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 the interactions of humans with computers to develop and evaluate user-centric user-interfaces by applying existing theories about telepresence, human-computer research, and characteristics of technology itself to produce social and spatial experiences similar to the ones computer users experience in the non-mediated world. An experiment is reported and its implications discussed.

Keywords--- **telepresence, spatial presence; social presence; user interface; cues**

1. Introduction

Despite progress over recent decades, computer use remains surprisingly burdensome and difficult. 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 and exponential development of technology which has led to information overload for computer users and an engineering-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 at least some unsatisfying and unpleasant computer use experiences, support this conclusion.

The field of Human Computer Interaction has improved the computer user-interface significantly but it can be made more satisfying and enjoyable for the computer user if it is designed with a user-centric criterion in which the computer is expected to accommodate the user rather than the reverse. We propose that designing a user-centric interface means using 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. Telepresence (hereafter, presence) is proposed as an effective way for users to communicate with and utilize the computer through the user interface. Two forms of presence are key to this effort, social presence and spatial presence, and the experiment reported here examines their independent and interactive effects on a variety of important outcome variables including satisfaction, enjoyment, comprehension of a task, perceived ability and likelihood to use a computer interface.

The sections that follow briefly review relevant literature, introduce the formal hypotheses, explain the method for the study, present the results and finally discuss benefits and future research.

2. Background

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 ([1], [2]), scientific exploration [3], physical medicine ([4], [5], [6]), psychological medicine ([7], [8], [9], [10]), building and architecture [11], and safety and automobile design ([12], [13]).

But presence is a multidimensional concept and phenomenon. Many different dimensions or types of presence have been proposed [14] but arguably the most common distinction is between social and spatial presence [15].

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” ([15], para.7e). 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 provides 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.

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 ” ([15], 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.

Research by Biocca [16], Heeter [17], Held and Durlach [18], Rice [19] 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 [20] and social presence [21] sought to match organizational tasks and media in order to achieve greater efficiency and satisfaction.

Social and spatial cues can lead to a more enjoyable experience; aside from the comfort with more 'natural' interaction, dynamic and dimensional images, sounds, and characters should be more entertaining than mere plain text. 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.

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. 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 advancement and 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. Few if any studies have systematically varied both types of cues and measured their impacts. The study reported here is a step toward that goal.

3. Hypotheses and research questions

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

3.1. Primary hypotheses

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

H2A Computer users will report greater overall satisfaction interacting with more rather than fewer social cues in a computer user-interface.

H2B Computer users will report greater overall satisfaction interacting with more rather than fewer spatial cues in a computer user-interface.

Enjoyment and Social and Spatial Cues

H3A Computer users will report greater enjoyment interacting with more rather than fewer social cues in a computer user-interface.

H3B Computer users will report greater enjoyment interacting with more rather than fewer spatial cues in a computer user-interface.

Comprehension and Social and Spatial Cues

H4A Computer users will report greater comprehension interacting with more rather than fewer social cues in a computer user interface.

H4B Computer users will report greater comprehension interacting with more rather than fewer spatial cues in a computer user-interface.

Perceived Ability and Social and Spatial Cues

H5A Computer users will report greater perceived ability interacting with more rather than fewer social cues in a computer user-interface.

H5B Computer users will report greater perceived ability interacting with more rather than fewer spatial cues in a computer user-interface.

Likelihood to Use an Application and Social and Spatial Cues

H6A Computer users will report that they would be more likely to use a computer user-interface with more rather than fewer social cues.

H6B Computer users will report that they would be more likely to use a computer user-interface with more rather than fewer spatial cues.

3.2. Secondary hypotheses

Satisfaction and Computer Experience

H7A The positive effect of social cues on satisfaction will be greater for computer users with less computer experience.

H7B The positive effect of spatial cues on satisfaction will be greater for computer users with less computer experience.

Enjoyment and Computer Experience

H8A The positive effect of social cues on enjoyment will be greater for computer users with less computer experience.

H8B The positive effect of spatial cues on enjoyment will be greater for computer users with less computer experience.

Comprehension and Computer Experience

H9A The positive effect of social cues on comprehension will be greater for computer users with less computer experience.

H9B The positive effect of spatial cues on comprehension will be greater for computer users with less computer experience.

Perceived Ability and Computer Experience

H10A The positive effect of social cues on perceived ability will be greater for computer users with less computer experience.

H10B The positive effect of spatial cues on perceived ability will be greater for computer users with less computer experience.

3.3. 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 a version of a software application for the submission of college admission applications that contained social cues (social pleasantries, an agent character) and/or spatial cues (images, animation and video) or neither in a 2 x 2 between subjects design. Other independent variables include gender, educational level, computer experience, age and ethnicity. The dependent variables are social presence, spatial presence, satisfaction, enjoyment, comprehension, perceived ability and likely to use or recommend the application. After interacting with the user interface, participants completed a questionnaire that assessed these variables.

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 (43.6% [n=82] males) at a diverse urban university, and represented a wide range of ages (mean 23.1 years), ethnic backgrounds and life experiences (including 52.4% [n=98] white; 20.3% [n=38] African American; and 13.4% [n=25] Asian).

4.2. Manipulation and measures

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

4.2.1. Social cues. Low social cues conditions featured an absence of social pleasantries in text and no visual representation of a person or character. 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).

4.2.2. Spatial cues. Low spatial cues conditions contained solely text directions indicating what the user should do next, while high spatial cues conditions depicted a three dimensional graphical representation of a physical space (an elevator and various admissions offices). See Figures 1-5 for screen shots that illustrate the four conditions.

4.2.3. Dependent variables. The measured dependent variables were social presences, spatial presence, satisfaction, enjoyment, comprehension, perceived ability, and likelihood to use the type of system. 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 questions such as: “Did the website seem sociable?” and “Did the website instruct or direct you like a person?” The items were adopted from the Temple Presence Inventory [22].

Spatial Presence. The level of spatial presence experienced by the user was measured by asking participants questions including: “To what extent did you feel surrounded by the environment you saw/heard?” and “To what extent did you feel mentally immersed in the experience?” The items were adopted from the Temple Presence Inventory [22].

Satisfaction. In Human-Computer Interaction research usability is commonly measured with the variables effectiveness, efficiency, and satisfaction. Satisfaction is measured in this study along with comprehension and ability as indirect indicators of efficiency and effectiveness. The level of satisfaction a user derives from interaction with the software was measured by asking participants questions including: “Did the website work as you expected?” and “Did the website do anything out of the ordinary?” The items were adapted from customer service satisfaction surveys and HCI interaction research ([23], [24], [25], [26], [27]).

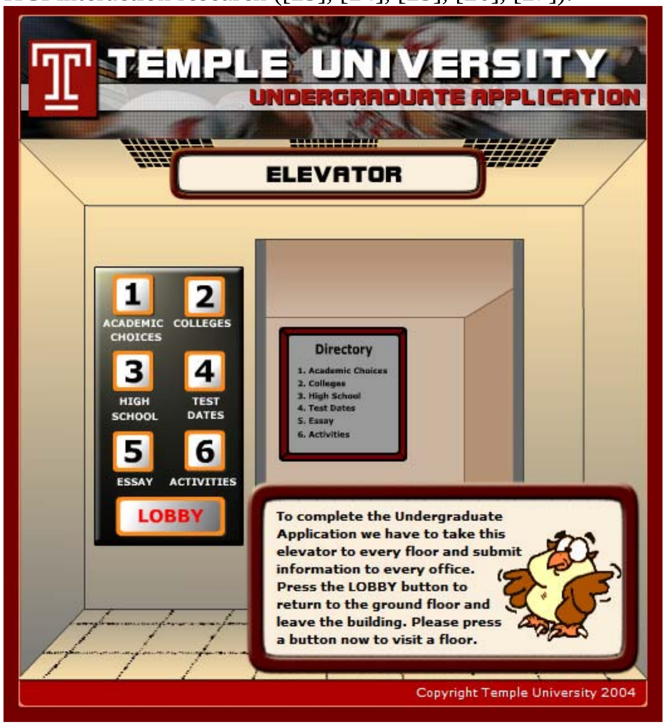

Figure 1 Menu for high social cues / high spatial cues condition

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

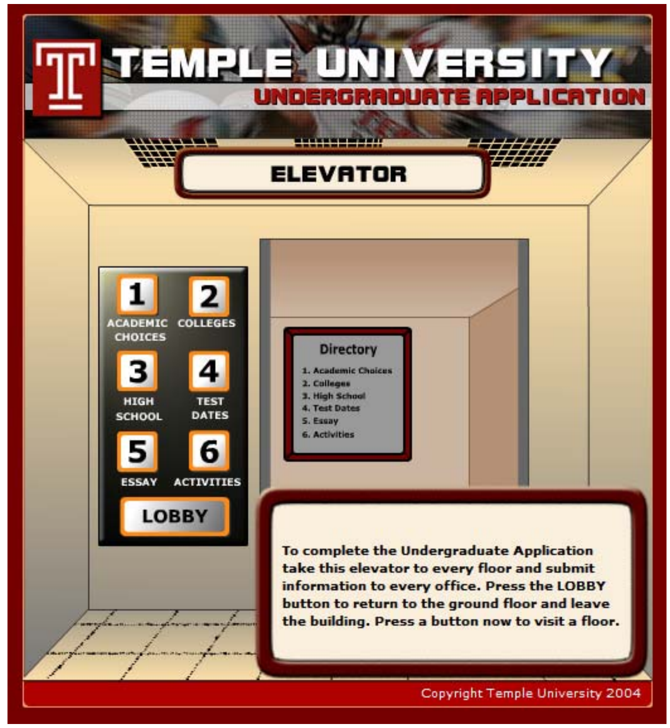

Figure 3 Menu for low social cues / high spatial cues condition

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

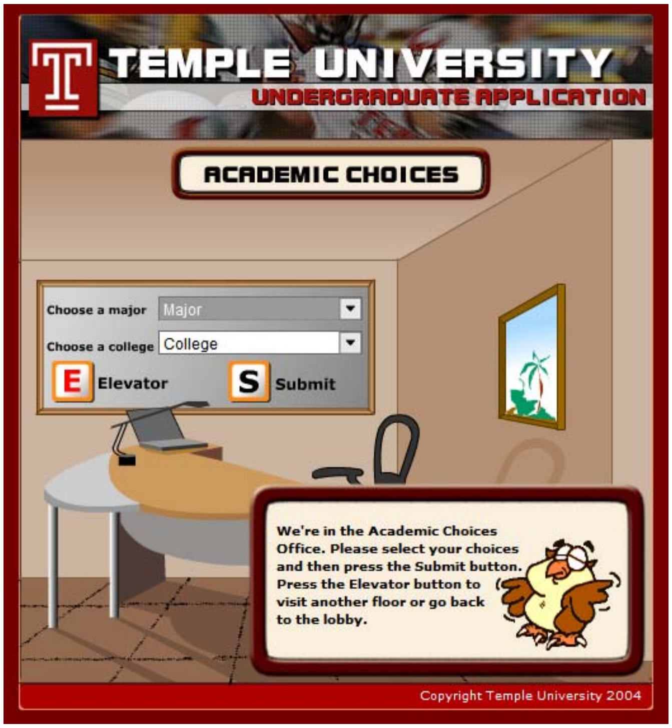

Figure 5 Office for high social cues / high spatial cues condition

Enjoyment. The level of enjoyment was measured by asking participants questions such as: "Did you enjoy working with the website?" and "Was the website entertaining?" The enjoyment measures were taken from HCI and presence research studies ([28], [29]).

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 questions including: "How well did you understand the instructions?" and "How difficult did the tasks seem?" The items are used in presence and HCI research ([22], [26], [27], [30], [31]).

Perceived Ability. The participants' perception of their ability to complete a task or understand and follow instructions was measured by asking them questions such as: "How capable did you feel using the website?" and "Did you feel confident the website could help you solve problems?" The items are used in HCI and presence research ([22], [26], [27], [30], [31]).

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 questions including: "Would you use an application like this again?" and "Would you recommend this type of application to another person?" Unlike the others, this dependent variable assesses behavioral intentions, a more distal and therefore more difficult outcome to measure and affect.

4.3. Procedures and apparatus

An interactive website application was presented to participants online and accessed via a URL provided via an e-mail message, hard copy printed message, or orally in a computer lab full of students. Either on their own computer or one 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 (estimated to take 15-20 minutes), and completed an online questionnaire.

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 (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 on 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 facilitate 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 to determine if the any of the stimuli or questionnaire materials required adjustment. Approximately five participants per test condition participated in the pretest. The pretest data were analyzed and adjustments made to optimize the testing conditions.

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

A small number (less than 2%) of data values were missing and the missing values were scattered randomly throughout the data (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.

5.2. Index construction

Indices were constructed for several dependent variables. Principal Components confirmatory factor analyses and Cronbach's Alphas were calculated to assess the unidimensionality and reliability of the indices. All indices were reliable, with Alphas .77 or greater (see Table 1 for details). A separate factor analysis on all of the social and spatial presence items together confirmed that they represented distinct concepts.

Table 1 Index items, eigenvalues and reliability

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: 4.33 Chronbach'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: 2.07 Chronbach's Alpha: .77	
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: 2.19 Chronbach's Alpha: .81	
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: 3.38 Chronbach's Alpha: .85	
Likely 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 Chronbach'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? .81
1 = not at all 9 = a lot

How was your experience interacting with the system?
1 = difficult 9 = easy .79
1 = very frustrating 9 = not at all frustrating .70

Eigenvalue: 3.23 Chronbach's Alpha: .86

Satisfaction from using the application

How much of a sense of satisfaction or accomplishment did you feel after you finished using the system? .88
1 = none at all 9 = a lot

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… .84
1 = worse 9 = better

How was your experience interacting with the system? .82
1 = not at all satisfying 9 = very satisfying

Eigenvalue: 2.18 Chronbach's Alpha: .77

5.3 Primary hypotheses results

All of the primary hypotheses were tested via independent samples, non-directional t-tests.

Social Presence

Hypothesis 1a, that social cues in computer software will evoke social presence in computer users, was supported (t (183) = 2.19, 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).

Spatial Presence

Hypothesis 1b, that spatial cues in computer software will evoke spatial presence in computer users, was tested using an independent samples, was supported (t (185) = 6.51, p = .01). 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).

Satisfaction

Hypothesis 2a, that computer users will report greater overall satisfaction using computer software with more rather than fewer social cues, was supported (t (183) = 2.19, p = .03). 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 (t (186) = 2.49, p = .01). 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 (t (185) = 2.03, 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 (t (187) = 4.63, p = .01). 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 (t (187) = 2.77, p = .01). 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 (t (187) = 3.77, p = .01). 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 (t (187) = 1.93 p = .01). 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 (t (186) = 3.44, p = .01). 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 of Use

Hypothesis 6a, that computer users will report that they would be more likely to use computer software with more rather than fewer social cues, was partially supported (t (184) = 1.61 p = .10). Participants in the conditions with high social cues reported that they were more likely to use 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).

To further investigate hypothesis 6a, the index (likelihood to use a similar application or recommend it to others) was disassembled and the individual variables were used to test hypotheses 6a and 6b. Two significant results emerged. Changing the likelihood of use index to the "likelihood to use a similar application" variable in hypothesis 6a produced a variation of the hypothesis that was significant (t (186) = 4.04 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). Additionally, changing the likelihood of use index to the "likely to recommend the application to others" variable in hypothesis 6a produced a variation of the hypothesis that was supported (t (185) = 2.29, p = .01). Participants in the conditions with high social cues reported that they were 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 (t (185) = 3.52, p = .01). 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

All of the secondary hypotheses were tested by examining the interaction term in 2-way Analyses of Variance; none of the analyses provided support for the hypotheses regarding the role of computer experience.

Satisfaction

The analysis for Hypothesis 7a, that the positive effect of social cues on satisfaction will be greater for computer users with less computer experience, revealed no significant main effect for computer experience (M= 4.03, F(1) = 1.13, p=.28), or for the social cues (M= 7.35, F(1) = 2.06, p = .15) and no significant interaction (M= 3.55, F(1) = .99, p=.32).

The analysis for Hypothesis 7b, that the positive effect of spatial cues on satisfaction will be greater for computer users with less computer experience, revealed no significant main effect for computer experience (M= 2.25, F(1) = .641, p=.42), showed a significant main effect for spatial cues (M= 21.22, F(1) = 6.03, p= .01) and no significant interaction (M= 3.74, F(1) = 1.06, p=.30).

Enjoyment

The analysis for Hypothesis 8a, that the positive effect of social cues on enjoyment will be greater for computer users with less computer experience, revealed no significant main effect for computer experience (M= 1.32, F(1) = 4.63, p=.49) a difference that approaches statistical significance for the main effect for the social cues (M= 10.1, F(1) = 3.52, p = .06) and no significant interaction (M= 1.13, F(1) = .396, p=.53).

The analysis for Hypothesis 8b, that the positive effect of spatial cues on enjoyment will be greater for computer users with less computer experience, produced no significant main effect for computer experience (M= .15, F(1) = .059, p=.80), a significant main effect for spatial cues (M= 56.73, F(1) = 21.59, p = .01) and no significant interaction (M= 3.09, F(1) = 1.17, p=.27).

Comprehension

The analysis for Hypothesis 9a, that the positive effect of social cues on comprehension will be greater for computer users with less computer experience, produced no significant main effect for computer experience (M= 1.39, F(1) = .569, p=.45), a significant main effect for social cues (M= 16.07, F(1) = 6.54, p= .01) and no significant interaction (M= .28, F(1) = .114, p=.73).

The analysis for Hypothesis 9b, that the positive effect of spatial cues on comprehension will be greater for computer users with less computer experience, produced no significant main effect for computer experience (M= .24, F(1) = .104, p=.74), a significant main effect for spatial cues (M=28.47, F(1) = 11.93, p= .01) and no significant interaction (M= .34, F(1) = .143, p=.70).

Perceived Ability

The analysis for Hypothesis 10a, that the positive effect of social cues on perceived ability will be greater for computer users with less computer experience, revealed no significant main effect for computer experience (M= .19, F(1) = .074, p=.78), a main effect for social cues that approaches significance (M= 7.47, F(1) = 2.78, p=.09) and no significant interaction (M= .20, F(1) = .076, p=.78).

The analysis for Hypothesis 10b, that the positive effect of spatial cues on perceived ability will be greater for computer users with less computer experience, produced no significant main effect for computer experience (M= .97, F(1) = .380, p=.53), a significant main effect for spatial cues

(M=25.46, F(1) = 9.09, p=.01) and no significant interaction (M= 1.35, F(1) = .527, p=.46).

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) =.409 p = .04). Female subjects did not report 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). Female subjects did not report 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) = 3.76 p = .001). Male subjects reported greater enjoyment using an application with more spatial presence (M = 6.41, SD = 1.62, n = 15) than social presence (M = 4.64, SD = 1.26, n = 23).

Research Question 4 asks whether male computer users report greater satisfaction using software that evokes spatial presence than using software that evokes social presence. This question was examined using an independent sample, non-directional t-test. The independent variable distinguished subjects in the two experimental conditions that included high social cues and the two that included high spatial cues. The dependant variable was the satisfaction index and cases with only male subjects selected. The t-test was not significant (t (29) = 1.27 p = .21). Male subjects did not report greater satisfaction using an application with more spatial presence (M = 6.33, SD = 2.11, n = 15) than social presence (M = 5.46, SD = 2.02, n = 23).

5.5 Social and spatial cues separately and combined

A series of two-way ANOVAs using the key dependent variables (comprehension, enjoyment, likely to use (a similar application), perceived ability, satisfaction, social presence, spatial presence) and the separate dichotomous social and spatial cues independent variables 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.

Discussion and conclusions

As technology becomes ever more intertwined into the infrastructure of society and modes of communication evolve, our dependency 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 – and thereby enhance computer users' satisfaction and enjoyment of computer systems, increase their comprehension while completing tasks and even encourage positive perceptions of their perceived ability.

In a systematic and controlled comparison in which basic content (i.e., the task) remained constant while format and design were varied, both social and spatial cues were shown to be effective but the combination of them was most effective.

The lack of significant results for the computer experience variable may merely reflect a lack of variance in the college student sample, but these results are also consistent with the argument that how we respond to social and spatial cues is deeply ingrained and unaffected by experience with a technology that incorporates those cues.

While only one of the research questions regarding gender differences yielded significant results, the tests lacked sufficient power given the small numbers of participants and the pattern of means for all of the tests was in the expected direction, suggesting the possibility that females respond more to social, and males to spatial, presence cues, at least in some contexts. Future study is warranted.

Overall, the findings contribute to our understanding of presence as a multidimensional rather than merely unidimensional concept and phenomenon. From an applied perspective, they suggest that interface designers consider and test for the causes and effects of presence in their work.

In addition to business or monetary benefits, considering presence in this way could enrich the relationship between people and technology. Technology could become more intuitive and adaptive, making it available to underserved populations such as the physically and cognitively disabled.

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