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The impact of avatar realism and anonymity on effective communication via mobile devices

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ABSTRACT

This research investigates the impact on social communication quality of using anonymous avatars during small-screen mobile audio/visual communications. Elements of behavioral and visual realism of avatars are defined, as is an elaborated three-component measure of communication quality called Social Copresence. Experimental results with 196 participants participating in a social interaction using a simulated mobile device with varied levels of avatar visual and behavioral realism showed higher levels of avatar Kinetic Conformity and Fidelity produced increased perceived Social Richness of Medium, while higher avatar Anthropomorphism produced higher levels of Psychological Copresence and Interactant Satisfaction with Communication. Increased levels of avatar Anonymity produced decreases in Social Copresence, but these were smaller when avatars possessed higher levels of visual and behavioral realism.

1. Introduction

Mobile communication devices are a central technology in social networking. Ample documentation of such devices' importance in fostering social connectedness can be found in the literature (Boyd, 2010; Cumiskey, 2007; Eagle & Pentland, 2005; Humphreys, 2007; Ling, 2004; Smith, 2005; Tomita, 2006). At present, most users of mobile communication devices for social networking rely on voice and text communication. Current use of video is primarily for viewing downloaded or streamed files of recorded video content. However, the emerging generation of mobile communication devices, especially those using true 4G network technology (*cf.* http://www.wirelessinternet.org/4G-network.php), will almost certainly feature increased use of direct person-to-person real-time video connections (e.g. the Apple iPhone 4 with FaceTime video chat).

Direct video connection between individuals raises some serious questions about ways to effectively communicate while still maintaining a modicum of privacy. While two-way video conversations hold the promise of making more emotionally connected and accurate person-to-person communication possible, they also present the problem of managing this communication when at least one of the persons does not desire to completely reveal his or her visual identity, as might be the case in casual conversations between non-acquaintances.

The obvious answer to this problem, "just turn off the video," reduces the 4G device to a simple mobile telephone and foregoes the potential positive benefits of the added visual information provided by a full videophone. These benefits come from adding nonverbal visual information to the auditory speech information, which addition likely improves the interpretive accuracy and possibly the emotional connection between communicators (cf. Bailenson, Yee, Merget, & Schroeder, 2006; Garau, 2003; Garau et al., 2003).

One frequently proposed way to add visual information to the communication without revealing visual identity is to use an abstract visual representation of the communicator, an avatar, instead of a full video presentation. Using avatars poses the central question investigated in this study: *do avatars used with mobile communication devices improve communication outcomes, and if so, what kind of avatar best provides the nonverbal information important for psychologically and emotionally connecting communicators while still providing visual anonymity*?

There is a fairly large body of research into the impact of avatars' characteristics on the communication process, some of which is reviewed in the following section. But almost uniformly, this research has been conducted with computer-based communication systems using large display screens rather than the small and fairly low-resolution screens of mobile communication devices (Mosmondor, Kosutic, & Pandzic, 2005). Visual information like facial expression may be very different when communicators use low or medium visual resolution devices with very small display areas. In addition, prior research has tended to focus on task-oriented communication among collaborating group members

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rather than on social communication that relies more on affective elements, a point made by Kang, Watt, and Ala (2008a, 2008b) and Kang, Watt, and Isbister (2006). This kind of social communication dominates the use of mobile devices. Both these limitations point to the need for new research into the effect of different avatar realism on social interactions via technologies that afford only limited visual displays, and which are used for socio-emotional purposes as well as focused tasks.

Although small display mobile devices do not have enough space for fairly good quality visual displays, we argue that it is important to display the nonverbal information of interaction partners. Conventional wisdom tells us that nonverbal communication is a key part of effective human-to-human communication because it adds important information beyond what's expressed verbally. Therefore, we first conducted a literature review to investigate how crucial a role visual displays play in mediating interactions through relaying the nonverbal information of interaction partners.

2. Literature review

2.1. Importance of visual nonverbal information in mediated interactions

Argyle (1972) argues that emotional states can be more effectively communicated when appropriate verbal signals are accompanied by nonverbal information and that people use nonverbal communication to manage their social relationships. Burgoon, Buller, and Woodall (1996) point out that "Nonverbal communication can express what verbal communication can't or shouldn't." Ekman and Friesen (1969) state that a nonverbal cue is a primary way of communicating emotions and indicating changes in the quality of interpersonal relationships. Many other theorists and researchers stress the importance of nonverbal cues, and particularly facial expressions, in producing accurate and effective communication (cf. Ekman & Friesen, 1969; Izard, 1997; Knapp & Hall, 2007; Littlejohn, 2002).

Similarly, the importance of facial and other visual cues conveying nonverbal information in Computer-Mediated Communication (CMC) has been emphasized. Media richness theory (Daft & Lengel, 1986; Dennis & Kinney, 1998) argues that richer media can facilitate tasks that have high equivocality, presumably by providing more cues to reduce uncertainty. This view is supported by research into affective communications by other researchers (Garau et al., 2003; Poggi & Pelachaud, 2000). Biocca, Harms, and Burgoon (2003) argue for the significance of nonverbal cues in establishing people's psychological access to the other beings, that is, as an important factor in producing interactants' "feelings of being connected" and "feelings of being together" in mediated interactions. Mediated visual cues are also used to assess communicator credibility (Nowak, 2004). However, it is not always the case that adding a visual element to mediated communication improves interactants' positive perceptions of success. Bengtsson, Burgoon, Cederberg, Bonito, and Lundeberg (1999) found that people reported slightly lower ratings of sociability when looking at static humanoid faces while communicating than when looking at a text-only presentation. But in other studies, the opposite has been found. (cf. Bickmore & Picard, 2003; Sproull, Subramani, Kiesler, Walker, & Waters, 1996). On balance, most studies have reported higher social presence, preference, liking for interactant partners, and other measures of effective communication for interactions using higher information media (audio, graphics, full motion video), as opposed to a text-based medium (Poggi & Pelachaud, 2000; Rice, 1993; Walker, Sproull, & Subramani, 1994).

These studies and others generally support the idea that adding visual nonverbal information improves the effectiveness of mediated social communication. This argues for the inclusion of a video channel for communications whenever possible, and against simply turning off the video in 4G devices as a strategy for preserving privacy. An alternative method of providing some degree of anonymity while possibly retaining the benefits of a visual presentation is to employ a visual avatar.

Therefore, we explored an avenue that would allow interactants to enjoy socially rich communication while securing their anonymity through the use of a visual avatar.

2.2. Avatar realism

Bailenson and colleagues (2006) define avatars as "digital models of people that either look or behave like the people they represent." Existing research has illustrated the impact of specific visual or behavioral characteristics of avatars on differing communication outcomes. These characteristics can be roughly described as differing dimensions that can take on a range of values. A simplified taxonomy of these is provided in Fig. 1.

Realism could range, for example, from full-motion photographic quality 3D video to a plain text "screen name" made up of random digits. Avatar realism is the degree to which the avatar accurately resembles the communicator it is representing. Overall, avatar realism can be characterized as possession of visual and/or behavioral attributes of a human being. Realism has two major subdimensions: *visual realism* and *behavioral realism*.

2.2.1. Visual realism

This is the degree to which the depiction of the avatar retains the visual characteristics of the communicator. It is also sometimes called *iconicity*. It, in turn, has two major subdimensions: *fidelity* and *anthropomorphism*.

2.2.1.1. Fidelity. This refers to the visual quality of the avatar image, that is, the degree to which the avatar reproduces the sensory experience of actually viewing the object which it represents. This object might be the communicator, but it also might be another entity like a unicorn or a building. Fidelity could range from a very simple abstract line drawing to a full quality photograph.

2.2.1.2. Anthropomorphism. This is the degree to which the avatar has a human-like visual appearance, ranging from none at all (e.g., a non-human graphic logo) to a fully-realized human depiction.

2.2.2. Behavioral realism

This is the degree to which the avatar acts in a way that conforms to the norms of human-to-human interaction. Its two major sub-dimensions are *kinetic conformity* and *social appropriateness.* Kinetic conformity is the degree to which dynamic movement of the avatar resembles the expected motion of the object that the avatar appears to be, *e.g.,* if the avatar is a human representation, how closely it mimics real human movement over time. Social appropriateness is degree to which the avatar responds verbally

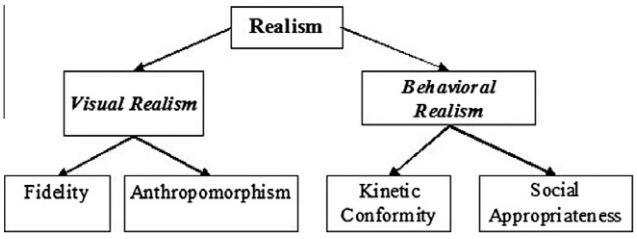


Fig. 1. A taxonomy of avatar characteristics.

and nonverbally in ways that conform to social norms of communication. This subdimension is extremely complex and is not investigated in the research described here.

Investigations of avatar realism (Bailenson, Blascovich, Beall, & Loomis, 2001; Bailenson et al., 2006; Garau et al., 2003) found that interactants' feelings of social presence were lower when they experienced a discrepancy between behavioral realism and visual realism of highly anthropomorphic virtual characters controlled by a computer, particularly when the characters did not display correct facial expressions or eye gaze movements. In general, research suggests that avatars' higher anthropomorphism also requires higher kinetic conformity to increase interactants' sense of social presence. This may be related to the "uncanny valley" phenomenon reported in robotics research (Seyama & Nagayama, 2007), in which anthropomorphic robots whose behavior (kinetic realism) is slightly inappropriate, but whose visual realism is high. These robots are seen negatively as somewhat "creepy." McGloin, Nowak, Stiffano, and Flynn (2010) have presented some evidence that expectancy violation may produce the uncanny valley effect. Users expect more realistic behavior from realistic anthropomorphic avatars, and if this expectancy is violated, evaluate the avatars more negatively than less realistic ones. In fact, some researchers (Blascovich, 2002; Ehrlich, Schiano, & Sheridan, 2000; Swinth & Blascovich., 2002) contend that kinetic conformity (realistic movement) is more important than anthropomorphism if there are any technical limitations that prevent fully implementing both types of avatar realism.

However, communicators' preferences for anthropomorphic avatars appears to be situational. Hamilton and Nowak (2010), Nowak (2004), Nowak and Biocca (2003), Nowak and Rauh (2005, 2006) report that interactants were in general more attracted to high anthropomorphic avatars and perceived them as higher in credibility and attractiveness, with the exception of those that produced the uncanny valley effect. Walker et al. (1994) reported that the anthropomorphic image of an avatar representing a software agent was one of the most attractive components in a computer interface, but other researchers (Koda & Maes, 1996) have found a preference for nonhuman avatars in different contexts. Preference for an anthropomorphic avatar appears to be shaped by factors beyond a simple desire for effective nonverbal communication. Importantly, it is not clear that users' preferences for avatars coincide with avatar choices that produce the most effective communication outcome.

2.3. Social presence and social copresence in mediated communication

The usual desideratum of mediated interpersonal communication is reproduction of a face-to-face situation. This implies that some sense of "being in each others' presence" is produced as a result of the communication, and this holds regardless of whether or not avatars are used to provide some level of anonymity.

Early theories of remote presence developed from virtual reality research and defined presence as a feeling of physical collocation (see Lee, 2004), e.g. of "being in the same room". This has been called "telepresence" by some researchers (Nowak & Biocca, 2003). Short, Williams, and Christie (1976) extended this definition to "social presence," defined as the "degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions. . .it is a subjective quality of the communications medium" (p. 65). The definition seems to be influenced by Goffman's notion of "copresence" (Goffman, 1963), which can be seen broadly as mutual awareness, but adds the idea of a psychological connection as a product of the characteristics of the communication medium. Rice (1993) also emphasized that within the scope of technologically-mediated communication, it is important to consider the nature and abilities of the mediating technology in producing effective communication.

Biocca and Harms (2002), Biocca et al. (2003) propose a definition of social presence that focuses more strongly on its psychological basis and extends beyond the concept of physical awareness or the medium's capabilities. This includes interactants' models of each other and their sense of access to the other's internal state. They argue that *copresence* should be part of definition of social presence. In general, the terms "social presence" and "copresence" are used interchangeably in research. Kang and her colleagues constructed a measure of "Social Copresence" (Kang, Watt, & Ala, 2008b) that added a dimension of "emotional credibility."

There are thus three main themes in prior conceptualizations: the feeling of physical collocation; production of psychological connection, both physical and emotional, that produces a mental model of the other interactant; and evaluation of the technology as appropriate for producing that connection. In this research study we will use a definition of "Social Copresence" that includes all of these elements, but in a somewhat different arrangement, and with a focus on socio-emotional outcomes appropriate to social interaction with a mobile device. The three psychological and social elements of Social Copresence are described in detail in Section 4.3 and their individual measurement items are presented in Appendix A.

3. Hypotheses and research question

The cited studies generally (although not uniformly) predict that higher realism avatars should be associated with perceptions of greater copresence and satisfaction with a communication, with some exceptions like the "uncanny valley" that is produced when there are discrepancies between an avatar's visual and behavioral realism.

In this research we investigate the impact of different types of avatar realism on the three dimensions of Social Copresence: Psychological Copresence, Social Richness of the Medium, and Interactant Satisfaction with Communication. The investigation is done in the context of a small-screen portable communication device being used within an interaction that is focused on social connection, rather than on accomplishing a concrete task. The findings in the above discussed literature provide the theoretical bases for our hypotheses. These formal hypotheses are shown graphically in the diagram shown in Fig. 4, where the paths are labeled with the corresponding hypothesis numbers listed above.

H1. People will report greater Social Copresence (H1.1: Psychological Copresence; H1.2: Social Richness of Medium; and H1.3: Interactant Satisfaction with Communication) when their interaction partners are represented by higher behavioral realism avatars.

Existing studies demonstrate that nonverbal cues are a key factor for affective communication as they deliver emotional signals that allow communicators to present their emotional intention. Garau and colleagues (2003) point out that avatars incorporate a high level of behavioral realism in order to augment the users' perception of copresence with their interaction partners. Other studies (Bailenson et al., 2001, 2006; Garau, 2003; Nowak & Biocca, 2003) note that the communicators' perceived level of social presence decreases when they experience a large discrepancy between the visual realism and behavioral realism of an avatar.

H2. People will report greater Social Copresence (H2.1: Psychological Copresence; H2.2: Social Richness of Medium; and H2.3: Interactant Satisfaction with Communication) when their interaction partners are represented by higher fidelity avatars.

H3. People will report greater Social Copresence (H3.1: Psychological Copresence; H3.2: Social Richness of Medium; and H3.3: Interactant Satisfaction with Communication) when their interaction partners are represented by more anthropomorphic avatars.

These hypotheses result from the reasoning that a human's face would be able to better present emotional signals using sophisticated facial expressions compared to an animated character's face. Even among animated characters, those able to demonstrate higher fidelity or anthropomorphism are able to show more sophisticated facial expressions.

H4. People will report greater Social Copresence (H4.1: Psychological Copresence; H4.2: Social Richness of Medium; and H4.3: Interactant Satisfaction with Communication) when their interaction partners are represented by non-anonymous avatars.

Another way that avatars may differ is in their ability to preserve the identity of the communicator. A non-anonymous avatar has a photographic representation of the communicator, whereas a more anonymous avatar might be a video or photo with degraded features in order to mask the communicator's identity. An example of a highly anonymous avatar, on the other hand, would be a cartoon caricature that does not resemble the communicator. Although anonymous avatars are less likely to carry meaningful nonverbal information that can be traced back to the communicator, non-anonymous avatars convey more nonverbal cues to the conversational partner as a result of the more accurate visual representation of the communicator.

H5. Interactants' Social Copresence (H5.1: Psychological Copresence; H5.2: Social Richness of Medium; and H5.3: Interactant Satisfaction with Communication) will be greater when their interaction partners are represented by avatars compared to a communication in which there are no avatars.

The literature reviewed in Section 2 is based on the idea that visual cues of any sort produce more effective communication. This comparative hypothesis tests that proposition.

Since the research involves use of a proposed rather than actual communication technology with which participants might have had prior experience, there is an interesting research question concerning the impact of the first use of the new technology during the experiment on users' perceptions of the technology's suitability for social interaction. This possibility is investigated in the Research Question below. The answers to this question may have some implication for the adoption of the actual video telephone technology, as perceptions preceding actual use are likely to drive adoption.

RQ1. Do people report different levels of Social Richness of Medium after actual use of a simulated video telephone which displays the images of their interaction partners compared to their perceptions before use?

Experience with the simulation may affect perceptions of the potential usefulness of an actual device, but in absence of prior research with such a simulation there is no clear reason to predict either higher or lower ratings, so this proposition is stated as a non-directional research question to be answered with data analysis.

4. Method

The basic study design is a 2 (behavioral realism) × 5 (visual realism) × 3 (gender dyad) between-subjects factorial experiment. As gender pairings can affect social interaction, equal numbers of M–M, F–F, and M–F dyads were used in each experimental group, and the type of gender dyad was added as a possible additional control factor in the analysis to remove the potential confounding effects of gender pairings. In addition, the study included an additional no-avatar "audio-only" comparison condition.

In the conditions of low behavioral realism, interactants looked at a static visual avatar displayed on a laptop screen presenting a simulated mobile telephone (see Fig. 2). The simulated telephone had a realistic small screen size (~3.0″) and low visual resolution (240 × 320 pixels). In the conditions of high behavioral realism, the interactants looked at video or dynamic animations of avatars on the identical simulated screen. High visual realism conditions used actual pictures (screen-capture) or video of the experimental subjects. The laptop was put at a normal arms-length distance from the interactants, simulating the visual angle of a display on an actual mobile video telephone.

The experiment used the three self-report measurements of Social Copresence, as described in detail in Section 4.3, as dependent variables. Scale items from the studies cited there were selected and the resulting scales tested for reliability. The items and scale reliabilities are shown in Appendix A.

4.1. Experimental participants and procedure

One hundred 98 college students (M = 19.76, SD = 1.411; 50% women, 50% men) at a northeastern U.S. university were recruited from different undergraduate courses to participate in the experiment (see Table 1 for N's in each experimental condition). Some earned extra course credits as a reward for participation. All participants were entered into a drawing for ten $20 gift certificates as further motivation for participation. Participants were paired to form gender dyads and the dyads were randomly assigned to an experimental condition. Participants were unlikely to know each other beforehand (only eight of the 198 reported that they thought they knew the other person in their dyad).

Participants were scheduled to arrive for the experiment at different times and were placed in physically separated rooms so that they did not meet each other before the beginning of the experiment. Participants completed an informed consent form and a pre-test questionnaire with demographic and mobile telephone use questions. This questionnaire included the scales of Pre-Use Social Richness of Medium used to test RQ1. The items are listed in Appendix A.

The experimental interaction took place in two isolated rooms. Participants were asked to imagine themselves in a hypothetical communication situation (see Appendix B for the scenario) which was designed to stimulate interactants' self-disclosure and emotional discovery. Participants were instructed to play the role of a student (not hard, since all were actually students) who wanted to discover whether his/her interaction partner would be an appropriate match with whom to share a four-room apartment and possibly shape a future friendly relationship. Anonymity in this type of self-revealing communication with a stranger may be critical, especially if the interactants realize that they do not like each other, but might have to have future face-to-face interactions.

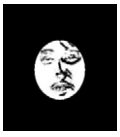
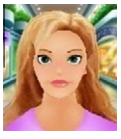
4.2. Apparatus and avatar design

Participants were given a laptop computer on which the mock-up of a mobile telephone screen and avatars were displayed and operated. A hands-free, mobile telephone head-set was connected to the laptop to provide the audio channel. The video and audio were combined within a custom software application that implemented the real-time video processing for each experimental condition, and conveyed the video telephone signal over a high bandwidth Local Area Network connecting the two isolated rooms in which the interactants were placed (see Fig. 2).

The interaction typically lasted about 10 min. When the participants completed the conversation, they were asked to fill out a post-test questionnaire with the Social Copresence scale items.

Fig. 2. Mock-up of a mobile telephone and its control panel used in experimental conditions. The control panel on the right was used to set up the experimental condition and was not seen by interactants during the experiment.

Table 1
Experimental conditions with examples of avatars.

	High visual realism, non-anonymous avatar	High visual realism anonymous avatars		Low visual realism anonymous avatars		No visual avatar
						(Audio Only)
High behavioral realism (video or animation)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)
Low behavioral realism (photo or drawing)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	$N = 18$ (3 gender dyads × 3 replication)	

Avatars included an unmodified video image (high fidelity and high anthropomorphism) and video processing and real-time graphical animation were used to create avatar variations with different levels of visual realism. Sample avatars are shown in Table 1.

4.2.1. Processed videos

Zhao and Stasko (1998) evaluated the ability of four kinds of video-filtering techniques to accomplish interactants' identity masking, and found that an edge-detected figure provided lower facial recognition than the fuzzy block pixelized technique frequently applied for identity hiding (Boyle et al., 2000). This was verified in pretest study that asked 17 people to identify the person shown in the edge detected photograph shown in Fig. 3 from an array of 16 unmodified photos.[1] Only 3 succeeded, a result that was not significantly different from chance.

Based on these results, real-time edge detection was used in this study. A second type of modified video added an outer-facial-masking effect to construct a higher anonymity avatar. It was based on the conclusions of Jarudi and Sinha (Jarudi & Sinha, 2005). They discovered that central facial cues were less critical than external cues—hair shape, foreshadow, chin, and so forth—in identifying a person at low visual resolution. This higher anonymity avatar was created by masking the peripheral features of the edge-detector filtered image.

4.2.2. Animated graphics

To construct lower fidelity graphical avatars that were both anthropomorphic and nonanthropomorphic, a commercial webcam (Logitech QuickCam Orbit MP) equipped with Logitech Video Effects software using Neven Vision tracking and real time avatar animation technology was used. This system tracked 22 facial points on the interactant and produced dynamic facial expressions on avatars that partially mimicked the human interactant's facial expressions.

[1] These 16 photo images were collected randomly via Google Images (http://images.google.com/).

Fig. 3. ID grid for pilot test of recognition of an edge detected image. Correct identification is indicated by the arrow.

4.3. Measurements

The individual measurement items are presented in Appendix A.

4.3.1. Psychological copresence

This construct borrows freely from the conceptualizations of Nowak (2001) and Nowak and Biocca (2003), who based their conceptualization and measures partially on the work of McCroskey and McCain (1974), Goffman (1963), and Horwitz (1958). Nowak and Biocca (2003) described copresence as "the sense of connection with another mind" and "connection with another human," which leads to the measurement of the degree to which "interactants feel they were able to perceive their interaction partner and that their interaction partner actively perceived them." The operational expression of this construct measures both an individual's perception of their interaction partner's involvement in the communication and their own feelings of engagement and involvement with their interaction partner.

4.3.2. Social richness of medium

The notion of Social Richness of Medium is rooted in the original concept of social presence presented by Short et al. (1976). It assesses communicators' subjective judgments of the ability of the medium itself to produce a feeling of effective copresence, and is essentially a measure of the social and emotional capabilities of the communication medium as perceived by the user (Biocca et al., 2003). In addition, it includes user reactions to the nature of the technology's appropriateness for the particular kind of socio-emotional communication that the technology is mediating.

4.3.3. Interactant satisfaction with communication

The notion of interactant satisfaction (Kang et al., 2008b) involves subjective judgments by communicators of the outcome of the communication. It combines elements of social attraction (Nowak, 2004; Nowak & Rauh, 2005) and emotional credibility (Kang et al., 2006, 2008b). The latter element is especially important in evaluating a communication that has the primary goal of establishing social connection, rather than accomplishing a task. It is based on the evaluation dimensions of an emotional intelligence test developed by Smith (2004), which originated in the studies of Salovey, Brackett, and Mayer (2004).

5. Results

5.1. Preliminary analyses

The impact of each type of gender dyad was first analyzed in three 2-way ANOVAs (experimental condition x gender dyad type) using each of the three variables making up Social Copresence as dependent variables in separate analyses. There was no significant effect of gender dyad for Psychological Copresence, $F(1; 176) = .02$, $p > .10$, Social Richness of Medium, $F(1; 176) = .08$, $p > .10$, or Interactant Satisfaction with Communication $F(1; 176) = 1.91$, $p > .10$. As the type of gender dyad did not covary significantly with any of the three dependent variables, all gender dyads in the

experimental conditions were pooled and gender dyad type was not introduced as a variable in subsequent analyses.

Hypotheses 1–4 were tested using a path analysis, also called an observed variable (OV) structural equation model (Holbert & Stephenson, 2002). Each hypothesis is represented by a separate path whose significance is tested with a *t*-test (see Fig. 4, where the paths are labeled with the hypothesis numbers introduced in the Hypotheses section). The coefficient for each path is comparable to a regression coefficient and tested against a null effect by associated *t*-test. Testing the hypotheses simultaneously in a path model isolates the effect of the single independent variable in each hypothesis from the indirect effects of all other independent variables, and thus prevents spurious significances that might result if the hypotheses were tested by multiple independent tests that do not offer this control.

Path analysis using summed indices as observed variables bypasses the benefits of constructing and testing a measurement model for each latent construct, and makes rather strong assumptions that the construct is internally consistent (exhibits convergent validity) and is distinct from other variables (exhibits discriminant validity). These assumptions should be verified for each construct, and if they hold, justify use of the OV model rather than a full structural equation model (SEM) in which questionnaire items are treated as separate observed variables.

There are additional benefits to using the OV approach in an analysis involving a relatively small number of observations and a high number of observed items. In this case, a full SEM model combining measurement and path models is susceptible to errors of inference equivalent to Type II error, that is, concluding that the model structure is inconsistent with the data as a result of a very large number of degrees of freedom for the many measurement items in the full model, coupled with large errors of estimation of the individual path coefficients due to small N's (Bagozzi & Heatherington, 1994). With $N = 198$ and 40 observed items, this is a serious concern in this experiment and suggests use of the OV model if the validity assumptions can confidently be made.

A formal analysis of the validity of the summed indices was conducted and the results supported use of the OV model with this data. Details of this methodological procedure can be obtained by contacting the authors.

5.2. Hypothesis tests

Given the results of these validity tests, the use of the computed indices for the path analysis in an OV model is deemed justified. Descriptive statistics for these 8-point scale indices of Social Copresence in each experimental group are shown in Appendix C.

As the three constructed variables making up Social Copresence are correlated, the use of three separate multiple regressions or simple analysis of variance (ANOVA) to test the hypotheses is undesirable, as correlated dependent variables may exhibit spurious indirect covariance via paths among the dependent variables. Multivariate analysis of variance (MANOVA) could appropriately be used in the hypothesis tests, but an OV path analysis gives a clearer view of the results of the tests by its partitioning of covariance into discrete paths.

5.2.1. Hypotheses 1–3

The first three hypotheses are shown in the path diagram in Fig. 4 as the causal arrows linking the avatar characteristics to the three correlated Social Copresence dependent variables. The independent variables are assumed to be correlated as well, as the research design was not a full factorial design incorporating crossing of all levels of the independent variables, with equal cell N's, both of which conditions would be required to produce uncorrelated independent variables (Cohen, Cohen, West, & Aiken, 2003).

Hypotheses 1–3 were tested in two ways. In the first analysis, the levels of fidelity and anthropomorphism were arbitrarily magnitude scaled as shown in Table 2. The assumption of equal interval scale points for the experimental manipulations is a bit strong, but is probably not more extreme than the common assumption that Likert scale points with floating verbal anchors like "some" and "more" are interval scales, an assumption that is commonly made in correlational analyses of scales. But to check this assumption, a second parallel analysis was conducted in which each of the experimental conditions were dummy coded as nominal variables. This eliminates the equal-interval scale assumption of the first analysis and is the equivalent of ANOVA assumptions for nominal independent variables.

Initially all paths in Fig. 4 were included. This is essentially a regression with correlated dependent variables and is an exactly identified model that cannot be tested for goodness of fit (no degrees of freedom for the structural test), although individual coefficients can be tested against the null. The *t*-test for significance of each path is a test of each individual hypothesis. The paths reaching a $p < .05$ significance level are shown in Fig. 5.

The significant paths provide partial support for Hypotheses 1–3, with H1.2, H2.2, H3.1, and H3.3 supported. It is interesting to note that two of the avatar components, Kinetic Conformity and Fidelity, affect only the perceived appropriateness of the medium for social interaction (Social Richness of Medium), while the other (Anthropomorphism) affects only the participants' feelings of Psychological Copresence and Interactant Satisfaction with Communication.

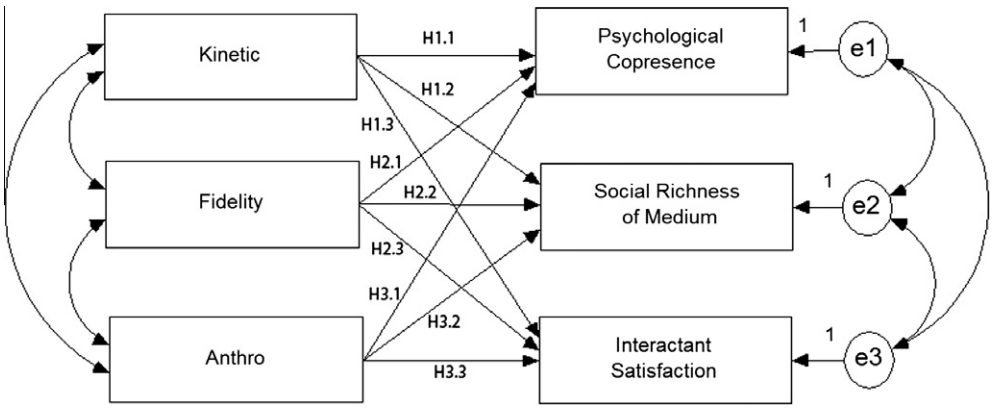


Fig. 4. Symbolic structural diagram of hypotheses, including correlated independent and dependent variables.

Table 2
Levels assigned to avatar characteristics.

Experimental condition	Fidelity	Anthro-pomorphism	Anonymity	Kinetic conformity
Unmodified video-full motion	5	1	0	1
Edge-detector processed video- full motion	4	1	1	1
Outer-masked processed video-full motion	3	1	2	1
High anthropomorphism graphic-full motion	2	1	3	1
Low anthropomorphism graphic-full motion	1	0	4	1
No avatar (audio only)	0	0	5	0
Unmodified video-static	5	1	0	0
Edge-detector processed video-static	4	1	1	0
Outer-masked processed video-static	3	1	2	0
High anthropomorphism graphic-static	2	1	3	0
Low anthropomorphism graphic-static	1	0	4	0

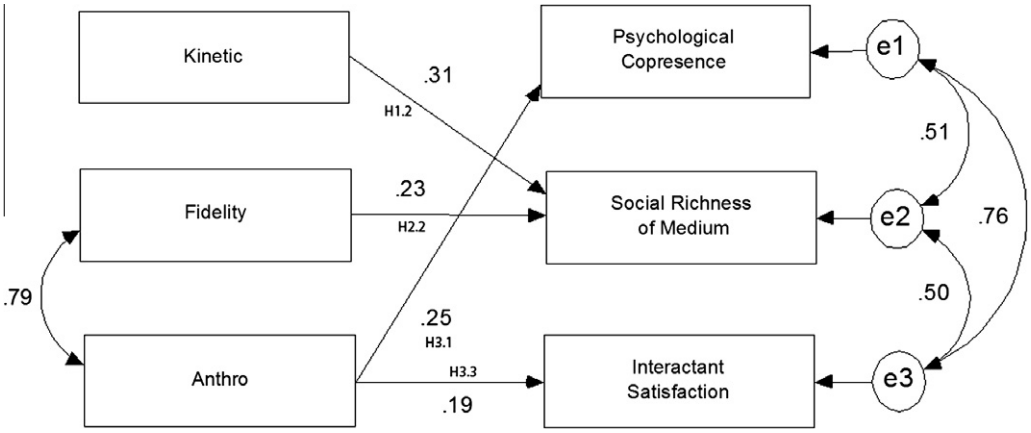


Fig. 5. Significant standardized path coefficients for avatar characteristics' effects on Social Copresence variables. All coefficients are significant at $p < .05$.

Nonsignificant ($p > .05$) paths corresponding to unsupported hypotheses from this first analysis were then deleted in a revised analysis. As expected, the dependent variables are correlated significantly, as are the Fidelity and Anthropomorphism independent variables.

Overall, this simplified model is a very good fit for the data, Chi-sq = 6.6 (7 d.f.), $p > .40$, with RMSEA less than .1 percent and GFI = .99.

The parallel analysis using nominal dummy coded independent variables to test Hypotheses 1–3 is shown in Fig. 6, and leads to equivalent results. The no-avatars (audio-only) experimental group was coded as the dummy variable reference group in this analysis, so tests of significance represent contrasts of other experimental conditions with this group, and the values of the path coefficients represent standardized differences between the means

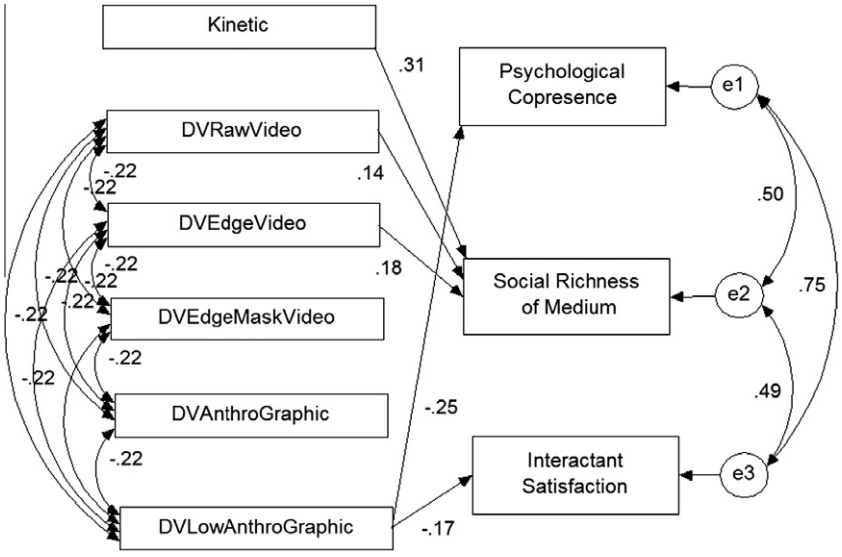


Fig. 6. Significant relationships between experimental conditions coded as dummy variables (DV prefix) and Social Copresence variables. All standardized coefficients significant at $p < .05$.

of other experimental groups and this audio-only reference group (Cohen et al., 2003).

Kinetic conformity (static vs. dynamic avatars) remains significantly associated only with increases in Social Richness of Medium over the audio-only group, as do the experimental conditions with the two with highest fidelity and anthropomorphic avatars (unmodified video and edge-detected processed video). Experimental conditions associated with lower levels of fidelity are not associated with social richness assessments greater than those observed in the audio-only group. Notably, the two graphic avatar conditions which are lowest on anthropomorphism and fidelity are associated with significant *decreases* in Interactant Satisfaction with Communication and Psychological Copresence, as compared to the audio-only group. These results are consistent with the partial support of Hypotheses 1–3 found in the first analysis.

5.2.2. Hypothesis 5

The analysis with nominally-coded independent variables also provides a test of Hypothesis 5. As Fig. 6 shows, the groups with dynamic avatars (Kinetic dummy variable) and higher fidelity and anthropomorphism (the unprocessed video and the edge-detected anonymized video) scored significantly higher on Social Richness of Medium as compared to the audio-only group. These results provide partial support for Hypothesis 5. Edge masked video and anthropomorphic graphic avatars did not differ significantly from voice-only results. Again, non-anthropomorphic graphic avatars scored significantly lower than the voice-only condition on Psychological Copresence and Interactant Satisfaction with Communication, in contradiction of the prediction of Hypothesis 5. The results indicate that in this experiment the impact of avatars is dependent on the characteristics of the avatar and may be positive, null, or negative, with the positive effects occurring with more "life-like" visual representations.

5.2.3. Hypothesis 4

The effect of anonymity on Social Copresence (Hypotheses 4.1–4.3) could not be tested in the first analysis, as the fixed experimental levels make the anonymity variable a linear combination of the other avatar characteristics, leaving no remaining independent covariance in the anonymity independent variable to be associated with the dependent variables (i.e., the covariance matrix is singular). To test Hypothesis 4, a separate path analysis was conducted, considering only the anonymity provided by the avatar. As with the tests of Hypotheses 1–3, two equivalent analyses were done, first assuming an equal interval scale representing magnitude levels of anonymity in the different experimental conditions, followed by a second parallel analysis treating anonymity as a nominal variable. Again, the analyses produced almost identical results, so only the results of the first are shown here.

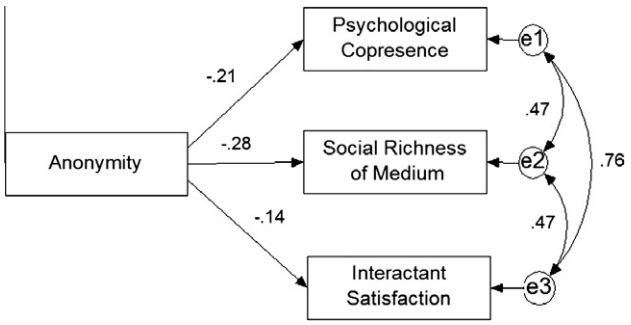


Fig. 7. Impact of magnitude scaled anonymity level on social copresence variables. All standardized coefficients significant at $p < .05$.

All paths in Fig. 7 are significant at $p < .05$, resulting in a fully-identified regression model that cannot be tested for structural goodness-of-fit. Coefficients should be interpreted as partial regression coefficients, with control for covariance among the Social Copresence dependent variables.

The models support Hypothesis 4, with increasing levels of anonymity associated significantly with lower levels of all three Social Copresence variables.

5.2.4. Research question 1

To investigate the research question, subjects were asked for their perceptions of the appropriateness of a video telephone for different social purposes (Social Richness of Medium) before they used the simulation in the experiment, and then again after the experimental manipulation. The difference between these two measurements represents the change in perception of the medium due to experience with it.

A dependent *t*-test (repeated measure) analysis revealed a very large and statistically significant increase in positive perception of the Social Richness of Medium in the two time periods, $t(197) = 10.33$, $p < .001$, Mean (before) = 3.09, Mean (after) = 4.24. As this test did not isolate the effects of different types of avatars, a more detailed repeated measures ANOVA with the experimental conditions as the independent variable was conducted. This analysis confirmed the effect of experience on the increase in positive perception of the Social Richness of Medium $F(1; 187) = 127.3$, $p < .001$, eta-squared = .45, but also revealed a significant interaction between the experimental condition and the before and after perceptions $F(1; 187) = 4.80$, $p < .001$. This interaction indicates that changes in perception of Social Richness of Medium were more dramatic with some avatars than with others. The estimated marginal means shown in Table 3 shows that perceptions increased more in conditions with higher kinetic conformity (dynamic avatars) than those with lower kinetic conformity, and decreasing fidelity and anthropomorphism of avatars was associated with lower improvements in perception of the social utility of the medium with both types of avatar.

6. Conclusions and discussion

The results generally support the idea that more realistic avatars improve Social Copresence which corresponds to existing findings that generally conclude that richer media enhance communication efficiency (Poggi & Pelachaud, 2000; Rice, 1993; Walker et al., 1994), but with some important distinctions. The Kinetic Conformity and Fidelity of the avatar improved only the perceptions of the suitability of the medium for social interaction (Social Richness of Medium), but did not produce positive effects on the other factors of Social Copresence (Psychological Copresence and Interactant Satisfaction with Communication). This does not replicate previous findings (Biocca et al., 2003) that demonstrated nonverbal signals played key roles in establishing communicators' psychological access to each other in mediated communications. In contrast, increased Anthropomorphism improved both Psychological Copresence and Interactant Satisfaction with Communication, while not affecting the perceived social usefulness of the technology.

The results of this study, provided they generalize beyond the single communication setting used in this laboratory experiment, provide a critical consideration for a designer of communication technology who must make decisions in the face of technological limitations like limited bandwidth. If the designer wishes to

Table 3
Estimated marginal mean improvement in perception of Social Richness of Medium after use of simulation.

Experimental condition	Improvement in perception of social richness of medium
DynamicRawVideo	2.31
DynamicEdge	2.21
DynamicEdge&Mask	1.56
DynamicHighHumanoid	1.10
DynamicLowHumanoid	0.90
StaticRawVideo	1.15
StaticEdge	1.58
StaticEdge&Mask	1.10
StaticHighHumanoid	0.24
StaticLowHumanoid	−0.04
VoiceOnly	0.56

present a medium that appeals to users as a means of social communication, he/she should emphasize Kinetic Conformity (realistic motion) and Fidelity (quality of image) of avatars. But if the priority is subsequent satisfaction with communication using the device, the designer should use highly Anthropomorphic avatars. Optimizing social communication appeal is essentially an initial marketing consideration, while psychological connection and satisfaction with communication may produce post-purchase long-term use.

As technical limitations like bandwidth are eased, the implication is that all three avatar realism factors should be provided to the greatest extent possible. Providing full motion, highly realistic video in a mobile communication device will result in the highest user evaluation on all three factors of Social Copresence. Person-to-person full-motion video interaction is thus an important product feature that might spur wide adoption of newer generations of mobile communication devices, while also providing long-term user satisfaction.

But this begs the question of how to preserve privacy while still obtaining the benefits of the highly realistic video avatar. To investigate this, we looked at the two experimental groups with the highest realism avatars but differing in anonymity level (the non-anonymous dynamic raw video and the anonymous dynamic edge-detected video). The results are shown in Fig. 8.

Although the positive coefficients indicate higher levels of two of the three Social Copresence variables in the non-anonymous video condition, a finding consistent with the hypothesis test results, the difference between anonymous edge-detected video and non-anonymous video is not sufficient to reach significance. Providing anonymity resulted in reduced Social Copresence when considering all levels of avatar realism, but the effect was more pronounced in the conditions using less realistic avatars than in the two most realistic conditions.

On its surface, the finding of non-significant differences between anonymized and unmodified video would seem to indicate that little is lost in modifying the video, but this result must be interpreted with great caution, as the test involved only $N = 36$ subjects. The null result may be due to low statistical power, rather than the equivalence of the two types of avatar.

Given the importance of privacy issues, coupled with the results of this experiment that indicate avatar anonymity in general reduces communication effectiveness, the impact of anonymity on effective mediated communication needs to be investigated in a more powerful research design.

One surprising finding was the negative effects on some aspects of Social Copresence that was produced by lower realism graphic avatars. These avatars produced scores on Psychological Copresence and Interactant Satisfaction with Communication that were lower than those observed with an audio-only telephone. This finding suggests the possibility of some potential deleterious effects on communication effectiveness with use of lower realism avatars. The reason for this negative outcome is not clear, although it might be related to the incongruity of the less realistic avatar coupled with the voice of a real human, violating interactant expectations in a kind of an "uncanny valley" effect. Confirmation of this negative outcome and explanation of its mechanism are important research agenda items.

This research, like most controlled laboratory studies, trades external validity (generalizability) for internal validity (controlled conditions that allow isolation of individual causal factors). The general results do not contradict prior research findings, but instead add additional detail and caveats to current knowledge. This consistency with earlier research that used different tasks, user groups and research methods is reassuring. But the data reported here are from a single non-random sample of homogenous users not representative of the general population and whose use of the technology was for a prescribed single communication task. Nor was the technology presented in a finished product, but rather in a prototype form. The results and conclusions of this study must thus be qualified in light of these limitations.

Using the simulated video telephone devices in this experiment resulted in improved users' perceptions of the technology as appropriate for social purposes. Further, higher realism avatars produced the largest improvement in this evaluation. From a technology adoption standpoint, this result suggests the potential value of product promotional methods that encourage trial usage of mobile devices that provide video. Our results imply that the utility of the visual medium for social purposes becomes clearer with their use.

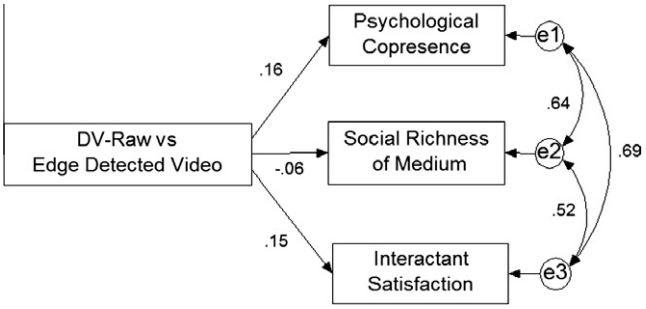


Fig. 8. Comparison of unmodified video with edge-detected anonymized video as the reference group. All causal coefficients not significantly different from zero, $p > .05$.

Appendix A. Social copresence index items

All items were presented using a Likert-type scale with an 8-point metric for each item, with only end points anchored by the appropriate verbal pair:

1 = Very Little; 8 = Very Much,
1 = Very Unlikely; 8 = Very Likely,
1 = Strongly Disagree; 8 = Strongly Agree.

Final variables were constructed by summation of the item scales, with reverse coded scale values transposed from negative to equivalent positive scale points.

Psychological copresence (Cronbach's alpha = .93)

S/he was intensely involved in our interaction.
S/he seemed to find our interaction stimulating.
S/he communicated coldness rather than warmth. (reverse coded)
S/he created a sense of distance between us. (reverse coded)
S/he seemed detached during our interaction. (reverse coded)
S/he was willing to share personal information with me.
S/he made our conversation seem intimate.
S/he created a sense of closeness between us.
S/he acted bored by our conversation. (reverse coded)
S/he was interested in talking to me.
S/he showed enthusiasm while talking to me
I did not want a deeper relationship with him/her. (reverse coded)
I wanted to maintain a sense of distance between us. (reverse coded)
I was unwilling to share personal information with him/her. (reverse coded)
I wanted to make the conversation more intimate.
I tried to create a sense of closeness between us.
I was interested in talking to him/her.

Social richness of medium (before device use) (Cronbach's alpha = .63)

To what extent do you feel like you are having a face-to-face meeting when you communicate via a mobile phone?
To what extent do you feel you are in the same room with your conversation partner when you communicate via a mobile phone?
How likely is it that you would choose to use a mobile phone for a conversation in which you wanted to persuade the other person of something?
To what extent do you feel you can get to know someone that you meet only through a mobile phone?

Social richness of medium (after device use) (Cronbach's alpha = .86)

To what extent did you feel able to assess your partner's reactions to what you said?
To what extent was this like a face-to-face meeting?
To what extent was this like you were in the same room with your partner?
How likely is it that you would choose to use a mobile telephone interaction for a meeting in which you wanted to persuade other person of something?
To what extent did you feel you could get to know someone that you met only through a mobile telephone?

Interactant Satisfaction with Communication (Cronbach's alpha = .90)

I think s/he could be a friend of mine.
I would like to have a friendly chat with him/her.
We could never establish a personal friendship with each other. (reverse coded)
S/he just wouldn't fit into my circle of friends. (reverse coded)
S/he would be pleasant to be with.
I don't care if I ever get to interact with him/her again. (reverse coded)
S/he recognizes my feelings and emotions.
S/he expresses feelings and emotions appropriately for the situation.
S/he uses feelings and emotions to create or organize thinking.
S/he uses feelings and emotions to make a decision or judgment.
S/he uses feelings and emotions to facilitate problem solving and creativity.
S/he responds appropriately to positive and negative emotions.
S/he understands complex feelings.
S/he knows how to control his/her own feelings and emotions effectively.
S/he handles others feelings and emotions sensitively and effectively.

Appendix B. Instructions to experimental subjects

Thank you for participating in this experiment.

The intent of the experiment is to simulate a situation where you want to get to know a person a bit better and are going to do it via telephone. To do this you will make a call, or be called by the other person, on a mock-up of a cell telephone screen on a laptop.

Here's the situation:

Suppose you are transferring to another distant university (for personal reasons not defined in this scenario). This university is located in an urban area in which off-campus housing is very difficult to obtain. Many students live in co-ed housing that is listed with the university. You applied for housing with the university housing office but failed to get it and had to find any off-campus housing. Fortunately, you could find one decent apartment which has been advertised through the mobile telephone service BOND*. This apartment has four bedrooms, with a shared living and kitchen space. You must make a decision about whether or not you will move in the apartment in about a week before the next semester starts. Your budget does not allow you to travel to the city until the beginning of the semester, so you have to make this decision without being able to meet the advertised apartment mates in person. The advertisement shows the telephone numbers of the people to be contacted, thus you've decided to make a call to one of them. Both your telephone and your conversation partner's telephone are equipped with cameras. Therefore, you and the other person can share each other's face. However, you may not want to expose your face to your conversation partner until you decide whether s/he is a decent person and a possible friend.

You're now going to talk to another person who is also applying for the apartment and deciding whether or not s/he wants to share it with you. You want to find out if you think the other person is a compatible apartment mate in a 10 min telephone conversation.

Please use only your FIRST name if necessary and remember that you're trying to remain anonymous in case you don't like your potential apartment-mate.

Appendix C. Descriptive statistics for social copresence variables in experimental conditions

Avatar type	Statistic	Interactant satisfaction with communication	Social richness of medium	Psychological copresence
Dynamic	Mean	5.86	5.38	5.99

(*continued on next page*)

Appendix C (*continued*)

Avatar type	Statistic	Interactant satisfaction with communication	Social richness of medium	Psychological copresence
UnprocessedVideo	N	18	18	18
	Std. Deviation	1.01	1.43	1.04
DynamicEdge	Mean	5.60	5.52	5.71
	N	18	18	18
	Std. Deviation	0.73	1.25	0.74
DynamicEdge&Mask	Mean	5.65	4.91	5.81
	N	18	18	18
	Std. Deviation	0.67	1.18	0.82
DynamicHighAnthro	Mean	5.29	4.43	5.19
	N	18	18	18
	Std. Deviation	0.75	1.00	1.23
DynamicLowAnthro	Mean	5.20	4.64	5.21
	N	18	18	18
	Std. Deviation	0.80	1.51	1.00
StaticUnprocessedVideo	Mean	5.34	4.31	5.51
	N	18	18	18
	Std. Deviation	1.15	1.18	1.14
StaticEdge	Mean	5.61	4.53	5.98
	N	18	18	18
	Std. Deviation	0.95	1.26	0.84
StaticEdge&Mask	Mean	5.40	4.16	5.52
	N	18	18	18
	Std. Deviation	1.06	1.61	1.00
StaticHighAnthro	Mean	5.80	3.73	5.90
	N	18	18	18
	Std. Deviation	0.71	0.98	0.84
StaticLowHumanoid	Mean	4.94	3.49	4.63
	N	18	18	18
	Std. Deviation	0.79	1.09	1.00
VoiceOnly	Mean	5.47	3.83	5.58
	N	18	18	18
	Std. Deviation	0.94	1.67	1.09
Total	Mean	5.47	4.45	5.55
	N	198	198	198

References

Argyle, M. (1972). Non-verbal communication in human social interaction. In R. A. Hinde (Ed.), *Non-verbal communication*. Cambridge: Cambridge University Press.

Bagozzi, R. P., & Heatherington, T. F. (1994). A general approach to representing mulitfacted personality constructs: Application to self-esteem. *Structural Equation Modeling, 1*(1), 35–67. http://dx.doi.org/10.1080/10705519409539961.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. (2001). Equilibrium revisited: Mutual gaze and personal space in virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 10*(6), 583–598. http://dx.doi.org/10.1162/105474601753272844.

Bailenson, J. N., Yee, N., Merget, D., & Schroeder, R. (2006). The effect of behavioral realism and form realism of real-time avatar faces on verbal disclosure, nonverbal disclosure, emotion recognition, and copresence in dyadic interaction. *PRESENCE: Teleoperators and Virtual Environments, 15*(4), 359–372. http://dx.doi.org/10.1162/pres.15.4.359.

Bengtsson, B., Burgoon, J. K., Cederberg, C., Bonito, J., & Lundeberg, M. (1999). The impact of anthropomorphic interfaces on influence, understanding, and credibility. In *Proceedings of the 32nd Hawaii international conference on system sciences* (pp. 1–15).

Bickmore, T., & Picard, R. (2003). Subtle expressivity by relational agents. In *Proceedings of CHI'03 workshop on subtle expressivity for characters and robots*. Retrieved <http://affect.media.mit.edu/pdfs/03.bickmore-picard.pdf>.

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *PRESENCE: Teleoperators and Virtual Environments, 12*(5), 456–480. http://dx.doi.org/10.1162/105474603322761270.

Biocca, F., & Harms, C. (2002). What is social presence? In F. Gouveia & F. Biocca (Eds.), *Proceedings of presence 2002*. Porto, Portugal: Pessoa Press.

Blascovich, J. (2002). Social influence within immersive virtual environments. In R. Schroeder (Ed.), *The social life of avatars: presence and interaction in shared virtual environments*. London: Springer-Verlag.

Boyd, D. (2010). Social network sites as networked publics: Affordances, dynamics, and implications. In Z. Papacharissi (Ed.), *Networked self: identity, community, and culture on social network sites* (pp. 39–58). New York, NY: Routledge.

Boyle, M., Edwards, C., & Greenberg, S. (2000). The effects of filtered video on awareness and privacy. In Proceedings of conference on computer supported cooperative work (CSCW '00) (pp. 1–10).

Burgoon, J., Buller, D., & Woodall, W. (1996). *Nonverbal communication: The unspoken dialogue*. New York: McGraw-Hill.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Cumiskey, K. (2007). Mobile fantasies on film: Fostering "co-presence" through the integrated use of real and imagined mobile technology. *PsychNology Journal, 5*(1), 83–99.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirement, media richness and structural design. *Management Science, 32*(5), 554–571. http://dx.doi.org/10.1287/mnsc.32.5.554.

Dennis, A., & Kinney, S. (1998). Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality. *Information Systems Research, 9*(3), 256–274. http://dx.doi.org/10.1287/isre.9.3.25.

Eagle, N., & Pentland, A. (2005). Social serendipity: Mobilizing social software. *IEEE Pervasive Computing, 4*(2), 28–34. http://dx.doi.org/10.1109/MPRV.2005.37.

Ehrlich, S. M., Schiano, D., & Sheridan, K. (2000). Communicating facial affect: It's not the realism, it's the motion. *Proceedings of the ACM conference on human factors in computing systems, 2000*, 252–253.

Ekman, P., & Friesen, W. (1969). The repertoire of nonverbal behavior: Categories, origins, and coding. *Semiotica, 1*, 49–98.

Garau, M. (2003). *The impact of avatar fidelity on social interaction in virtual environments*. PhD, University College (PhD Dissertation), London.

Garau, M., Slater, M., Vinayagamoorthy, V., Brogny, A., Steed, A., & Sasse, M. A. (2003). The impact of avatar realism and eye gaze control on perceived quality of communication in a shared immersive virtual environment. In *Proceedings of the SIGCHI conference on human factors in, computing systems* (pp. 529–536).

Goffman, E. (1963). *Behavior in public places*. New York: The Free Press.

Hamilton, M. A., & Nowak, K. L. (2010). Advancing a model of avatar evaluation and selection. *PsychNology Journal, 8*(1), 33–65.

Holbert, R. L., & Stephenson, M. T. (2002). Structural equation modeling in the communication sciences, 1995–2000. *Human Communication Research, 28*(4), 531–551. http://dx.doi.org/10.1093/hcr/28.4.531.

Horwitz, M. (1958). The veridicality of liking and disliking. In R. Tagiuri & L. Petrullo (Eds.), *Person perception and interpersonal behavior* (pp. 191–209). Stanford, CA: Stanford University Press.

Humphreys, L. (2007). Mobile social networks and social practice. A case study of Dodgeball. *Journal of Computer Mediated Communication, 13*(1), 341–360.

Izard, C. E. (1997). Emotions and facial expressions: A perspective from differential emotions theory. In J. A. Russell & J. M. Fernandez-Dols (Eds.), *The psychology of facial expression* (pp. 57–77). Cambridge, U.K.: Cambridge University Press.

Jarudi, I., & Sinha, P. (2005). Relative contributions of internal and external features to face recognition. Retrieved <http://web.mit.edu/bcs/sinha/papers/jarudi_sinha_2005.pdf>.

Kang, S., Watt, J. H., & Ala, S. (2008b). Social copresence in anonymous social interactions using a mobile video telephone. In *CHI '08 Proceedings of the twenty-sixth annual SIGCHI conference on human factors in computing systems* (pp. 1535–1544). doi: 10.1145/1357054.1357295.

Kang, S., Watt, J. H., & Isbister, K. (2006). The effect of static anthropomorphic images on emotion perception in mobile phone communication. In *Proceedings of 9th international workshop on presence*.

Kang, S., Watt, J. H., & Ala, S. (2008a). Communicators' perceptions of social presence as a function of avatar realism in small display mobile communication device. In *Proceedings of Hawaii International Conference on System Sciences* (pp. 147–156).

Knapp, M., & Hall, J. (2007). *Nonverbal communication in human interaction*. Boston: Wadsworth.

Koda, T., & Maes, P. (1996). Agents with faces: The effects of personification. *Paper presented at the human-computer interaction* '96, London.

Lee, K. M. (2004). Presence, explicated. *Communication Theory, 14*(1), 27–50. http://dx.doi.org/10.1111/j.1468-2885.2004.tb00302.x.

Ling, R. (2004). *The mobile connection: The cell telephone's impact on society*. San Francisco, CA: Morgan Kaufmann.

Littlejohn, S. (2002). *Theories of human communication* (7th ed.). Belmont, CA: Wadsworth.

McCroskey, J., & McCain, T. (1974). The measurement of interpersonal attraction. *Speech Monographs, 41*, 261–266. http://dx.doi.org/10.1080/03637757409375845.

McGloin, R., Nowak, K. L., Stiffano, S. C., & Flynn, G. M. (2010). *The effect of avatar perception on attributions of source and text credibility*. Working paper, university of connecticut department of communication sciences.

Mosmondor, M., Kosutic, T., & Pandzic, I. (2005). LiveMail: Personalized avatars for mobile entertainment. In *Proceedings of 3rd international conference on mobile systems, applications, and services* (pp. 15–23). doi: 10.1145/1067170.1067173.

Nowak, K. L. (2004). The influence of anthropomorphism and agency on social judgment in virtual environments. *Journal of Computer Mediated Communication, 9*(2). http://dx.doi.org/10.1111/j.1083-6101.2004.tb00284.x.

Nowak, K. L. (2001). Defining and differentiating copresence, social presence and presence as transportation. In *Proceedings of the presence 2001 conference*.

Nowak, K. L., & Rauh, C. (2005). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication, 11*(1). Retrieved <http://jcmc.indiana.edu/vol11/issue1/nowak.html>.

Nowak, K. L., & Biocca, F. (2003). The effect of the agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 12*(5), 481–494. http://dx.doi.org/10.1162/105474603322761289.

Nowak, K. L., & Rauh, C. (2006). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication, 11*, 153–178. http://dx.doi.org/10.1111/j.1083-6101.2006.tb00308.x.

Poggi, I., & Pelachaud, C. (2000). Performative facial expressions in animated faces. In J. Cassell, J. Sullivan, S. Prevost, & E. Churchill (Eds.), *Embodied conversational agents*. Cambridge, MA: The MIT Press.

Rice, R. E. (1993). Media appropriateness: Using social presence theory to compare traditional and new organizational media. *Human Communication Research, 19*(4), 451–484. http://dx.doi.org/10.1111/j.1468-2958.1993.tb00309.x.

Salovey, P., Brackett, M., & Mayer, J. (2004). *Emotional intelligence: Key readings on the mayer and salovey model*. Port Chester, NY: Dude Publishing.

Seyama, J. I., & Nagayama, R. S. (2007). The uncanny valley: Effect of realism on the impression of artificial human faces. *PRESENCE: Teleoperators and Virtual Environments, 16*(4), 337–351. http://dx.doi.org/10.1162/pres.16.4.337.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunication*. London: John Wiley & Sons.

Smith, J. (2004). Emotional Intelligence Report: EIQ16 Questionnaire. Retrieved <http://www.myskillsprofile.com/eiq16_sample_report.pdf>.

Smith, I. E. (2005). Social mobile applications. *Computer, 38*(4), 84–85. http://dx.doi.org/10.1109/MC.2005.140.

Sproull, L., Subramani, M., Kiesler, S., Walker, J. H., & Waters, K. (1996). When the interface is a face. *Human-Computer Interaction, 11*, 97–124. http://dx.doi.org/10.1207/s15327051hci1102_1.

Swinth, K., & Blascovich., J. (2002). Perceiving and responding to others: Human and human-computer social interaction in collaborative virtual environments. In *Proceedings of fifth annual international workshop: presence 2002* (pp. 310–340).

Tomita, H. (2006). Geitai and the intimate stranger. In M. Ito, D. Okabe, & M. Matsuda (Eds.), *Personal, portable, pedestrian: Mobile phones in japanese life* (pp. 183–204). Cambridge, MA: MIT Press.

Walker, J. H., Sproull, L., & Subramani, R. (1994). Using a human face in an interface. In *Proceedings of CHI'94 human factors in computing systems* (pp. 85–91). Retrieved <http://smg.media.mit.edu/library/UsingHumanFaceInterface.pdf>.

Zhao, Q., & Stasko, J. (1998). Evaluating image filtering based techniques in media space applications. In Proceedings of the 1998 ACM conference on computer supported cooperative work (pp. 11–18).