Investigating the Relationship between Presence and Learning in a Serious Game

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Abstract. We investigate the role of presence in a serious game for intercultural communication and negotiation skills by comparing two interfaces: a 3D version with animated virtual humans and sound against a 2D version using text-only interactions with static images and no sound. Both versions provide identical communicative action choices and are driven by the same underlying simulation engine. In a study, the 3D interface led to a significantly greater self-reported sense of presence, but produced significant, but equivalent learning on immediate posttests for declarative and conceptual knowledge related to intercultural communication. Log data reveals that 3D learners needed fewer interactions with the system than those in the 2D environment, suggesting they benefited equally with less practice and may have treated the experience as more authentic.

Keywords: presence, serious games, intercultural competence, virtual humans.

1 Introduction

After the release of *Avatar*, more than 1000 posts appeared on a website from fans who wanted to share ideas for how to "cope with the depression of the dream of Pandora being intangible" [1]. The use of high-fidelity 3D animation and sound apparently left some viewers in a state of deep sadness upon realization that Pandora, the fictional world depicted in the film, was not their reality. Interestingly, some of the more common suggestions on the forum for coping included playing the Avatar video game and exploring recreations of Pandora in virtual worlds.

Examples like this have driven researchers to dig deeper into the psychology of immersive experiences and how they relate to entertainment, learning, and addiction.[1] Whether reading a book, watching a movie, or playing a game, people seem capable of changing their frame of reference such that narrative or virtual experiences are temporarily experienced as reality [2]. This phenomenon has generated enthusiasm from many education theorists (e.g., [3]) and researchers (e.g., [4]) who perceive it to have potential to enhance learner engagement, motivation to learn, and time-on-task. In this paper, we consider the question of whether sense of presence matters in a serious game for learning intercultural communication skills and how it affects learner behaviors within that game.

[1] http://mediagrid.org/groups/technology/PIE.TWG/

2 Games, motivation, presence, and learning

There is a growing body of evidence that educational games, when built on sound pedagogical design principles, are effective at promoting learning [5-6]. However, it has been suggested that these learning gains are often due to instructional design features (e.g., availability of feedback) rather than any unique properties of games [7]. Of course, advocates quickly point out that there is more to learning than just cognitive gain. A good example comes from Malone and Lepper [8] who focused on nurturing *intrinsic motivation*—the "will to learn" for its own sake, without extrinsic reward. They analyzed opinions of elementary school students on a variety of games (circa 1980) in order to identify which properties were most appealing. A key finding was that the children displayed a preference for *fantasy* contexts that could evoke "mental images of physical or social situations not actually present" (p. 240). Further, for educational games, they assert that fantasies should be made *endogenous*, which means mastery of the learning content should lead to success in the game. Fantasy, something that is not typically considered important in instructional design, has been shown to enhance learning and dramatically increase learner motivation [9-10].

Fantasy therefore seems like an important element for educational game design, but how can we determine whether a learner has chosen to engage the fantasy? Answering this question requires a closer look at the learning experience from the learner's point of view. One potential indicator is whether the learner experiences a greater *sense of presence* while using the game. We adopt Lombard and Ditton's definition of presence as "the illusion of non-mediation" in which "a person responds as if the medium were not there" [11]. For the purposes of our task domain, intercultural communication, we are specifically interested in *social presence*—the degree to which a learner feels that an interaction with a virtual character is real.

Most studies examining the role of presence in immersive learning environments have not shown a direct link. Crystal Island, a 3D game for teaching microbiology and genetics, has been shown to enhance presence, involvement, and motivation, but not learning when compared to a comparable non-game-based control [12]. An immersive version of Design-a-Plant [13] was compared with a less immersive counterpart, but produced no differences in learning. However, *personalization* did lead to a greater sense of social presence with a pedagogical agent, and this positively influenced learning. In a study of the virtual Puget Sound, presence also lead to better conceptual understanding of water movement and salinity [14]. The authors hypothesize that higher presence may pay off only when the targeted domain knowledge directly involves it (e.g., understanding of a physical space in this case).

3 BiLAT: A serious game for intercultural communication

The context for our work is BiLAT, a serious game for practicing the preparation, execution, and understanding of bi-lateral meetings in a cultural context. Here, we focus on face-to-face meetings between learners and virtual characters, even though BiLAT's overall scope is much broader [15]. Our focus is on basic intercultural communicative skills necessary to build trust and reach agreements.

Figure 1. Screenshots from BiLAT, a game for intercultural communication.

In BiLAT, learners meet with one or more characters to achieve a set of pre-defined objectives. For example, the learner may need to convince a high-ranking local official to stop imposing an unjust tax on their people, or reach an agreement about who will provide security at a local marketplace. In all cases, the learner is required to adhere to Arab business cultural rules, establish a relationship, and apply integrative negotiation techniques. Specifically, BiLAT is designed as a practice environment for learning win/win negotiation techniques, which suggest learners should proactively strive to meet characters' needs as well their own [16]. To achieve these goals, learners must also apply their understanding of the character's culture to modify their communicative choices [17].

Two screenshots of the BiLAT 3D interface are shown in Figure 1. On the left is one of several navigation screens used in the game. On the right is the meeting screen, where learners spend much of their time during play. Figure 2 shows an alternative, 2D version of the BiLAT meeting screen. To take a communicative action in either, the learner selects from a menu of conversational actions. The user can engage in small talk (e.g., "talk about soccer"), ask questions (e.g., "ask who is taxing the market" and "ask if he enjoys travel"), state intentions (e.g., "say you are interested in finding a mutually beneficial agreement"), among other possibilities. Physical actions are also available (e.g., "remove sunglasses" or "give medical supplies"). There are roughly 70 actions for each character in BiLAT. In both interfaces, corresponding dialogue text is displayed in a dialogue window and available for the duration of the meeting.

Guidance is provided by an intelligent tutoring system (a "coach") that monitors the meeting and provides unsolicited help [18]. Help can come in the form of *feedback* about a previous action (e.g., explain a reaction from the character by describing an underlying cultural difference) or as a *hint* about what action is appropriate at the given time. Further, this coaching support is withdrawn gradually with time and learner success (i.e., it is "faded"). These messages appear in the dialogue window of BiLAT. After each meeting, the system also guides the learner through an interactive review that digs deeper into underlying cultural issues and decisions made by the user [15], but in the study reported below, this functionality was disabled since it is not available in the 2D interface.

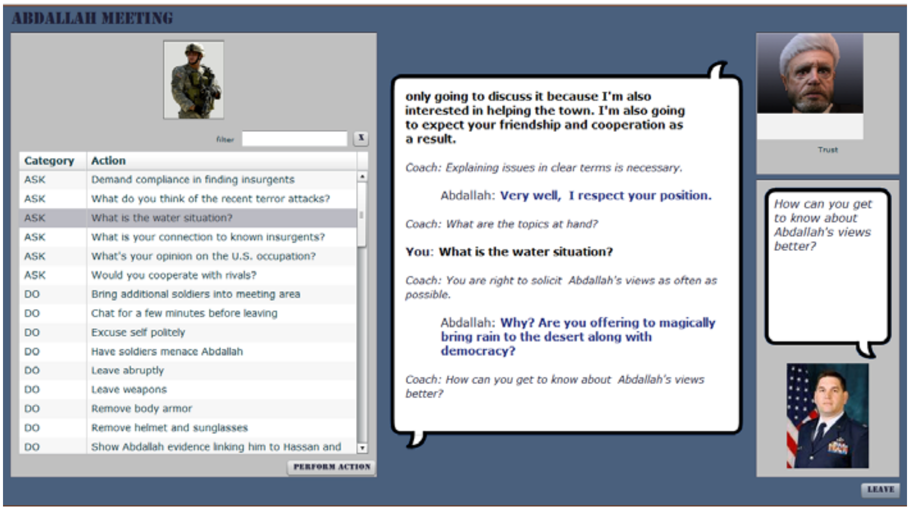

Figure 2. A flash-based, non-immersive interface for BiLAT.

BiLAT characters possess culturally-specific models of how they expect meetings to progress. This includes expectations for an opening phase, a social period, a business period, and a closing social period. These phases are derived from live role playing sessions with subject-matter experts early in the development of BiLAT [15]. An example of a knowledge component taught by BiLAT is to *follow the lead of your host*. If a learner chooses an action that is not appropriate for the current phase of a meeting, the character will respond negatively. The intelligent tutoring system provides support for phase-related problems as well as other culture-related topics [18]. Trust, which is directly affected by the ability of the learner to take appropriate and effective actions, is a major factor in whether BiLAT characters will be agreeable or difficult. It is common for learners to conduct multiple meetings with the same character to achieve objectives.

Both interfaces are controlled by the same simulation and differ only in their appearance and use of sound. Characters in the 3D version respond in a synthesized voice with physical gestures. The facial expressions, nonverbal behaviors, and speech of the characters are all synced with their utterances [15]. In the 2D interface, character images are static and only show their face. No sound is available in the 2D interface which means that learners must read character responses in the dialogue window. In both interfaces, coaching messages appear only as text and thus must also be read by the learner (if desired).

4 Method

In this section we describe an experiment intended to determine how the two interfaces differed in terms of their ability to create a sense of presence in the learner, and whether this had any impact on learning and learner behaviors.

4.1 Participants

Participants were 46 U. S. Citizens who were college students from universities in southern California. They were between 18 and 42 years of age and reported that they were able to speak English on a native level.

4.2 Design

There was a single independent variable: interface. It was manipulated between-subjects. One group of participants conducted their meetings in the 3D environment (Figure 1), which included simulated speech and animation. The other group used the less immersive—but functionally equivalent—2D interface (Figure 2).

4.3 Procedure

Pretest. After responding to fliers posted at universities in southern California, participants were emailed a link to an online pretest. The pretest had two parts. The first part was the Situational Judgment Test (SJT). The SJT presents eight scenarios, each of which is followed by three or four possible responses. Participants provided ratings (0 = "very poor action," 5 = "mixed/okay action," 10 = "very good action") for each of a total of 28 to-be-rated actions (for details on the SJT, see [15]).

The second part of the pretest comprised seven Cultural Assimilator (CA) items [19]. Each presents a scenario and four interpretations, from which the learner is asked to choose the best. Fourteen scenarios were selected using a voting process with the first two authors and a third intercultural researcher. The selected scenarios involved topics related to interpersonal situations (e.g., explaining why a waiter was confused by the behavior of an international customer) and focused on various cultural settings, including Arab, Japanese, Swedish, and more. Participants were awarded two points for selecting the best interpretation, one point for selecting a plausible but less culturally sophisticated interpretation, and zero points for selecting the weakest explanations [19]. Items were counterbalanced between pre- and posttests and the two versions were determined to be roughly equally difficult in a pilot study.

Practice with coaching. After completing the pretest and scheduling an appointment, participants arrived at our institute to interact with the BiLAT system. They were given printed orientation materials (which contained no instructional content) and were randomly assigned to encounter the 2D or 3D interface. They then spent up to 100 minutes meeting with three virtual Iraqi characters in attempts to solve a problem with a fictional U.S.-built marketplace in Iraq. All participants received hints and feedback from the coach during these meetings.

Practice without coaching. Next, participants spent up to 30 more minutes meeting with a fourth virtual Iraqi character to resolve a problem at a hospital. Participants used the same interface as they did when solving the market scenario, but the coach provided no hints or feedback during the doctor scenario.

Table 1. Summary of results between conditions (means, * = significant)

Sense of Presence (TPI, self-report)	**2D**	**3D**
Social	2.77	3.49*
Spatial	2.30	3.21*
In-game posttest (probability of errors)		
All errors	0.32	0.27
Phase-mismatch errors	0.18	0.16
Declarative knowledge (SJT correlation)		
Pretest	0.594	0.516
Posttest	0.718	0.718
Cultural knowledge (CA score)		
Pretest	10.17	9.41
Posttest	10.78	10.36

Presence. Participants then completed the social and spatial subscales of the Temple Presence Inventory (TPI), a series of self-report measures intended to capture a user's feelings of non-mediation [11]. For example, an item on the social subscale is "How often did you have the sensation that people you saw/heard could also see/hear you?" Items were rated from 1 (low) to 7 (high) and those that did not apply to both interfaces (e.g., questions about the authenticity of sound) were omitted.

Posttest. After completing the TPI, participants again completed the SJT and the counter-balanced CA (the seven previously unused questions). After completing the posttest, participants were thanked, compensated, and debriefed.

5 Results

5.1 Presence

Participants' ratings of presence are shown in Table 1. The 2D interface (M = 2.76, SD = 1.04) created less social presence than did the 3D interface (M = 3.49, SD = .88). This difference was statistically significant: $t(44) = 2.54$, $p = .02$. Similarly, the 2D interface (M = 2.30, SD = .99) created less spatial presence than did the 3D interface (M = 3.21, SD = .99): $t(44) = 3.09$, $p < .01$. These results suggest that our manipulation of presence was successful.

5.2 Learning

Declarative knowledge. The SJT required participants to rate actions based on their understanding of Iraqi cultural values. Thus, the SJT was our measure of declarative knowledge. Answers previously provided by three subject-matter experts (SMEs) were considered "correct." We defined improved declarative knowledge as an increase in participants' correlation with SMEs from pretest to posttest. Across conditions, SJT scores increased from pretest (M = .56, SD = .20) to posttest (M = .72, SD = .13), with a large effect size (d = .92). It appeared that participants became more correlated with SMEs—an interpretation that was supported by a repeated-measures ANOVA: $F(1, 44) = 40.04$, $p < .01$. This result suggests that BiLAT, with the assistance of the coach, is able to improve the acquisition of declarative knowledge.

Further, a median-split analysis revealed a greater improvement in SJT scores for participants with low SJT pretest scores (M = .28, SD = .14) than for those with high SJT pretest scores (M = .04, SD = .12). This difference was reliable: $t(44) = 6.27$, $p < .001$, d = .93, and is consistent with that the general result that lower-ability students tend to benefit most from higher levels of guidance [20]. This further suggests that the SJT taps knowledge that is reinforced by coaching.

Table 1 also suggests that participants' SJT scores increased (posttest minus pretest) more with the 3D interface (M = .20, SD = .18) than with the 2D interface (M = .13, SD = .17). However, this difference was unreliable: $t(44) = 1.52$, $p = .14$. It may appear that between-groups differences on the pretest masked this effect; participants assigned to the 2D interface (M = .59, SD = .18) seem to have scored higher than those assigned to the 3D interface (M = .52, SD = .21). However, this difference was also not reliable: $t(44) = 1.33$, $p = .19$. There was also no interaction between interface and median-split ($p = .88$). Thus, although the 3D interface created more presence, it did not produce gains in declarative knowledge.

Applied knowledge. As discussed above, the coaching system assesses all actions. We defined the learner's ability to apply knowledge as the probability that s/he would select a correct action based on this assessment. To diagnose participants' knowledge, we measured the probability that they would perform an action that was inappropriate in general or was a violation of the current meeting phase (experimenter error corrupted the data from two participants). Participants made approximately as many errors with the 2D interface (M = .23, SD = .08) as with the 3D interface (M = .22, SD = .05): $t(42) = .27$, $p = .79$. The same was true for meeting-phase errors; participants made approximately as many with the 2D interface (M = .14, SD = .03) as the 3D interface (M = .14, SD = .04): $t(42) = .09$, $p = .93$. This result suggests that there was little difference between the 2D and 3D interface in terms of errors committed.

In-game posttest. As described above, learners interacted with a fourth character with no coaching support. Although it was silent, the coaching system continued to provide records of the errors analyzed above. Table 1 shows the frequency of these errors in the doctor scenario (a software problem corrupted the data from two additional participants). As can be seen, the 2D interface (M = .31, SD = .10) led to more errors than did the 3D interface (M = .27, SD = .10). This difference, however, was not reliable: $t(40) = 1.54$, $p = .13$. Meeting-phase errors followed a similar pattern. The 2D interface (M = .18, SD = .12) led to more errors than did the 3D interface (M = .16, SD = .11), but the difference was not reliable: $t(40) = .58$, $p = .56$. These values were substantially greater than those observed during coached meetings, suggesting that coaching may have become a crutch. However, it appeared not to matter whether assistance had been delivered by the 2D or 3D interface.

Far-transfer test. The CA required participants to diagnose a short scenario based on their general understanding of intercultural interactions. It taps general intercultural skills and involves different cultural contexts than those in BiLAT. Table 1 shows participants' CA scores as a function of interface on the pretest (M = 9.80, SD = 2.24) and posttest (M = 10.58, SD =2.10). Although the increase appeared numerically small, a repeated-measures ANOVA revealed it to be relatively consistent: $F(1, 43)$ = 3.35, p = .07 (one participant's data were lost due to experimenter error). This result is consistent with the SJT data; practice with coaching improves declarative knowledge and marginally improves the ability to transfer that knowledge to other situations.

A median-split analysis revealed a greater improvement in CA scores for participants with low CA pretest scores (M = 1.96, SD = 2.68) than for those with high CA pretest scores (M = -1.00, SD = 2.06). This difference was reliable: $t(43)$ = 3.97, p < .001, d = .27. As with the SJT, low-performing learners enjoyed greater gains from using the system [20]. The decrease for high performers was not reliable and may be due to a ceiling effect (the top performers' average score was 12.06 out of 14 on the pretest). Thus, the increase in score for lower-performing learners (pretest score of 8.30 out of 14) shows that the CA taps knowledge relevant to BiLAT.

Table 1 also shows that participants' CA scores improved more with the 3D interface (M = .96, SD = 3.28) than with the 2D interface (M = .61, SD = 2.41). However, this difference was unreliable: $t(43)$ = .40, p = .69. There was also no interaction between interface and median-split (p = .70) suggesting that the 3D interface did not promote more general cultural understanding than the 2D interface.

5.3 Interaction patterns with virtual characters

We analyzed the data collected over meetings, actions, and time. Recall that multiple meetings with the same character are often necessary to succeed in BiLAT. During the training period (up to 100 minutes with three characters), participants needed more meetings in the 2D interface (M = 13.67, SD = 4.15) than they did in the 3D interface (M = 10.30, SD = 2.88): $t(42)$ = 3.14, p < .01. Participants also performed more actions in each coached meeting in the 2D interface (M = 17.70, SD = 4.12) than they did in the 3D interface (M = 15.09, SD = 2.57): $t(42)$ = 2.55, p = .02. With more meetings per session and more actions per meeting, participants in the 2D interface performed nearly 50% more actions than did participants in the 3D interface.

Drilling down into meeting actions, we calculated the amount of time between actions in each interface. During the training period, participants spent slightly longer deciding on their next action in the 3D interface (M = 20.67 sec; SD = 8.75) than they did in the 2D interface (M = 17.42, SD = 4.92), but this difference was not reliable: $t(42)$ = 1.37, p = .18. During the in-game posttest (no coach), however, participants took substantially more time per action in the 3D interface (M = 17.02, SD = 9.63) than they did in the 2D interface (M = 11.44, SD = 2.44). This difference was reliable: $t(40)$ = 2.46, p = .02. A repeated-measures ANOVA revealed a differential reduction in the interval between actions when the coach was deactivated: $F(1, 40)$ = 4.24, p = .05. It seems that learners in the 3D system took more care in selecting actions, which, along with their higher ratings of social presence, may suggest that they may have treated it as a more authentic social interaction.

5.4 Discussion

Although learners had a greater sense of presence using the 3D version of BiLAT, we are unable to conclude from our data that presence caused any differences in learning. Both interfaces produced similar learning gains on tests of declarative knowledge (SJT), in-game success (without coaching), and on a far-transfer test of general cultural knowledge (CA). When we combined conditions in our analysis, we found increases in learning for both the SJT (reliably) and on the CA (marginally), as well as significant gains for lower-performing learners on both measures. Since the BiLAT simulation engine drove both interfaces, we conclude that the simulated social interactions are responsible for the observed learning gains. This is consistent with well-known principles of multimedia learning [21], as well as the suggestion that sense of presence is most beneficial for learning when domain knowledge specifically demands it [14]. Our analysis of the behavioral data prevents the conclusion that the 3D interface and the 2D interface are interchangeable, however. Participants who used the 2D interface made decisions more quickly, made more decisions per meeting, and had more meetings with each character. Although the average time to take an action was not statistically different during training, we did find a significant difference in the time participants took to act when coaching was unavailable.

Why, then, were participants in the 2D interface more prone to act than participants who used the 3D interface? One hypothesis is that the 3D interface encourages participants to take meetings more seriously—a direct result of the differential presence experienced. It is also possible that the 3D interface requires more attention and cognitive resources, thereby increasing the time between actions. It took learners more actions per meeting and more meetings per character to build up relationships and successfully complete objectives in the 2D interface than in the 3D interface. If we had designed the experiment to limit the total number of actions (rather than the total amount of time at 100 minutes), then we may have observed greater, reliable differences in our learning measures.

Relatedly, these data suggest that characters' responses and coach feedback in the 3D interface were more economical in producing learning gains. With fewer actions and fewer meetings overall, participants who used the 3D interface nevertheless trended toward greater learning gains than those who used the 2D interface. One hypothesis is that learners in the 3D interface may have reflected on their actions more often than those in the 2D. As the fidelity of immersive simulations continues to increase, along with their ability to create a sense of presence, it will be worthwhile to examine whether there is a concomitant increase in learning along these lines.

Our study has a number of limitations. Perhaps most critically, we included only the meeting component of BiLAT. The full version of the game requires learners to understand a broader context, decide which characters to meet with, conduct research on characters, select an interpreter, conduct more elaborate negotiations, and review their meetings with a reflective tutoring system [15]. Because of time constraints and limitations on the flash-based, 2D interface, we were not able to incorporate these other components of the full BiLAT system, which may have further enhanced learning and presence. A second limitation is that no delayed posttest was given to participants. It is possible that a heightened sense of social presence would enhance retention of knowledge related to social communication skills (similar to [10]).

Finally, we note the domain knowledge in this study focused on general communicative skills; nonverbal behaviors, tone or rate of speech, or proxemics were not involved. It is possible that social presence and 3D interaction hold greater importance for skills related to these issues.

6 Summary and conclusion

In this paper we compared two interfaces that used the same underlying simulation engine for the practice of intercultural communication and negotiation skills in a serious game. The 3D interface used animated characters with sound while the 2D version used static images without sound. Participants reported a significantly greater sense of presence with the 3D version, but measures of learning revealed that both conditions showed significant but statistically equal gains in terms of declarative and conceptual understanding of cultural knowledge. Analysis of usage data revealed that learners using the 2D interface had significantly more interactions with characters than the 3D version. This means 3D users learned equivalently well with fewer interactions. We hypothesize that they may have been more thoughtful in their communicative choices and perhaps treated the virtual meetings as more authentic.

There are many other factors that should be considered when analyzing learning with virtual human role players. For example, it is important to consider whether learners independently establish social goals, which has been shown to be an antecedent for cultural learning with virtual humans [22]. Another important aspect is the relationship between explicit guidance and presence. In future studies, we plan to examine different feedback policies and assess their impact on users' learning and feelings of presence. The results from this study will form a baseline for comparing other feedback policies and hopefully shed light on identifying optimal levels of presence in virtual environments for learning.

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