosaic created for head mounted display.*

the user and hence to render the scene from an appropriate point of view in real time. Latency was noticeable, but the images themselves were high resolution. The way that images were stitched together in real time resulted in a rather grainy, impressionistic view. It should be noted that this was the technology at the time. By the end of the project a number of the technological issues had been improved.

Those who took part in the study in virtual environment were instructed on how to use the HMD and then told to explore and experience the environment. They were made aware of the movement restrictions of the HMD but encouraged to move freely within the available space. They were also told that they would be immersed in the virtual environment for a period of time and that they would be informed when that time was up. When the time was up they were helped out of the HMD and taken through to a separate room where they completed the Place Probe. After this they were offered some light refreshment as reward for taking part in the study.

A typical example of the data gathered from the description section of the probe in the VE shows up some of the technical constraints. In a similar vein the sketch maps are less clear (Figure 4).

> *The view was from a hill overlooking a city in southern Europe on a sunny day with birds and some church bells in the distance. I was standing on a paved circle with a statue behind me. The picture was a bit blurry especially the trees. Perspective seemed natural. There were camera/lens reflections hanging in midair behind*

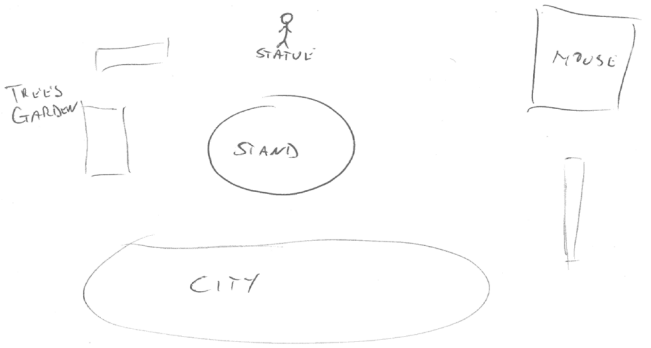

Figure 4. *Sketch map of the virtual viewpoint.*

me, though it was not possible to see the sun only a white sky.

(24, male, Danish, First time user of HMD technology)

In the virtual environment, the participants seemed to rank the church, castle, city and statue as the most important features. Overall, the statue/sculpture was most frequently noted. The view was mentioned on six occasions as was the large white house/monastery. To a lesser extent birds, platform, city, trees, bench, camera stand, roofs, and sunshine were noted. Some participants made a note that it was difficult to see the details in the environment and there was a mention on two occasions about the feeling of quietness.

In a similar manner to the study of the real viewpoint a number of themes began to emerge from the words used by participants to articulate their experience of the virtual viewpoint. Peaceful/relaxing, Interesting were again important, but so was Grainy, and Restrictive (want to move, inability to join in, non-explorative, restricted, captured, limited, stuck, static, locked up).

Table 4. *Comparing Emergent Themes from the Viewpoint Studies*

Real viewpoint	BENOGO viewpoint
Physical attributes	
The statue, the benches, paths and stairs, platform, plaque, background buildings, trees, birds, hillside, cold, local sounds, distant sounds, cityscape.	The statue, the benches, paths and stairs, platform, plaque, background buildings, trees, birds, hillside, grainy/blurry, realism, sounds, cityscape, people, weather.
Activities	
Looking at the cityscape, exploring, and moving about.	Standing, restricted movement, restricted looking, and blurry images.
Affect	
Enjoyment/contentment, refreshing/revitalizing, interesting/engaging, peaceful/relaxing, amazement, beautiful.	Interesting/exciting/fun, nice/pleasant/beautiful, peaceful/relaxing, stressful, restricted movement, mediterranean, holiday, dizziness, loneliness.

5.3 Comparing the Results

Table 4 provides a comparison of the main themes that emerged grouped by the three components of Relph's model of place (1976). The themes that emerged across both environments were predominantly those ones related to the physical/visual make up of the environment, with some of the affective aspects also translating well. The quality of images in the VE was clearly an issue participants still identified, and they located the buildings in and around the view. However due to the lack of resolution in the VE and also the fact that they had not actually been visiting Prague, they were unable to name the specific buildings and tended to generalize about the nature of the city rather than picking out specific locations.

Table 5. *Semantic Differential Tables of the Real (Left) and Virtual (Right) Environments*

	Very	Quite	Neither	Quite	Very			Very	Quite	Neither	Quite	Very	
Attractive	23	3	1	1	1	Ugly	Attractive	7	15	7	—	—	Ugly
Big	7	12	6	2	1	Small	Big	2	11	13	2	1	Small
Colorful	5	12	8	4	—	Colorless	Colorful	—	14	5	9	1	Colorless
Noisy	4	8	5	8	4	Quiet	Noisy	3	7	9	6	4	Quiet
Temporary	1	7	6	8	7	Permanent	Temporary	3	6	8	8	4	Permanent
Available	4	11	10	4	—	Unavailable	Available	1	9	11	5	2	Unavailable
Versatile	2	11	8	7	1	Limited	Versatile	2	6	12	7	2	Limited
Interactive	5	8	5	6	5	Passive	Interactive	1	7	6	10	5	Passive
Pleasant	23	5	—	—	2	Unpleasant	Pleasant	4	16	5	4	—	Unpleasant
Interesting	19	6	2	1	1	Boring	Interesting	8	11	5	4	—	Boring
Stressful	1	1	3	4	20	Relaxing	Stressful	—	5	5	11	8	Relaxing

Themes such as Peaceful, Interesting, Beautiful, and Nature appeared in both studies, but themes that appear only the real world include Enjoyment, Refreshing, and Amazing. This shows the lack of a positive emotional affect in the users of the virtual world that was a particular aspect of the real viewpoint. Themes that appear in the virtual world but were not part of the real world were Grainy, Restrictive, Faded, Realism, Stressful, and Lonely. These themes often point to the technical aspects of the VE highlighting problems that interfere with a sense of presence and place and lead to negative emotional responses such as lonely and stressful.

Looking at the two semantic differential tables from each study (Table 5), there is a shift from the extremes in the real environment towards the middle for the virtual environment. This suggests that the real environment had a much more powerful effect on participants than the virtual one. Breaking it down into the three main sections it becomes obvious that the real environment was considered to be more attractive, felt bigger, and was more colorful than the virtual one. There is no clear response to the noise differential or the perceived permanence of the place in either environment, although there was a slight trend towards the more permanent in the real world.

With regard to the participants' responses to the activities section of the differentials, there was again a shift away from the extremes in the VE. In the real environment the trend was towards experiencing the environment as quite available, quite versatile, and quite interactive. In the virtual environment there was a move towards neither available nor unavailable, neither versatile nor limited. There was also an opposite trend towards passive rather than interactive, which was a very different response to the real world.

What the data from the two studies appears to show is that the experience of the virtual representation is similar to that of the real environment but that the responses are less strong. That is to say that the virtual world does not have the same intensity of effect on the participants as the real environment does. Although participants clearly responded to parts of the probe in similar ways in each study, there are clear differences between the two. While the virtual environment was able to recreate a sense of peacefulness, beauty, and interest similar to the real place, it was unable to recreate the refreshing sense of enjoyment and amazement that the real place engendered.

5.4 Summary

The goal for BENOGO is a sense of presence, a sense of being there, the illusion of non-mediation (Lombard & Ditton, 1997). Using the Place Probe we

are able to uncover aspects of the technology that interfere with that illusion and these are the areas that the engineers should concentrate on improving. Furthermore, the initial Place Probe study of the real environment provides a goal towards which the VE should attempt to move towards.

The overall impression from the data obtained from the descriptive section of the probe was that there seems to be a greater emphasis towards the self (i.e., experiences, emotions, memories, etc.) in the real environment, while the data from the virtual environment shows more of an emphasis on the environment itself and the participant's relationship to that environment.

When the studies are compared in more detail, it is interesting to note that several of the participants who experienced the virtual environment commented on the realism of the scene. However, it also seems to be that the technology itself detracts from this sense of the real and produced a less convincing virtual experience. Poor resolution and restricted movement were seen to cause feelings of annoyance and frustration and sometimes dizziness among participants in the virtual environment. This is in direct contrast to the more relaxed, content, and comfortable feelings experienced in the real world. Nevertheless, despite these technical drawbacks, many participants felt they were in a nice place with a nice view and similar to the real environment they showed their appreciation of it though maybe not quite as strongly as in the real environment.

In both studies certain landmarks were frequently noted, though the main difference was that participants in the virtual study found it difficult to identify them. This was mainly due to poor resolution and lack of detail in the virtual environment. This was compounded as many of the participants in the virtual study were unfamiliar with the real place. In the real study, the participants were aware they were in Prague and they could locate and name certain landmarks in the distance.

On comparing the sketch maps from the real and virtual locations the drawings of the real scene were found to contain more detail than those from the virtual study. Typical areas of variation included the cityscape not being drawn in as much detail. For example, the statue at the viewpoint was not described in the same way, it would not be marked as "Maria statue." Also the naming of buildings and locations in the rest of the environment also appeared to vary substantially between the real and virtual environment. Again, as with the descriptive data, this was attributable to the lack of familiarity with the city.

Analyzing the data from both the real and virtual scene led to a series of emergent themes that were grouped within the Gustafson model of place (2001). While it is not claimed the Gustafson model of place is a perfect fit for our study it does allow the comparison of the types of themes emerging in relation to a person (i.e., self), the environment, and any other people. These are summarized in Table 6.

An emergent theme across both environments was that feelings related to self were much less prominent within the virtual environment (see Table 6). For example, people did not appear to interpret the environment with the same degree of enjoyment or amazement and did not feel refreshed or revitalized. However in the case of being refreshed and revitalized, this may be due to a combination of the cold weather at the real location and the stunning view that it created across the city. In contrast, the main feeling of self appeared to be almost directly related to dizziness, which may be explained by the lack of realism, the grainy display, and other technical problems that were prevalent within the virtual environment.

Among the areas of agreement were the feelings contained within the self and environment category, for example, people found both environments interesting, nice, pleasant, and peaceful. Although there was not the same sense of elation (e.g., enjoyment or amazement) between the real and virtual spaces, people were still experiencing similar emotions. At a very basic level it was possibly the case that the technology inhibited higher-level feelings such as amazement, but was still sufficient for people to enjoy their experience.

6 Developing the Place Probe

Work with the Place Probe version 1 indicated that there was clearly some mileage in the approach at

Table 6. *Emergent Themes from the Real and Virtual Environments in terms of Gustafson (2001) Constructs*

Group	Real environment	Virtual environment
Self	Enjoyment/contentment, amazement, refreshing/ revitalizing	Dizziness
Self/Environment	Interesting/engaging, beautiful, peaceful/relaxing, cold	Interesting/exciting/fun, nice/ pleasant/beautiful, peaceful/ relaxing, weather, stressful, restricted movement, mediterranean.
Environment	Viewpoint local (the statue, the benches, paths and stairs, platform, plaque, background buildings, trees, birds, hillside)	Viewpoint local (the statue, the benches, paths and stairs, platform, plaque, background buildings, trees, birds, hillside), grainy/blurry
Self/environment/others		Realism
Self/others	Local sounds, distant sounds, cityscape	Loneliness
Environment/others		Sounds, cityscape
Others		People

least from the perspective of gathering some rich, contextual data that could be used to critique virtual representations of real places. However, the second purpose of the probe, namely to communicate between evaluators, designers, and engineers, had not been successful. The data from the Place Probe was too vague. Also, it was felt that there were important aspects of places that were not being captured.

A second version of the Place Probe was developed following the Prague Viewpoint studies and analysis of these at project workshops. This version was subsequently used, evaluated, and refined following another study comparing a CAVE and an HMD rendering of the Technical Museum in Prague. This study is reported in McCall et al. (2005). The results of this further work is Place Probe version 3 (see Appendix 1).

The Place Probe version 3 demonstrates a number of improvements over version 1. One key aspect that was only implicit in version 1 of the Place Probe was sound. As the project progressed it became increasingly clear that the soundscape that accompanied any visual representation was a key component of the sense of place. Accordingly a separate section of the Place Probe was devoted to sound. The other main finding from version 1 was that the semantic differentials provided an effective and quick method of data collection and analysis.

Although we felt that eliciting data from people unprompted can be effective at finding key, personal issues, coming up with free-form descriptions and key words is demanding on the participants and time consuming for both the participants and for the analysis. We therefore expanded the semantic differentials section of the Place Probe, developing it in line with the Relph model of place (1976) and including a new section specifically on the impact of technologies on the experience of a virtual environment.

Relph's model of Place is based around three constructs: physical aspects, activities, and affect and meanings. Our studies of places have so far revealed specific elements that are experienced underneath these three

categories. For example, our initial Place Probe study of the Prague Technical Museum identified a number of aspects that participants attributed to their experiences that were specific to that place. It was bright, open, and made one feel close to objects. It was exciting, interesting, and so on. This then amounts to our understanding of the experience of being in the Technical Museum in Prague. Accordingly each of the three elements of the Relph model was given its own section of the semantic differential part of the Place Probe.

From analyzing the data and from further project workshops, each element was broken down into a number of characteristics. The activity differential includes ratings on the scales: passive–active, free–restricted, disorientated–oriented, inside–outside, and mobile–immobile. The physical differential focuses on characteristics of the space: small–big, empty–full, light–dark, enclosed–open, permanent–temporary, colorless–colorful, static–moving, responsive–inert, far–near, and untouchable–touchable. The affective/meaning differential is rated on the scales: ugly–beautiful, pleasant–unpleasant, stressful–relaxing, harmful–harmless, exciting–boring, interesting–uninteresting, memorable–forgettable, meaningful–meaningless, confusing– understandable, and significant–insignificant.

When it comes to producing a virtual representation of a place, we should aim to achieve as similar a sense of place as possible to the real environment. As such the themes that emerge through studies using the Place Probe in a real environment can be considered the requirements that the BENOGO system has to support in order to produce an effective representation of that place.

While we know that it is almost impossible to directly reproduce the exact experience of being in a real place, we also know that the BENOGO technology offers new opportunities to produce experiences that are as close to the real experience as we can make them. In developing the BENOGO technology what is important to understand is which aspects of the technology affect what elements of the experience of place. In other words, how can we develop BENOGO technology towards the illusion of nonmediation?

BENOGO technology consists of two main aspects that directly affect the experience of place: the quality of the image and movement of the images. Image quality is dependent on the image acquisition resolution, the texture resolution, the frame rate, and the field of view. The movement of the images is concerned with the motion resolution and with the region of exploration (i.e., the area within which the images are authentic). For example, at the viewpoint in Prague, the photographs were taken in a 60 cm diameter circle from a static location. The region of exploration, then, is 60 cm. Some of these elements are interrelated, for example, motion resolution has an effect on the image quality.

In the Place Probe version 3 we included a semantic differential specifically aimed at eliciting views on how effective the technology was and hence how aware people were of its mediating effect in the VE. Images are rated as: grainy–clear, realistic–unrealistic, unbelievable–believable, and distorted–accurate. The movement of images is rated as: smooth–jerky, broken–unbroken, slow–fast, and consistent–erratic.

The Place Probe is now more specifically focused on the requirements of the BENOGO technology. However, it is easy to replace the technology differential with any other specific technology. For example if the technology were more traditional graphics-based VE, then the technology differential might focus on whether the images were jagged, realistically colored, and so on. If we were to compare a rendering in an HMD or in a CAVE, we might attend to the pixilation of the images, the refresh rate, and the field of view. In short, the Place Probe can easily be modified to deal with any mediating technology by selecting the key characteristics of that technology.

7 Conclusions

This paper has discussed the development and application of the Place Probe. The aim of the probe is to gather data that will be of use to the designers of virtual environments that aim to recreate real places. The probe gathers a mixture of qualitative and quantitative data to give a rich description of people's experiences of a place—whether real of virtual. It also provides a mea-

sure of people's sense of presence and the impact of any mediating technology in a virtual environment.

Analysis of the data generated by the Place Probe suggests that people were having broadly similar experiences in both the real and virtual environments of the city viewpoint location. Furthermore the data highlighted both technical and nontechnical issues that were altering the experience from the desired objective to recreate the real scene. In that sense the subsequent analysis was able to report to the designers and evaluators of such virtual places what is lacking (e.g., a sufficiently high resolution, the lack of other people contributing to a sense of loneliness).

The data gathered from the Place Probe has been used to develop a set of templates, or patterns of place. The aim of these patterns is to capture key aspects of design knowledge in a way that is suitable for designers of virtual places. It is an approach to representing design knowledge that has been used in architecture by Christopher Alexander (e.g., Alexander, 1979), in software development (e.g., Coad, 1992), in Web design (Graham, 2003) and in human-computer interaction (Borchers, 2001). Our patterns of place are reported in Smyth et al. (2006).

In conclusion, the Place Probe provides a method of exploring real and virtual places and demonstrates the potential to make a valuable and timely contribution to the design of virtual places. The technique has been successfully used to compare similarities and differences, and to identify areas of both strength and weakness within virtual spaces. From a technical standpoint the technique can highlight areas demanding technical solutions, while from a creative standpoint it can point to the key characteristics of a place that need to be recreated. While the probe continues to be refined the initial indications are positive in terms of its potential for contribution to the design, implementation, and evaluation of virtual environments.

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Appendix 1. The Place Probe

Instructions

Please read the following questions carefully and answer all parts of the booklet. It should take around 10 minutes to complete. Once finished please return the booklet to the researchers. Thank you for your cooperation.

Background Information

Age: Sex:
Nationality:
First time visitor/regular visitor:

1 General Impression of the Place

1.1 Description

Please write a paragraph of description telling us about your experience of being in the place you have just visited.

1.2 Map

Please draw us a map of the place you have just visited. Indicate the most important features that you remember and the best place to stand to see them.

1.3 Features

Pick three features of the environment that you remember and rank them in order of importance.

1.
2.
3.

1.4 Pictures

From the photographs provided, please select one that best captures your experience of being in the place you have just visited. Write the number from the back of the photograph onto this page and tell us why you chose it (if no photographs are provided skip this section).

1.5 Sounds

Please describe any sounds that you remember from the environment you have just visited.

1.6 Words

Please write down six individual words that best capture your experience of being in the place you have just visited.

2 Key Features of the Place

On the tables provided in each question below, please mark a cross in the box that best describes your experience in relation to the adjectives provided at either side. Below is an example for an experience that was "quite bad" and "very light."

(Example)

	Very	Quite	Neither	Quite	Very	
Good				x		Bad
Light	x					Dark

Did the images that were displayed seem?

	Very	Quite	Neither	Quite	Very	
Grainy						Clear
Realistic						Unrealistic
Unbelievable						Believable
Distorted						Accurate

Did the movement of the images seem?

	Very	Quite	Neither	Quite	Very	
Smooth						Jerky
Broken						Unbroken
Slow						Fast
Consistent						Erratic

Did you feel that you were?

	Very	Quite	Neither	Quite	Very	
Passive						Active
Free						Restricted
Disorientated						Oriented
Inside						Outside
Mobile						Immobile

Did you feel that the environment was?

Very	Quite	Neither	Quite	Very	
Small					Big
Empty					Full
Light					Dark
Enclosed					Open
Permanent					Temporary
Colorless					Colorful
Static					Moving
Responsive					Inert
Far					Near
Untouchable					Touchable

Did you feel that the environment was?

Very	Quite	Neither	Quite	Very	
Ugly					Beautiful
Pleasant					Unpleasant
Stressful					Relaxing
Harmful					Harmless
Exciting					Boring
Interesting					Uninteresting
Memorable					Forgettable
Meaningful					Meaningless
Confusing					Understandable
Significant					Insignificant

3 Feelings of Presence

Please answer the following questions by placing a tick in the box that best expresses your feelings.

1 = I totally disagree
2 = I disagree
3 = I neither agree nor disagree
4 = I agree
5 = I totally agree

		1	2	3	4	5
Q1.1	I devoted my whole attention to the [medium].					
Q1.2	I concentrated on the [medium].					
Q1.3	The [medium] captured my senses.					
Q1.4	I dedicated myself completely to the [medium].					
Q2.1	I was able to imagine the arrangement of the spaces presented in the [medium] very well.					
Q2.2	I had a precise idea of the spatial surroundings presented in the [medium].					
Q2.3	I was able to make a good estimate of the size of the presented space.					
Q2.4	Even now, I still have a concrete mental image of the spatial environment.					
Q3.1	I felt like I was actually there in the environment of the presentation.					
Q3.2	It was as though my true location had shifted into the environment in the presentation.					
Q3.3	I felt as though I was physically present in the environment of the presentation.					
Q3.4	It seemed as though I actually took part in the action of the presentation.					
Q4.1	I had the impression that I could be active in the environment of the presentation.					
Q4.2	I felt like I could move around among the objects in the presentation.					
Q4.3	The objects in the presentation gave me the feeling that I could do things with them.					
Q4.4	It seemed to me that I could do whatever I wanted in the environment of the presentation.					
Q5.1	I thought most about things having to do with the [medium].					
Q5.2	I thoroughly considered what the things in the presentation had to do with one another.					
Q5.3	The [medium] presentation activated my thinking.					
Q5.4	I thought about whether the [medium] presentation could be of use to me.					
Q6.1	I concentrated on whether there were any inconsistencies in the [medium].					
Q6.2	I didn't really pay attention to the existence of errors or inconsistencies in the [medium].					
Q6.3	I took a critical viewpoint of the [medium] presentation.					
Q6.4	It was not important for me whether the [medium] contained errors or contradictions.					
Q7.1	I am generally interested in the topic of the [medium].					
Q7.2	I have felt a strong affinity to the theme of the [medium] for a long time.					
Q7.3	There was already a fondness in me for the topic of the [medium] before I was exposed to it.					
Q7.4	I just love to think about the topic of the [medium].					
Q8.1	When someone shows me a blueprint, I am able to imagine the space easily.					
Q8.2	It's easy for me to negotiate a space in my mind without actually being there.					
Q8.3	When I read a text, I can usually easily imagine the arrangement of the objects described.					
Q8.4	When someone describes a space to me, it's usually very easy for me to imagine it clearly.					