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Social and Spatial Presence: An Application to Optimize Human-Computer Interaction

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ABSTRACT

This study provides a framework for researchers who study human-computer interaction to develop and evaluate user-centric user-interfaces by applying existing theories about telepresence, human-computer research, and characteristics of technology to produce social and spatial experiences similar to the ones computer users experience in non-mediated experience. Female and male college age university students (N=189) participated in an experiment in which they used a software application with low and high values of a set of social cues (social pleasantries, an agent character) and spatial cues (three dimensional graphical representation of physical spaces) in a 2 x 2 between subjects design. Subjects experienced greater presence, satisfaction, enjoyment, comprehension, perceived ability, and likelihood to use and recommend the application when they use software with high social and spatial cues. The findings support a research framework that considers different forms of telepresence separately and in combination, the cues that evoke them and their impacts, in the design of computer user-interfaces.

Keywords: *telepresence, spatial presence, social presence, user interface, cues, human computer interaction, usability, user interface design*

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1. Introduction

Despite progress over recent decades, computer use remains surprisingly burdensome and difficult (Krug, 2006). Problems with comprehension and perceived lack of ability cause many users to enjoy computer use less and become unsatisfied. Ironically, these problems are worsened by rapid development of technology which has led to information overload for computer users and an engineering-centric rather

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than user-centric perspective in the design of computers and user interfaces. Anecdotal observations in computer support situations and the fact that all computer users, from novice to expert, report a substantial number of inefficient, unsatisfying and unpleasant computer use experiences, support this conclusion (Nielsen, 1993).

At the same time, a growing cross-disciplinary literature is examining telepresence phenomena, in which users of various media technologies including computers overlook the existence or nature of the technology (International Society of Presence Research, 2003; Lombard & Ditton, 1997; Moore, 1997; Nass, Fogg, & Moon, 1997; Nass, Lombard, Henriksen, & Steuer, 1995; Nass & Steuer, 1994; Nass, Steuer, Tauber, & Reeder, 1993; Nass, Reeves, & Leshner, 1996; Nass, Moon, Fogg, Reeves, & Dryer, 1995). In telepresence (hereafter, presence) scholarship, both spatial cues that provide information about the environment and social cues that provide information about social interactants, have been associated with this "illusion of nonmediation" (Lombard & Ditton, 1997) and a variety of impacts including learning and enjoyment (Blythe, Monk, Overbeeke, & Wright, 2003; Perlman, 1997).

The study reported here investigated the utility of applying telepresence theory and research to address computer use problems and increase the value of these human-computer interactions. A brief review of background concepts and literature is followed by the presentation of formal hypotheses and research questions, the study's method and results, and a discussion of their implications.

2. Background

One cause of computer use problems is that computer science continues to move forward, developing hardware and software, and computer users often cannot keep up by revising skills, remembering changes between different versions of software and purchasing equipment that can accommodate more powerful software. The nature of changing technology causes a condition of information overload for computer users. While the added functionality and power made possible by advances in hardware and software may offer benefits to users, they often require the user to continually adapt and revise or relearn skills to make the software work (Law, Hvannberg, Cockton, Jeffries, & Wixon, 2008).

Another reason for human-computer problems is computer and software design processes that do not place an emphasis on how humans use computers. An engineering-centric design perspective, with the people involved in creating computers failing to relate to them as a novice user does, can result in the creation of inflexible, non-intuitive computer systems (Pruitt & Adlin, 2006). When the average user encounters an error that confuses them it is a sign that the system is communicating in an engineering-centric manner.

Varied and interchangeable names are often used to describe computer hardware, software and the computer as a whole, including ‘computer,’ ‘software,’ ‘hardware,’ ‘application,’ ‘system,’ ‘machine,’ ‘workstation,’ ‘browser,’ ‘site,’ ‘program’ and ‘user-interface.’ The computer user-interface, the intended primary point of contact and communication between the computer and the computer user, is the source of many computer use problems (Bailey, 1996; Scott & Neil, 2009; Shneiderman, Plaisant, Cohen, & Jacobs, 2010; Tidwell, 2005) and the object of this study.

The user-interface of any device or tool provides users with the understanding of what the tool can do and how to use it. A shovel’s handle and an automobile’s steering wheel and foot pedals provide an understanding of how to dig and drive, respectively. A computer user-interface is the input and output devices that provide and/or exchange visual (images, text, graphics), aural (voice, sound effects) and haptic (motion, vibration) information when a person interacts with (uses) the computer (Bailey, 1996; Scott & Neil, 2009; Shneiderman et al., 2010; Tidwell, 2005). Manipulating the user-interface allows a computer user to compose a document or complete another task (Norman, 1990).

Computers were and often still are developed with a focus on basic practical concerns of functionality, reliability and power, which can result in a computer user having to conform to the capabilities and limitations of the computer rather than the computer accommodating the behavior of the computer user. Creating a computer that functioned was a higher priority than the computer user’s experience (Bailey, 1996; Shneiderman et al., 2010; Shiva, 2000). But the study of Human Computer Interaction (HCI) has focused on variables such as the user’s satisfaction, comprehension, ability (efficiency) and enjoyment (Chin & Newsted, 1995; Lawrence & Low, 1993; Preece et al., 2003; Shackel, Preece, & Keller, 1990). And Computer Mediated Communication (CMC) research has addressed similar concerns with a focus on the quality of human-to-human interaction via computers (Rice, 1984; Sproull & Kieshler, 1991; Wiesenfeld, Raghuram, & Gurad, 1998).

The first author’s observations regarding the effects of standard user-interfaces over 18 years providing and overseeing the provision of support to computer users in business and non-profit organizations for a variety of commercial and proprietary computer systems echo many of the results of HCI and CMC research. Support requests most often revolved around problems with comprehension and inability to utilize the user-interface. Users reported they were unable to understand the meaning of tasks or the steps necessary to complete them, and a perceived inability to complete tasks or in some cases even use the computer. Many users communicated feelings of dissatisfaction and a lack of enjoyment regarding computer use, and a desire to avoid using computer systems unless absolutely necessary. Using systems less meant less exposure to the systems, inhibiting learning and leading to more calls for computer support. Some users became so frustrated experiencing these problems they displayed emotions of anger, frustration and even fear. Despite a long term trend in which computers have become not only more powerful and capable but (somewhat) easier to use, these user experiences suggest the need for significant improvements in the computer user-interface.

The ideal user-interface would put the user within a computing environment that allows them to concentrate on the task at hand and not the computer itself. In effect the computer would perform so effectively that the user would be unaware of it. This is different than ubiquitous computing (computers embedded into appliances and other objects in our environment (Weiser, 1993; Xerox Palo Alto Research Center, 2003); here the computer becomes an extension of human consciousness, adapting to the user rather than requiring the user to adapt to it. Ultimately, the computer user-interface would be so connected with the computer user that problems of comprehension, ability, satisfaction and enjoyment would be minimized or eliminated.

A concept that captures this notion is (tele)presense. Presence refers to a phenomenon in which users of media at some level and to some degree overlook the true role of technology in the experience (International Society of Presence Research, 2003**;** Lombard & Ditton, 1997). Users of virtual reality, high definition television, simulation rides and other entertainment media experience presence (Campanella Bracken & Skalski, 2009). The phenomenon is also evoked to a lesser degree with traditional technology such as the telephone and television. For example, when we watch television and become engrossed in an engaging program we may feel like “we are there”. Our actual physical surroundings drop away from consciousness and we mentally enter the world of settings, people and events we are watching.

A growing body of research demonstrates that presence can enhance interaction for media users and enable new efficiencies and discoveries. Some of the areas explored in this research are training and education (Chu & Schramm, 1967; Hackman & Walker, 1990), scientific exploration (Stoker, Barch, Hine, & Barry, 1995), physical medicine (Crump & Pfiel, 1995; Hamit, 1995; Ota, Loftin, Saito, Lea, & Keller, 1995), psychological medicine (Abkarian, King, & Krappes, 1987; Dongier, Tempier, Lalinec-Michaud, & Meunier, 1986; Jerome, 1986; McNally, 1987), building and architecture (Yan & Ouhyoung, 1994), and safety and automobile design (Hoffmann & Mortimer, 1994; McLeod & Ross, 1983).

Presence is a multidimensional concept and phenomenon. Many different dimensions or types of presence have been proposed (Lombard & Ditton, 1997; Lombard & Jones, in press) but arguably the most common distinction is between social and spatial presence (International Society of Presence Research, 2003).

Social presence occurs ”when part or all of a person’s perception fails to accurately acknowledge the role of technology that makes it appear that s/he is communicating with one or more other people or entities” (International Society of Presence Research, 2003, para. 7e; Reeves & Nass, 2000). Social cues can lead to social presence when, for example, a television anchor or character talks to the camera and thus apparently the viewer, computer software can provide a friendly character that interacts with the user, or a computer or other technology itself seems to have a personality or otherwise “behave” like a person (Moon & Nass, 1996b).

Spatial presence occurs “when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that the person is in a physical location or environment different from her/his actual location and environment in the physical world” (International Society of Presence Research, 2003, para. 7a). Spatial cues such as 3D, audio, video, haptics and odors can be used to evoke spatial presence. Examples of this are seen in the experience of IMAX films, simulation rides and virtual reality.

Researches by Biocca (1995), Heeter (1992), Held and Durlach (1992), Rice (1993) and many others shows that cues that evoke presence can be systematically applied to computers and computer software to effectively elicit both feelings of social interaction and a sense of three-dimensional space. The general argument is that applying cues in this context can trigger similar psychological mechanisms that people use for social and spatial interaction in the “real” world and thereby lead to a variety of important responses. Early theories of media richness (Rice, 1992) and social presence (Short, Williams, & Christie, 1976) sought to match organizational tasks and media in order to achieve greater efficiency and satisfaction, important goals of much work in HCI.

The discussion so far suggests that computer use can be made more satisfying and enjoyable – the computer can be made more usable – if the user-interface is designed with a user-centric criterion in which the computer is expected to accommodate the user. One way to design such an interface is to provide social and spatial cues for computer users so they can interact with user-interfaces in the same ways they interact with the world in everyday life. Presence is thus proposed as an effective framework to help users to communicate with and utilize the computer.

The link between presence and usability can be observed in presence related research conducted under the rubric Computers Are Social Actors (CASA) (Reeves & Nass, 1996; Nass et al., 1995; Nass & Steuer, 1994; Nass, Steuer, & Tauber, 1994; Nass et al., 1993; Nass et al., 1996; Nass et al., 1995). The CASA research established that computer users respond to and interact with technology as they would with people. In their book, *The media equation: How people treat computers, television, and new media like real people and places*, Reeves and Nass (1996) explain that people experience a sense of social interaction with computers (and other technologies) as we do with other people because our “old brains” are “hard wired to be social” (p. 12). According to this view, we can’t help but act and react to social stimuli regardless of whether they come from humans or machines due to evolution-based default behaviors.

There are many kinds of social and spatial cues that should evoke social and spatial presence in a computer user-interface. Social cues include human speech (Nass & Brave, 2005); text that includes social pleasantries (Nass, Steuer, & Tauber, 1994; Nass et al., 1993); and photorealistic or drawn and still or animated visual representations of a person’s or a character’s body or face (Nowak & Biocca, 2003; Reeves & Nass, 1996). Spatial cues likely to evoke spatial presence follow research with other media and include visual simulations of three-dimensional space via photos or drawings of environments, and text references to spaces and movement within spaces (Biocca & Delaney, 1995; Heeter, 1992; Held & Durlach, 1992; Lombard, 1995; Lombard & Ditton 1997). While these cues should lead to social and spatial presence, their absence or reduced use should evoke lower levels of presence.

Social and spatial cues and presence in the context of a user-interface should lead to a more efficient, satisfying and enjoyable experience. Aside from the comfort with more “natural” interaction, dynamic and dimensional images, sounds, and characters should be inherently more entertaining than mere plain text (So & Brush, 2008). As a result of greater efficiency, satisfaction and enjoyment, the user's perception of their computer skills and abilities may be increased by presence, which may lead them to access more powerful features of software (Nosper et al., 2005; Sylaiou, Mania, Karoulis, & White, 2010).

Both quality and quantity of social and spatial cues in a computer interface should influence the degree to which social and spatial presence are evoked and lead to positive effects (Gunawardena & Zittle, 1997). Quality is arguably more important since a great number of cues with poor quality may remind the user of the mediated nature of the experience. The particular task at hand and the context of the interaction also make a difference in how the user experiences presence.

The continuing evolution of technology offers the real possibility for the design of computer systems that can evoke presence for human users. Greater power and storage allow the use of more graphics, objects, and automated tasks; artificial intelligence allows more personalized interactions; increasingly sophisticated algorithms produce increasingly realistic images and sounds; and this combined with new modes of interaction such as intuitive motion-based input devices and augmented and ubiquitous computing will permit the use of robust social and spatial cues that evoke presence.

All of this represents an exciting set of challenges for those who study and design computer interfaces. But despite the growing presence literature, we have little understanding of the relative contributions of social and spatial cues, and their combination, to social and spatial presence and to the variety of positive outcomes they are thought to influence.

Based on the discussion above, the experiment reported here examines the independent and cumulative effects of social and spatial cues on outcome variables including satisfaction, enjoyment, comprehension of a task, perceived ability and likelihood to use a computer interface.

3. Hypotheses and research questions

This section presents the hypotheses and research questions for the study.

3.1 Primary hypotheses

The primary hypotheses, based on the literature reviewed above, concern the relationships among social and spatial presence and a diverse set of dependent variables.

Social and Spatial Cues Evoke Presence in Computer Users

H1a Social cues in a user-interface will evoke social presence in computer users.

H1b Spatial cues in a user-interface will evoke spatial presence in computer users.

Satisfaction and Social and Spatial Cues

H2 Computer users will report greater overall satisfaction interacting with more rather than fewer social (H2a) and spatial (H2b) cues in a computer user-interface.

Enjoyment and Social and Spatial Cues

H3 Computer users will report greater enjoyment interacting with more rather than fewer social (H3a) and spatial (H3b) cues in a computer user-interface.

Comprehension and Social and Spatial Cues

H4 Computer users will report greater comprehension interacting with more rather than fewer social (H4a) and spatial (H4b) cues in a computer user interface.

Perceived Ability and Social and Spatial Cues

H5 Computer users will report greater perceived ability interacting with more rather than fewer social (H5a) and spatial (H5b) cues in a computer user-interface.

Likelihood to Use an Application and Social and Spatial Cues

H6 Computer users will report that they would be more likely to use a computer user-interface with more rather than fewer social (H6a) and spatial (H6b) cues.

3.2 Secondary hypotheses

The secondary hypotheses were based on the suggestion supported by some research (e.g., see Nass et al., 1993; Reeves & Nass, 2000) that individuals with less computer experience (novice users vs. expert users) will benefit more from user-interface designs that incorporate real world cues.

H7 The positive effect of social (H7a) and spatial (H7b) cues on satisfaction will be greater for computer users with less computer experience.
H8 The positive effect of social (H8a) and spatial (H8b) cues on enjoyment will be greater for computer users with less computer experience.
H9 The positive effect of social (H9a) and spatial (H9b) cues on comprehension will be greater for computer users with less computer experience.
H10 The positive effect of social (H10a) and spatial (H10b) cues on perceived ability will be greater for computer users with less computer experience.

3.3 Research questions

A complex pattern of results in the presence literature (Heeter, 1992; Lombard & Jones, in press; Nass & Green, 1993; Nicovich, Boller, & Cornwell, 2005; Reeves & Nass, 1996) suggested four research questions:

RQ1 Will female computer users report greater enjoyment using a computer user-interface that evokes social presence than using a computer user-interface that evokes spatial presence?
RQ2 Will female computer users report greater satisfaction using a computer user-interface that evokes social presence than using a computer user-interface that evokes spatial presence?
RQ3 Will male computer users report greater enjoyment using a computer user-interface that evokes spatial presence than using a computer user-interface that evokes social presence?
RQ4 Will male computer users report greater satisfaction using a computer user-interface that evokes spatial presence than using a computer user-interface that evokes social presence?

4. Method

An experiment was conducted in which participants used one version of a software application for the submission of college admission applications. The versions included identical or near identical content but featured user-interfaces with high and low levels of social cues (social pleasantries, an agent character) and spatial cues (3D representation of physical spaces) in a 2 x 2 between subjects design (see Table 1). Other independent variables include gender, educational level, computer experience, age and ethnicity. After interacting with the user-interface, participants completed a questionnaire that assessed the dependent variables, social presence, spatial presence, comprehension, perceived ability, satisfaction, enjoyment, and likelihood to use or recommend the application.

		Spatial Cues	
		LOW	HIGH
Social Cues	LOW	Software Version 1 Few social cues Few spatial cues	Software Version 2 Few social cues Many spatial cues
	HIGH	Software Version 3 Many social cues Few spatial cues	Software Version 4 Many social cues Many spatial cues

Table 1. Study Design.

4.1 Participants

University students were chosen to participate in this experiment since they represent a significant group of individuals who use software now and will use it into the future for work and personal tasks. The participants were 189 students (including 82 males and 106 females) at a diverse urban university, and represented a wide range of ages (M= 23.1, SD= 7.8), ethnic backgrounds (52% white) and life experiences.

4.2 Manipulation and measures

The two primary independent variables are social cues and spatial cues**.**

Social cues. The low social cues conditions featured an absence of social pleasantries in text and no visual representation of a person or character. The high social cues conditions featured text expressions and phrases that denoted conversation (such as “please click the button if you are satisfied with your selection”) linked to the visual representation of an agent (an animated owl).

Spatial cues. The low spatial cues conditions contained only text instructions indicating what the user should do to complete a task, while the high spatial cues conditions contained a three dimensional graphical representation of physical spaces (an elevator and various admissions offices).

See Figures 1-5 for screen shots that illustrate how these attributes were combined to create the four conditions. Figures 1-4 present examples of the menu in each of the four conditions; Figure 5 presents a typical image of an office destination in the high social / high spatial cues condition.

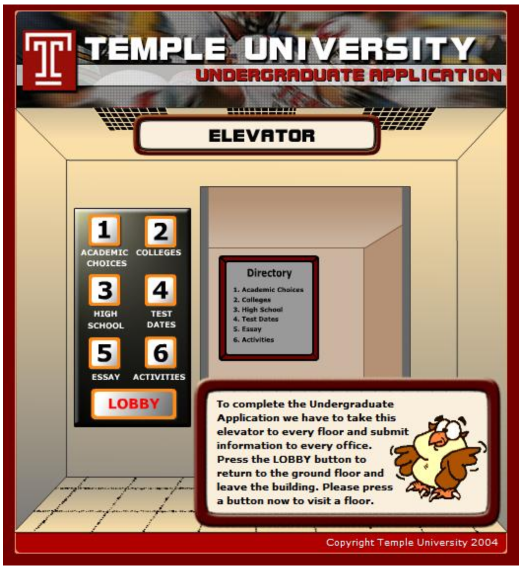

Figure 1. Menu for high social cues / high spatial cues condition.

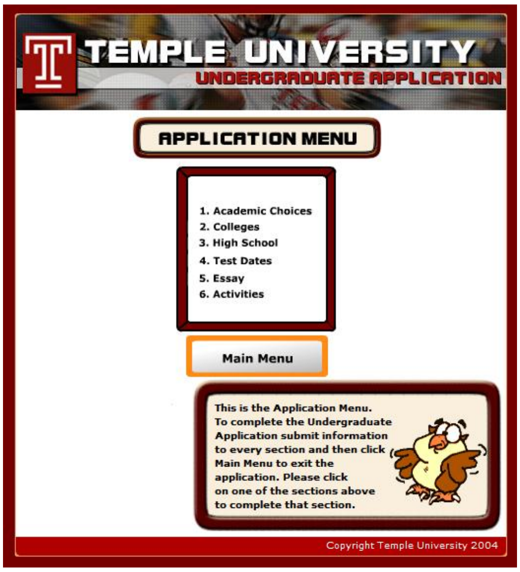

Figure 2. Menu for high social cues / low spatial cues condition.

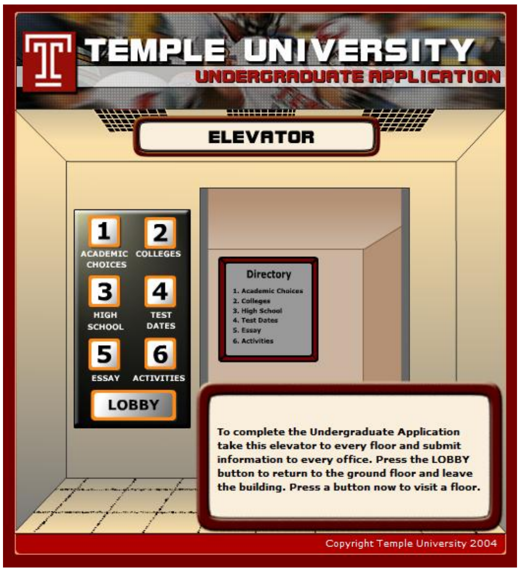

Figure 3. Menu for low social cues / high spatial cues condition.

Figure 4. Menu for low social cues / low spatial cues condition.

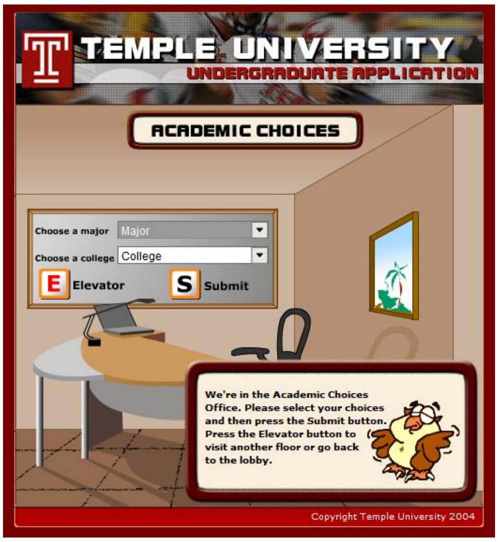

Figure 5. Admissions Office for high social cues / high spatial cues condition.

Dependent variables. The measured dependent variables were social presence, spatial presence, satisfaction, enjoyment, comprehension, perceived ability, and likelihood to use/recommend the application. These variables were assessed via post trial questionnaire items using a 9-point Likert scale (all of the items can be found in Table 1).

Social Presence. The level of social presence experienced by the user was measured by asking participants 6 questions including: "The system seemed [1=sociable 9=unsociable]" and "How often did it feel as if the system were like a person you were interacting with [1=never 9=always]?" The items were adopted from the Temple Presence Inventory (see Lombard, Ditton, & Weinstein, 2009; Lombard et al., 2000).

Spatial Presence. The level of spatial presence experienced by the user was measured by asking participants 3 questions including: "To what extent did the system or something in the system seem like a three dimensional space or place [1=not at all 9=a lot]?" and "To what extent did you see things you could reach out and touch while interacting with the system [1=not at all 9=a lot]?" The items were adopted from the Temple Presence Inventory (Lombard et al., 2009; Lombard et al., 2000).

Satisfaction. In Human-Computer Interaction research usability is commonly measured via the variables effectiveness, efficiency, and satisfaction. Comprehension and perceived ability (see below) were used to assess efficiency and effectiveness. The level of satisfaction a user derives from interaction with the software was measured by asking participants 3 questions including: “How much of a sense of satisfaction or accomplishment did you feel after you finished using the system [1 = none at all 9 = a lot]?” and “How was your experience using the system [1=not at all satisfying 9=very satisfying]?” The items were adapted from customer service satisfaction surveys and HCI research (Chin & Newsted, 1995; Lawrence & Low, 1993; Picard, 1998; Preece et al., 1994; Nielsen, 2003; Shackel et al.,1990).

Enjoyment. The level of enjoyment was measured by asking participants 6 questions including: “How was your experience interacting with the system [1=not at all enjoyable 9=very enjoyable]?” and “How was your experience interacting with the system [1=not at all entertaining or 9=very entertaining]?” The enjoyment measures were taken from HCI and presence research studies (Blythe et al., 2003; Perlman, 1997).

Comprehension. The level of the participants’ comprehension or understanding of the tasks they had to complete with the computer system was measured by asking them 3 questions including: “How was it to learn the system [1=difficult 9=easy]?” and “How were the instructions that appeared on the screen [1= confusing 9 = clear]?”. The items are used in presence and HCI research (Byrne, 2001; Gillan & Cooke, 1995; Lombard et al., 2000; Neilson, 2003; Shackel et al., 1990).

Perceived Ability. The participants’ perception of their ability to complete a task or understand and follow instructions was measured by asking them 5 questions including: “To what extent did you feel like an expert while using the system [1=none at all 9=a lot]?” and “To what extent did you feel confident while using the system [1=not at all 9=a lot]?” The items are used in HCI and presence research (Byrne, 2001; Gillan & Cooke, 1995; Lombard et al., 2000; Neilson, 2003; Shackel et al., 1990).

Likelihood to use this or a similar application. The likelihood that the participants would use the software application in the study or one similar to it was assessed by asking them 2 questions including: “How likely would it be for you to use this or a similar system [1=not at all likely very likely]?” and “How likely are you to recommend this or a similar system to a friend [1=not at all likely very likely]?” Unlike the others, this dependent variable assesses behavioral intentions, a more distal and therefore more difficult outcome to measure and influence.

***Other measured variables*.** Computer experience was assessed with 2 questions: “How much do you know about using computers [1 = None at all to 9 = A lot]?” and “How many hours do you spend using a computer in a typical day?“ A variety of demographic variables, including ethnicity and education level, were measured with standard questionnaire items (only variables for which results were noteworthy are reported below) (Nass & Moon, 1996).

4.3 Procedures and apparatus

An interactive website application was presented to participants online and accessed using a URL provided via an e-mail message, hard copy printed message, or in person orally in a computer lab full of students. Most participants used their own computer, less than a third used a computer in a campus lab. Participants visited the study web site, read and acknowledged an Institutional Review Board Human Subjects consent form, completed a series of subtasks required to submit a mock application for college admission (which took 15-20 minutes), and completed an online questionnaire (10-12 minutes).

The software was created using hypertext markup language (html) and rendered output files from Adobe Flash (swf), Adobe Photoshop (a graphic and image manipulation program), active server pages (ASP; dynamic web pages using visual basic script) and a Microsoft Access database. Most of the web site applications were constructed using Adobe Flash (software that creates interactive rich media) and the web-editing tool Adobe Dreamweaver. Participants were able to interact with the software using a variety of operating system platforms and web browsers. All participants visited the same web site and web page to start the experiment. Active server pages were programmed to produce random assignment to one of the four application versions (i.e., conditions) as each participant visited the site.

4.4 Pretest

A pretest prior to the actual trial was conducted to evaluate experiment procedures and determine if any of the stimuli or questionnaire materials required adjustment. The pretest consisted of a limited version of the Web application and an abbreviated survey. Approximately five participants per condition participated and results indicated they had a clear understanding of the instructions, purpose of the test and how to use the Web application, but also suggested minor changes that were made in the application to promote usability.

5. Results

All analyses were conducted using SPSS for Windows (version 11.5). In all tests the statistical significance criterion was $p<.05$ and p-values between .06 and .10 were considered to approach significance.

5.1 Missing values

The small number (less than 2%) of data values that were missing were scattered randomly across variables and cases. For all (scale level) variables that had missing values, the means for the variables were calculated across all responses and those values were then substituted for the missing values. This method was not applied to nominal level variables, for which missing values remain as they are. This approach is considered appropriate when missing responses are few and random (Field, 2009, p. 233).

5.2 Index construction

Indices were constructed for several dependent variables. Principal Components confirmatory factor analyses and Cronbach’s Alphas were calculated on the set of items intended to measure each variable to assess the unidimensionality and reliability of the indices. All indices were reliable, with Alphas .77 or greater (see Table 2 for details). A separate factor analysis on all of the social and spatial presence items together confirmed that they represented distinct concepts (results indicated two factors with items loading appropriately on each).

5.3 Primary hypotheses results

The primary hypotheses were tested via two multivariate analyses of variance (MANOVAs) each including all of the dependent variables and in one analysis the social cues independent variable and in the other analysis the spatial cues independent variable (analyses using both key independent variables would violate

Index/Items	Factor Loadings
Social presence	
The system seemed…1 = unsociable 9 = sociable	.86
How often did it feel as if you were interacting with a character or person within the system? 1 = never 9 = always	.86
The system seemed… 1 = impersonal 9 = personable	.83
How often did it feel as if the system was like a person you were interacting with? 1 = never 9 = always	.83
To what extent did you feel the system was like a helper? 1 = not at all 9 = a lot	.76
The system seemed… 1 = unemotional 9 = emotional	.64
How often did it feel as if you were interacting with the programmer or creator of the system? 1 = never 9 = always	.63
Eigenvalue: 4.30 Percent of variance: 61.5 Cronbach's Alpha: .89	
Spatial presence	
To what extent did the system or something in the system seem like a three-dimensional space or place? 1 = not at all 9 = a lot	.88
To what extent did you see things you could reach out and touch while interacting with the system? 1 = not at all 9 = a lot	84
To what extent did the system or something in the system seem like a space or place that could or does exist in the real world? 1 = not at all 9 = a lot	.75
Eigenvalue: 2.08 Percent of variance: 69.2 Cronbach's Alpha: .77	
Satisfaction from using the application	
How much of a sense of satisfaction or accomplishment did you feel after you finished using the system? 1 = none at all 9 = a lot	.88
If you compare your interaction with this system to other computer systems that you've seen or used to accomplish the same or similar tasks, is this system somewhat… 1 = worse 9 = better	.84
How was your experience interacting with the system? 1 = not at all satisfying 9 = very satisfying	.82
Eigenvalue: 2.18 Percent of variance: 72.8 Cronbach's Alpha: .77	
Enjoyment while using the application	
How was your experience interacting with the system?	
1 = not at all entertaining 9 = very entertaining	.90
1 = not at all interesting 9 = very interesting	.89
1 = not at all engaging 9 = very engaging	.88
1 = not at all enjoyable 9 = very enjoyable	.80
1 = relaxing 9 = exciting	.58
Eigenvalue: 3.39 Percent of variance: 67.8 Cronbach's Alpha: .85	

Comprehension of the objective and tasks	
How were the instructions that appeared on the screen? 1 = confusing 9 = clear	.86
How often did you understand what to do next while using the system? 1 = never 9 = always	.86
How was it to learn the system? 1 = difficult 9 = easy	.83
Eigenvalue: 2.20 Percent of variance: 73.2 Cronbach's Alpha: .81	
Perceived ability to use the application and accomplish tasks	
To what extent did you feel confident interacting with the system? 1 = not at all 9 = a lot	.87
To what extent did you feel like an expert while using the system? 1 = not at all 9 = a lot	.82
To what extent did you feel like you could control the system? 1 = not at all 9 = a lot	.81
How was your experience interacting with the system?	
1 = difficult 9 = easy	.79
1 = very frustrating 9 = not at all frustrating	.70
Eigenvalue: 3.24 Percent of variance: 64.8 Cronbach's Alpha: .86	
Likelihood to use or recommend a similar application	
If it were available, how likely would you be to use a system similar to the one you just used to accomplish this task or a different task in the future? 1 = not at all likely 9 = very likely	.95
How likely are you to recommend this or a similar system to a friend? 1 = not at all likely 9 = very likely	.95
Eigenvalue: 1.82 Percent of variance: 91.2 Cronbach's Alpha: .81	

Table 2. Index items, eigenvalues and reliability.

the required assumption of independence due to the overlapping of participant groups that constituted each variable; see Field, 2009, p. 360).

Social Presence

Hypothesis 1a, that social cues in computer software will evoke social presence in computer users, was supported (F(1) = 4.94, p = .03). Participants in the conditions with high social cues reported that they experienced more social presence (M = 5.91, SD = 1.89, n = 96) than those in the conditions with few social cues (M = 5.33, SD = 1.71, n = 93). The spatial cues manipulation also produced a significant difference in social presence (F(1) = 12.91, p = .001), with the participants in the conditions with high spatial cues reporting that they experienced more social presence (M = 6.10, SD

= 1.76, n = 96) than those in the conditions with few spatial cues (M = 5.17, SD = 1.78, n = 93).

Spatial Presence

Hypothesis 1b, that spatial cues in computer software will evoke spatial presence in computer users, was supported (F(1) = 42.39, p = .001). Participants in the conditions with high spatial cues reported that they experienced more spatial presence (M = 6.29, SD = 1.83, n = 93) than those in the conditions with few spatial cues (M = 4.47, SD = 1.99, n = 95). The social cues manipulation did not produce a significant difference in spatial presence (F(1) = 0.15, p = .7).

Satisfaction

Hypothesis 2a, that computer users will report greater overall satisfaction using computer software with more rather than fewer social cues, received tentative support (F(1) = 3.35, p = .07). Participants in the conditions with high social cues reported that they experienced more satisfaction (M = 5.91, SD = 1.71, n = 96) than those in the conditions with few social cues (M = 5.33, SD = 1.89, n = 93).

Hypothesis 2b, that computer users will report greater overall satisfaction using computer software with more rather than fewer spatial cues, was supported (F(1) = 7.23, p = .008). Participants in the conditions with high spatial cues reported that they experienced more satisfaction (M = 6.31, SD = 1.91, n = 94) than those in the conditions with few spatial cues (M = 5.63, SD = 1.83, n = 95).

Enjoyment

Hypothesis 3a, that computer users will report greater enjoyment using software with more rather than fewer social cues, was supported (F(1) = 4.26, p = .04). Participants in the conditions with high social cues reported that they experienced greater enjoyment (M = 5.57, SD = 1.62, n = 96) than those in the conditions with few social cues (M = 5.07, SD = 1.74, n = 93).

Hypothesis 3b, that computer users will report greater enjoyment using software with more rather than fewer spatial cues, was supported (F(1) = 21.8, p = .001). Participants in the conditions with high spatial cues reported that they experienced greater enjoyment (M = 5.87, SD = 1.75, n = 94) than those in the conditions with few spatial cues (M = 4.78, SD = 1.45, n = 95).

Comprehension

Hypothesis 4a, that computer users will report greater comprehension using a system with more rather than fewer social cues, was supported (F(1) = 7.31, p = .007). Participants in the conditions with high social cues reported that they experienced greater comprehension (M = 7.71, SD = 1.27, n = 96) than those in the conditions with few social cues (M = 7.08, SD = 1.81, n = 93).

Hypothesis 4b, that computer users will report greater comprehension using a system with more rather than fewer spatial cues, was supported (F(1) = 13.75, p = .001). Participants in the conditions with high spatial cues reported that they experienced greater comprehension (M = 7.08, SD = 1.32, n = 94) than those in the conditions with few spatial cues (M = 6.09, SD = 1.72, n = 95).

Perceived Ability

Hypothesis 5a, that computer users will report greater perceived ability (to complete the task or use the application) using a system with more rather than fewer social cues, was supported (F (1) = 4.01, p = .05). Participants in the conditions with high social cues reported that they experienced greater perceived ability (M = 7.26, SD = 1.43, n = 96) than those in the conditions with few social cues (M = 6.80, SD = 1.81, n = 93).

Hypothesis 5b, that computer users will report greater perceived ability using a system with more rather than fewer spatial cues, was supported (F(1) = 12.4, p = .001). Participants in the conditions with high spatial cues reported that they experienced greater perceived ability (M = 7.43, SD = 1.55, n = 94) than those in the conditions with few spatial cues (M = 6.63, SD = 1.64, n = 95).

Likelihood to Use and Recommend Application

Hypothesis 6a, that computer users will report that they would be more likely to use computer software with more rather than fewer social cues, received very tentative support (F(1) = 2.6, p = .108). Participants in the conditions with high social cues reported that they were more likely to use/recommend computer software with more social cues (M = 6.60, SD = 2.09, n = 95) than those in the conditions with few social cues (M = 6.09, SD = 2.27, n = 93). Separate nondirectional independent samples t-test analyses revealed significant differences for each constituent item (t (186) = 4.04 p = .01 and t (185) = 2.29, p = .01). Participants in the conditions with high social cues reported that they were more likely to use a similar application (M = 1.50, SD =.50, n =

93) than those in the conditions with few social cues (M = 1.23, SD =.42, n = 95) and more likely to recommend the application to other users (M = 1.46, SD =.50, n = 92) than those in the conditions with few social cues (M = 1.43, SD =.46, n = 95).

Hypothesis 6b, that computer users will report that they would be more likely to use computer software with more rather than fewer spatial cues, was supported (F(1) = 12.39, p = .001). Participants in the conditions with high spatial cues reported that they were more likely to use computer software with more spatial cues (M = 6.90, SD = 2.04, n = 93) than those in the conditions with few spatial cues (M = 5.81, SD = 2.20, n = 95).

5.4 Secondary hypotheses results

A dichotomous variable was created via median splits for an index of the two computer experience questionnaire items. All of the secondary hypotheses were tested by examining the interaction terms in 2-way MANOVAs with the independent variables being computer experience and experiment condition (either social cues (low/high) or spatial cues (low/high). None of the analyses provided support for the hypotheses regarding the role of computer experience.

5.5 Research question results

Research Question 1 asks whether female computer users will report greater enjoyment using software that evokes social presence than using software that evokes spatial presence. An independent samples, non-directional t-test comparing responses from female participants in the two experimental conditions that included high social cues and the two that included high spatial cues was not significant (t (51) =.424 p = .67), although the participants reported greater enjoyment using an application with more social cues (M = 5.45, SD = 1.32, n = 23) than one with spatial cues (M = 5.27, SD = 1.75, n = 30).

Research Question 2 asks whether female computer users will report greater satisfaction using software that evokes social presence than using software that evokes spatial presence. An independent samples, non-directional t-test comparing responses from female participants in the two conditions that included high social cues and the two that included high spatial cues was not significant (t (47) = .533 p = .59), although participants reported greater satisfaction using an application with more social cues (M = 6.23, SD = 1.95, n = 23) than one with spatial cues (M = 5.94, SD = 1.93, n = 30).

Research Question 3 asks whether male computer users report greater enjoyment using software that evokes spatial presence than using software that evokes social presence. An independent samples, non-directional t-test comparing responses from male participants in the two experimental conditions that included high social cues and the two that included high spatial cues was significant ($t (24) = 3.56$ $p = .01$). Male subjects reported greater enjoyment using an application with more spatial presence ($M = 6.41$, $SD = 1.26$, $n = 23$) than social presence ($M = 4.64$, $SD = 1.62$, $n = 15$).

Research Question 4 asks whether male computer users report greater satisfaction using software that evokes spatial presence than using software that evokes social presence. An independent samples, non-directional t-test comparing responses from male participants in the two experimental conditions that included high social cues and the two that included high spatial cues was not significant ($t (29) = 1.26$ $p = .21$), although the participants reported greater satisfaction using an application with more spatial presence ($M = 6.33$, $SD = 2.12$, $n =15$) than social presence ($M = 5.46$, $SD = 2.02$, $n = 23$).

5.6 Social and spatial cues separately and combined

The pattern of means for the key dependent variables (social presence, spatial presence, satisfaction, enjoyment, comprehension, perceived ability, likelihood to use/recommend a similar application) across the four conditions revealed a consistent pattern in which the combination of high social and high spatial cues produced the largest means. Following the high social / high spatial combination, the low social / high spatial and high social / low spatial conditions produced lower means, and the low social / low spatial cues condition consistently produced the lowest means.

6. Discussion

As technology becomes more intertwined into the infrastructure of society and modes of communication evolve, our dependence on computer technology grows. Technology fundamentally changes workflow, socialization, daily living and the discovery of unrealized ability. Too often our interactions with computers are substantially less productive and pleasant than they could be because the user interface is designed from a technology-centric perspective that makes us accommodate the technology rather than a user-centric perspective that makes the technology accommodate our natural and intuitive interaction habits.

While it is only a single study examining responses from a relatively narrow demographic using a particular type of software application, the study reported here provides evidence that incorporating social and spatial cues that lead to social and spatial presence – allowing users to overlook irrelevant aspects of the technology and interact using familiar cues and habits – can enhance computer users' satisfaction and enjoyment of computer systems, increase their comprehension while completing tasks and even encourage positive perceptions of their perceived ability.

The findings contribute to our understanding of presence as a multidimensional rather than merely unidimensional concept and phenomenon. Social and spatial presence are typically examined one at a time or confounded conceptually and operationally without comment. This study showed that it is possible to systematically manipulate sets of cues that affect each type of presence (though spatial cues also affected social presence) and permit comparisons of their relative impacts. The results establish that with basic content (i.e., the task) held constant, relatively simple format and design cues can be applied to computers and computer software to effectively elicit feelings of social interaction and a sense of three-dimensional space. Both types of presence cues were consistently linked to improved outcomes, with the combination of social and spatial cues most effective.

The lack of significant results for the computer experience variable may merely reflect a lack of variance in the college student sample. Seventy two percent of the subjects reported that they considered themselves highly experienced computer users and over 25 percent considered themselves computer experts; only 13 percent reported they had little or no computer experience. It's also possible that participants over-estimated or purposely exaggerated their experience. But the results are also consistent with the argument that how we respond to social and spatial cues is deeply ingrained (based on human evolution) and unaffected by experience with a technology that incorporates those cues (Reeves & Nass, 1999). The results for spatial cues and social presence also indicate that spatial cues alone may increase the perception of 'personality' so that users feel like they're interacting with social software even when the user interface contains minimal social pleasantries and no faces or characters.

Future research should attempt to replicate and expand the results here with participants from different age groups; socio-economic classes; and levels of ability, disability, and nationality and cultural background coupled with more general computer applications (e.g., word processing). More generally, HCI, CMC, Artificial Intelligence (AI) and interface usability research and theory could usefully be expanded to incorporate the roles of social and spatial presence.

As technology rapidly evolves, techniques using the methods presented in this study, and previous social and spatial presence research, could be organized and combined into an integrated presence-based measurement and design evaluation tool. Classifying presence research findings regarding the effects of different manipulations of social and spatial cues, including those here, in different applications and contexts, could lead to an effective metric for evaluating the likely usability of prospective computer user-interfaces.

Usability studies and testing center on creating optimal experiences for computer users to elicit enjoyment and create satisfying experiences. Social and spatial cues and presence are well suited for corresponding user-centered theories and methodologies. Questions to consider with evaluation tools that incorporate manipulations and measures along the lines of those used in this study include: How much or little of an application should be optimized to appeal to human sensibilities? When an application is social-spatial rich, do new concerns arise? Under what circumstances does the inclusion of (types of) cues detract from usability, or merely become cost-ineffective? If appropriate types and levels of cues vary with demographic and personality attributes of users, could software be customized based on user responses to simple questionnaires before use?

The benefits of applying these findings in other contexts are potentially great. For example, incorporating social and spatial presence cues in the design of collaborative business tools could improve organizational and business interaction, work flow and efficiency (Rice, 1993; Rice, D'Ambra, & More, 1998; Scott & Timmerman, 1999). Providing familiar social (avatars and agents) and spatial environments (3-D conference rooms, boardrooms) may make working with CMC systems more like a real life interaction. AI-enhanced software agents could be effective mediators or consultants and specialize in areas such as international customs, languages or even human resource gender and racial issues (Agentweb, 2005; Bradshaw, 1997; Moon & Nass, 1996a). Presence cues could make massive information stores more usable (as seen in the film Disclosure (1994) in which the protagonist gains access to a virtual data storage room in a large corporation with the assistance of a virtual agent). Assistive technology for people with disabilities who want to use computers, applications or the Internet (American Disabilities Act, 2004; Universal Usability, 2004;

Equal Access to Software and Information, 2005) could be enhanced with presence-based cues that compensate for user limitations (using one type of cue when the user is unable to process another).

Regardless of the application area, the results here provide new evidence of the value of applying telepresence scholarship in HCI and CMC in our continuing efforts to develop more successful computer use experiences.

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