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The Effects of Actual Human Size Display and Stereoscopic Presentation on Users' Sense of Being Together with and of Psychological Immersion in a Virtual Character

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Abstract

This study examined the role of display size and mode in increasing users' sense of being together with and of their psychological immersion in a virtual character. Using a high-resolution three-dimensional virtual character, this study employed a 2×2 (stereoscopic mode vs. monoscopic mode×actual human size vs. small size display) factorial design in an experiment with 144 participants randomly assigned to each condition. Findings showed that stereoscopic mode had a significant effect on both users' sense of being together and psychological immersion. However, display size affected only the sense of being together. Furthermore, display size was not found to moderate the effect of stereoscopic mode.

Introduction

VIRTUAL CHARACTERS HAVE OFTEN BEEN USED to represent human counterparts or computers when users play video games, interact with other humans via online messengers, or post their opinions on social networking sites. These virtual characters are called ''embodied agents'' when they are designed to represent computers, whereas they are called ''avatars'' when they are intended to represent human counterparts.[1,2] However, these terms for virtual characters are often used interchangeably.

Although it is obvious that the virtual characters are not real, people typically respond to virtual characters as if they were real.[3] One of the important features of virtual characters that makes possible the realistic social responses to the social actors is the degree of realistic representation of human forms and behaviors.[4,5] Two important technological aspects of realistic visual appearance of virtual characters are the large display size and stereoscopic mode of the virtual characters on a display. For example, when virtual characters are displayed actual human size on a large screen display, the realistic representation of the human form would be enhanced dramatically. Stereoscopic mode on a display would also allow viewers to perceive the social actors to be more realistic through the illusion of depth and three-dimensional (3D) imaging technologies because stereoscopic display is technically designed to present the same scene to each eye. These two factors are expected to maximize users' feelings of being together with and of being vividly immersed in the virtual characters. Thus, this study focuses on the two social and technological aspects of actual human size and stereoscopic mode of the virtual character on a display, and explores if these two factors influence users' psychological feelings associated with the virtual characters.

Copresence is a concept that can theoretically explain how users psychologically feel the sense of being together with and being immersed in the virtual characters. Although there is no consensus on what copresence is,[6] here, copresence, as a subtype of presence, is defined as users' immersive psychological experiences of perceiving virtual characters and spatial environments as actual ones.[7] As the two components of copresence, users' sense of being together and their psychological immersion are assumed to highlight the role of display size and mode in enhancing users' virtual experiences with the virtual characters.

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The sense of being together is closely associated with users' perception of their virtual experiences that are reflected as either real or not real through their media use.[8] Such a reality perception about media virtuality is also highlighted by a widely cited definition of presence as a psychological state that virtual entities are perceived to be actual ones.[7] Depending on the nature of virtual entities, presence can be classified into four types: spatial presence (entities representing spatial environment), physical presence (entities representing physical objects), social presence (entities representing other humans), and self-presence (entities representing users themselves).[9] In this classification, copresence involves properties of both social presence and spatial presence.[10] Copresence includes social presence because the objects that users perceive being with are social entities. Copresence also has the property of spatial presence because the social entities that users perceive they are with are spatially located. Thus, one property of copresence is whether users perceive social entities in a spatial environment as real social entities in a real spatial environment.

Users' psychological immersion in the virtual characters may be another important component of copresence because it indicates that users' subjective experience of being immersed in social entities that are represented in the media interface. In fact, Lombard and Ditton argue that users' psychological immersion in virtual characters should be regarded as being as important as the technologically immersive features of media.[11]

Large display size and stereoscopic mode of the virtual characters on a display are expected to increase users' sense of copresence. In fact, display size is a well-known factor of media features that has an impact on media usage. Enlarging screen size increases the amount of sensory information for media users.[12] A larger display size is likely to attract more visual field by providing more pictures that can be seen in the perimeter of vision.[13] Indeed, much empirical evidence supports that a larger display can induce a greater sense of presence.[14,15] Thus, as a subtype of presence, copresence is expected to be maximized when display size becomes as enlarged as actual human size.

This study predicts two separate hypotheses instead of one. One is associated with the sense of being together and the other with psychological immersion or immersive experiences. Although the sense of being together and psychological immersion are the components of copresence, they may represent different psychological processes. The sense of being together represents the perception of virtual objects as actual, whereas psychological immersion represents the degree of paying attention to the objects. Based on this reasoning, the following hypotheses are formally formulated:

H1a: Viewers who watch the virtual character on an actual human size screen will have a stronger sense of being together with the virtual character than viewers who watch the virtual character on a small screen.

H1b: Viewers who watch the virtual character on an actual human size screen will have a stronger immersive experience with the virtual character than viewers who watch the virtual character on a small screen.

Stereoscopic display mode is also expected to amplify users' sense of copresence with the virtual character. As a way of increasing the amount of sensory information that users receive, stereoscopy is a technique that presents at least two views of the same scene to each eye so that viewers experience the illusion of depth and 3D imaging.[16] In other words, stereoscopic display is an illusory technique of 3D imaging that provides visual information via more than two visual channels. Based on the function of stereoscopy, it is reasonable to predict that stereoscopic mode should increase the two components of copresence (i.e., the sense of being together and immersive experience) as stated by the following hypotheses:

H2a: Viewers who watch the virtual character in a stereoscopic display will have a stronger sense of being together with the virtual character than viewers who watch the virtual character in a monoscopic display.

H2b: Viewers who watch the virtual character in a stereoscopic display will have a stronger immersive experience with the virtual character than viewers who watch the virtual character in a monoscopic display.

However, in previous studies, stereoscopic display mode was found to affect presence inconsistently. While many studies found that a stereoscopic display generated higher sense of presence than a monoscopic display,[17–20] a more recent study did not find the same direction of the effect.[21] One possible reason for this inconsistent result can be explained by problem dosage. Small screen size might not present enough sensory information for a stereoscopic display so that it would not have induced the experience of the illusion of depth and 3D imaging. In this sense, enlarging display size, particularly to actual human size, should have a more prominent effect of stereoscopic display on the two components of copresence compared to a small size display. Thus, we propose the following hypotheses:

H3a: The effect of a stereoscopic display mode on the participants' sense of being together with the virtual character will be more salient when the screen is actual human size than when the screen is small.

H3b: The effect of a stereoscopic display mode on the participants' immersive experience with the virtual character will be more salient when the screen is actual human size than when the screen is small.

Methods

Research design, stimuli, participants, and procedures

The present study used a 2×2 (display mode: stereoscopic vs. monoscopic display $\times$ display size; human size vs. small) between-subjects factorial design. Three 55-inch TV screens were added vertically together and installed on the wall for the human size display condition. One 55-inch TV screen was installed on the wall for the small size display condition. A full size avatar was featured on the screens, but its size was fitted to the screen size. As a result, four experimental conditions were created to reflect four types of TV screen display: (a) stereoscopic and human size display, (b) stereoscopic and small size display, (c) monoscopic and human size display, and (d) monoscopic and small size display. Across the four conditions, the virtual character was a realistic human 3D character created by *WorldViz*, a company specializing in 3D visualization.

A total of 144 college students were recruited as the participants at a large university in Seoul, South Korea. Thirty-six participants were randomly assigned to each of the four display conditions. In order to control for the possible effect of gender, the same number of male and female participants was assigned to each condition. When visiting the experimental site, the participants were first asked to pay attention to an onscreen virtual character that presented a 5 minute news story about the university that they attended. After watching the virtual character and listening to its narration on the screen, they were asked to fill out a follow-up survey questionnaire. Subjects' mean age was 22.4 years.

Operational measures

Copresence has two components: the sense of being together and psychological immersion. Thus, participants' sense of being together with the virtual character displayed on the screen and psychological immersion were dependent variables.

Participants' sense of being together with the virtual character. Three 7-point Likert-type items adapted from the Temple Presence Inventory (TPI)[22] measured participants' senses of being together physically with the virtual character displayed in the same site, where 1 = ''not at all'' and 7 = ''very much.'' Specifically, the three items asked the participants to indicate the perceived feeling of being together with the virtual character in the same physical space, such as (a) ''To what extend did you feel you could interact with the virtual avatar you saw in the place where you were?''; (b) ''To what extent did you feel you and the virtual avatar you saw were together in the place where you were?''; and (c) ''How much did it seem as if you and the virtual avatar you saw were together in the same place?'' This scale exhibited a high degree of internal consistency among the measurement items ($M = 3.55$, $SD = 1.43$, Cronbach's $\alpha = 0.91$).

Participants' immersive experience with the virtual character. Four 7-point Likert-type items adapted from the TPI[22] measured participants' media immersion, where 1 = ''not at all'' and 7 = ''very much.'' Specifically, the items asked the participants to indicate the perceived feeling of immersion during the virtual character session in the lab, such as (a) ''To what extend did you feel mentally immersed in the experience with the virtual avatar?''; (b) ''How involving was the experience with the virtual avatar?''; (c) ''How completely were your senses engaged with the experience with the virtual avatar?''; and (d)''How engaging was the story from the virtual avatar?'' This scale exhibited an acceptable degree of internal consistency among the measurement items ($M = 4.36$, $SD = 1.09$, Cronbach's $\alpha = 0.83$).

Results

Effect of display mode and size on the sense of being together

A two-way analysis of variance (ANOVA) found that both display mode and display size had positive main effects on participants' sense of being together with the virtual character displayed on the TV screen. Specifically, first, the results demonstrated that the stereoscopic display mode ($M = 3.85$, $SD = 1.34$) generated a stronger sense of being together with the virtual character than the monoscopic display mode ($M = 3.25$, $SD = 1.48$), $F(1, 140) = 6.97$, $p < 0.01$, $\eta_p^2 = 0.05$. In addition, the results showed that the human size display ($M = 3.94$, $SD = 1.46$) engendered a stronger sense of being together than the small size display ($M = 3.17$, $SD = 1.30$), $F(1, 140) = 11.41$, $p < 0.001$, $\eta_p^2 = 0.08$. Therefore, H1a and H2a were supported. However, there was no statistical evidence that display size moderated the main effect of the display mode, $F(1, 140) = 0.01$ $p = 0.92$, $\eta_p^2 = .0001$. Therefore, H3a was not supported.

Effect of display mode and size on the immersive experience

Another two-way ANOVA showed that display mode had a positive main effect on participants' immersive experience with the virtual character displayed on the TV screen. However, display size was found not to affect the immersive experience. Specifically, the results showed that the stereoscopic display mode ($M = 4.60$, $SD = 0.88$) generated a higher level of immersive experience with the virtual character than the monoscopic display mode ($M = 4.11$, $SD = 1.22$), $F(1, 140) = 7.22$, $p < 0.01$, $\eta_p^2 = 0.05$, supporting H2b. However, the results showed no difference in the immersive experience between the human size display ($M = 4.46$, $SD = 1.12$) and the small size display ($M = 4.25$, $SD = 1.06$), $F(1, 140) = 1.36$, $\eta_p^2 = 0.01$, $p = 0.25$, rejecting H1b. In addition, no statistical evidence was found that display size moderated the main effect of the display mode, $F(1, 140) = 0.73$ $p = 0.39$, $\eta_p^2 = 0.005$. Therefore, H3b was not supported.

Discussion

The purpose of this study was to examine the effects of actual human size display and stereoscopic display mode of a virtual character on users' sense of being together with and of psychological immersion in the virtual character. The study also explored whether display size moderated the effect of stereoscopic mode on the two components of copresence. The results of this study showed that stereoscopic display mode significantly increased both the users' sense of being together and psychological immersion. However, unexpectedly, actual human size display only increased the sense of being together. Further, display size did not moderate the effect of stereoscopic display on the two components of copresence. Overall, these findings validated the idea that the realistic representation of virtual characters influenced both the sense of being together and psychological immersion by increasing the amount of sensory information in media, especially when the virtual character is displayed in a stereoscopic mode. In addition, stereoscopic mode and actual human size display independently increased the sense of being together.

The findings of this study also revealed that the realistic representation of virtual characters is limited to a certain degree in inducing the sense of copresence. The actual human size display did not influence psychological immersion. This is surprising because the sense of being together and psychological immersion are two main components of

the sense of copresence, and they are closely related, and previous studies consistently found an impact of size on presence.[14,15]

A possible reason for the inconsistent result may be due to the stimuli. That is, the ''small'' size display used in this study might be perceived as rather impressively large, which still might make the users' experience immersive with the virtual character. The actual size of the small screen used in the study was 55 inches. In the current market situation, such a size may be considered large by participants who are usually exposed to a more conventional size screen that is smaller than the display used in this study.

A theoretical account for the inconsistent result is that the sense of being together and psychological immersion might be different concepts rather than similar ones, although the sense of being together and psychological immersion are closely related. The sense of being together is about reality perception, or the extent to which media users perceive virtual entities (spatial environment and characters) as actual ones. Thus, the sense of being together should be directly influenced by a screen size that makes virtual objects on-screen closely simulate actual objects.

On the other hand, psychological immersion is a subjective experience that might not necessarily be influenced by screen size. Immersion literally refers to the state of being submerged in a liquid. This meaning is expanded to refer to the psychological experience of media that range from a narrative text to an immersive virtual environment that occupies media users' attention.[23–25]

Indeed, in the study by Lombard et al.,[14] the effect of size on presence was obviously found. However, in the study, no difference was found in involvement (i.e., psychological immersion) between large and small size screen conditions, and the effect of size was only observed in users' perception of speed of objects' movement, sense of physical movement, enjoyment of movement, relationship of ''participant'' with terrain, and excitement of scene. With the exception of users' enjoyment of movement, these aspects are mostly associated with users' reality perception of the media content, which is strikingly similar to the findings of the present study. In this sense, the effect of size may be limited to reality perception rather than psychological involvement (i.e., psychological immersion). These findings may suggest that users' sense of being together may be the primary or sole component of users' sense of copresence, offering a new perspective on the sense of copresence. Here, we propose a new concept, a sense of coexistence, which excludes the users' subjective perception of psychological immersion and only highlights the users' reality perception of their sense of being together with virtual objects. In this regard, future research should be called for examining the true nature of users' psychological immersion with virtual environments and characters. This may offer a more nuanced approach in the research on presence.

It is also intriguing that an interaction effect of display size and stereoscopic mode on users' psychological immersion in virtual characters was not found in this study. That is, compared to small size display, actual human size display did not enhance the effect of stereoscopic mode on copresence. One possibility is that the 55-inch small size display might present as much immersive information to users as the three vertically installed human size large display, particularly when it is incorporated with the stereoscopic mode. That is, in such a condition of the small size display, users' psychological involvement with the virtual characters may have been unexpectedly immersive enough because their level of attention for information processing may have been paid and their state of immersion may have been already maximized by the stereoscopic mode of the characters presented in this display. In this sense, future studies should investigate how users' psychological immersion would interact with their limited capacity for cognitive processing of information in the virtual environments

This study has several limitations. First, in this study, participants simply watched the virtual character without interacting with it. Thus, the results of this study may have limited generalizability to interactive media environments. Second, in order to manipulate the screen size, three 55-inch TV screens were installed vertically instead of horizontally to represent the actual human size display. In other words, both the large and small screen conditions occupied the same amount of visual field horizontally. Thus, it is possible that the vertically large display might not be an immersive feature to users. Future research is required to test the role of large display size using a horizontally wider screen.

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