Collaborative Decision-Making and Presence in Shared Dynamic Virtual Environments

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Summary

This document reports in brief the findings of a study conducted to observe the relationship between a sense of presence and team training in decision making in dynamic high risk environments. A simple desktop virtual game environment is used to explore the possibility that, in this context, such semi immersive dynamic virtual environment (VE) could be used to achieve a sense of presence sufficient to provide trainees with an experience of the same cognitive value as one in the real world, without the need to construct a full immersive VE with all its associated costs.

Main Document

Decision Making Training in a Collaborative Context

Decision making activities in contexts such as fires, police incidents, hospital trauma units, intensive care units, offshore gas installations and other high hazard situations, cannot be described by the traditional "rational" decision making theories based on surveying and evaluating a known fixed set of alternatives. In the cases in which we are interested, the goal and the situation dynamically change from one moment to another and it is impossible to do a full risk analysis. Consequently, it is very difficult to establish what is absolutely right or wrong at any one time.

Two models have been developed for naturalistic decision making behaviour in dynamic high risk contexts by Klein (1993) and by Orasanu (1993). They both describe an expert decision-maker as able to identify the problem's characteristics, formulate an action plan and forecast the possible consequences mainly from previous experience. Training for on-site decision making has to provide the trainee with rapidly recallable knowledge of previous situations as well as a set of reliable practical skills.

Presence in a Collaborative Training Context

A major reason for using a Collaborative Virtual Reality Environment (CVE) for training is that we believe that the 3D reproduction of a real high risk dynamic environment combines with the complexity of the communication demands made on team members to create high levels of cognitive load with opportunities for highly situated decision making. This is associated with a strong sense of presence, which we regard as essential for improving the quality of the training, leading to knowledge recallable in the real world as a consequence of an engrossing experience acquired in the "virtual world".

Such a CVE is effective partly because it contextualises the training. At a physical level, this helps to enable trainees to become "immersed in the experience" (Kalawsky, 1993, p80) interacting with an external representation of an environment that might be difficult or too expensive to reproduce in the real world. In addition, it has been observed by researchers in cognitive science that "a main advantage of virtual reality is that simulations can be constructed to have an higher level of fidelity with the object they represent, compared with other kinds of external representation - in term of having more functional, physical and spatial resemblance" (Scaife and Rogers, 1996, p 203).

Immersed in the experience means, according to Kalawsky, that the person involved feels part of the actual environment. This "immersion"can take place slowly or fast, as the person adjusts and adapts to the situation. Lombard and Ditton (1997) argue that such a sense of physical presence is an all or nothing experience with a greater sense of presence being associated with longer and/or more frequent experiences of "being there".

Ellis (1993) indicates that "a large part of our sense of physical reality is a consequence of internal processing rather than being something that is developed only from the immediate sensory information we receive". Also Barfield, Sheridan, Zeltzer and Slater (1995) report that "the fact that presence for an environment can occur when the observer attends to only a subset of the sensory information impinging upon the senses, has a significance for producing presence in virtual environments. We believe that is possible to invoke a high level of presence in virtual environments without having to stimulate every sensory system of the human. In fact, many current virtual environment systems successfully invoke presence by stimulating only the visual and auditory modalities - providing strong cues for presence".

This leads to the question: how small can this subset of sensory information be, given that the external input is only the "start key" for an internal processing of the reality we are facing?

An immersive virtual environment (VE) usually requires a considerable investment. Therefore it would be interesting to determine if a simple desktop VE could be used to achieve a sense of presence sufficient to provide trainees with an experience of the same cognitive value as one in the real world without the need to construct a full immersive VE with all its associated costs.

At this point, it is worth pointing out that the decision making tasks under consideration take place in contexts involving a team of people working together in the same environment to achieve a positive resolution of the problem. Orasanu and Salas (1993) define team decision making as "the process of reaching a decision undertaken by interdependent individuals to achieve a common goal". Also they express that this decision making process is facilitated when the individuals involved are a team, meaning that they are used to working together and they can easily predict each others' possible moves. Such team decision making can also be described as collaborative.

Collaboration has been defined as the "mutual engagement of the participants in a co-ordinated effort to solve the problem together" (Roschelle & Teasley, 1995). According to this definition, team decision making in dynamic environments is a collaborative task, where each participant contributes in different ways to the final decision; whether the participants have an equal power for making decisions, or whether decision making power is located mainly in the hands of a few of the team with others having a limited amount of decision power.

Thus in addition to issues related to a sense of physical presence we also have the notion of social presence. Lombard and Ditton (1997) argue that a strong sense of social presence can overcome deficiencies in the VE in terms of the technical limitations or lack of sensory immersion. Slater (1998) provides a related analysis:

- Personal presence is related to the sense of being in a virtual space as the individual's state of mind and his acts in the environment.
- Shared presence is related with the perception of others being in the same environment and the group behaviour.

Both aspects of presence are required for an effective training system for collaborative decision making, and the suggestion is that a strong sense of social presence may well reduce the requirements for a physical sense of presence.

Pilot Study

As part of our work on naturalistic decision making in high risk dynamic situations, we studied how collaborative decision-making takes place in a shared dynamic desktop VE, and how a sense of presence influences this collaborative process as well as single and team performances in the study.

A well-known multi-participant desktop virtual game has been used to observe to what extent the participants feel "present" in an environment with only visual and auditory information. A 3D representation of a maze is given and the players have to find their way out while surviving the attack of other humans and animals represented in the 3D world.

Subjects

There were twelve participants in the experiment, seven female and five males, of age varying in a ten year range from the mid twenties to the mid thirties. They were all familiar with the use of multimedia desktop personal computers and some with the game itself. A preliminary training on the basic features of the game was given to the subject that had never played before.

Materials

The material used in the experiment were two complete multimedia personal computers with 15" monitors and the game installed on each computer. A video camera in a fixed position with an overview of the subjects and the screen on which the game is played was used to be able to examine the results later.

The game represented a world with constraints similar to reality, where the player has to breathe if swimming, dies if shot by the hostile creatures and so on. A limited number of lives were given. The only visual perception that each participant has of himself is the representation of his gun on the screen, while he can see the overall body of the other players and of the creatures of the environment.

A combination of mouse and arrow keys has to be used to move to interact with the game.

Different game modalities were utilised. The one used in the collaborative experiment had two participants fighting together to find the way out. The two players could not harm one another, but if one of the players killed one of the enemy the figure destroyed will not reappear again for the benefit of both players. The two players for each session of the experiment were used to working as a team in real life.

Results

Burton, Brna and Treasure-Jones (1997) suggest that roles peoples adopt within a group are strictly related to the effectiveness of the group collaboration and to the learning gains. Therefore the roles undertaken in the collaborative exercise were examined.

We noticed that the behaviours in the virtual environment resembled those of the real world and we have categorised three types of behaviour. Each of these was shown by two different couples, and are:

- The teacher-pupil role, where one player does most of the talking, guides the other through the maze and looks after him as he kills all the hostile entities and takes decisions considering the other player's needs. The other would follow the teacher as happens in reality and perform what is requested with a better competence and confidence than it is likely he would have done when playing on his own. In this case the teacher also reported that this way of playing was more stressful and required more concentration than playing alone.

- The equal contribution players, that share all the resources and come to decisions by reaching a consensus. Those also waited for the partner to join them during movements around the virtual world, guiding them to the location describing what they could see. They did not report more concentration than when playing alone, and found the game more enjoyable. Also team performance was far superior to the single performances demonstrated, showing both team members benefited from the form of the collaboration.

- Dominant behaviour where one of the two players, despite the knowledge of the other player, ignored his suggestions most of the time and taking decisions for both players. In this case the second player followed the first player, keeping his distance so that he could enjoy playing the game on his own while monitoring the first player's behaviour. The dominant player's performances were not improved and the second player reported that he would have done better playing on his own. This was considered to be a case of non collaboration.

A post event questionnaire was completed by the participants. The validity and reliability of it need to be established, but it suggests that 92% of the subjects in the experiment felt they were in the place they were looking at on the screen always (58%) or sometimes (33%). Also players with a greater experience reported a higher sense of personal presence.

As for shared sense of presence 33% of the players felt that their partner was always in the environment presented by the game, while 67% felt that he was sometimes in the environment. Nobody reported that he never felt the partner in the environment on the screen. On the other hand, 58% felt that they were both in the environment and that collaboration was possible even if they did not see their partner on the screen. While 33% felt that collaboration was enhanced when they could see their partner and sometimes they both felt themselves to be in the environment.

Only one person (8%) reported that she never felt a sense of personal presence during neither the training nor the collaborative experiment, but for shared presence she reported that she felt sometime her partner on the screen and always both together in the environment.

Similarly one person (8%) reported that despite him feeling himself or the partner sometime in the virtual environment, he never felt both together. This was reported in one of the couples where the dominant behaviour was noticed.

This game had been chosen since it seemed to us that its popularity was due to a strong sense of presence being felt by the players of the game. In fact, even subjects not generally interested in video games once trained and confident, found it very difficult to stop playing. The post event questionnaire after the training revealed that 92% of the subjects felt a sense of personal presence at least sometime. Also it was noticed that most of the trainees that felt only sometime present on the screen, changed their answer to complete sense of presence after the collaborative experiment.

It is also interesting to report that in the post event questionnaire the mouse, which allowed the player to look around, was described as the players' head movements, while the arrow keys, which allow backwards, forwards and sideways movements were related to the legs of the player.

Conclusions

The game scenario is strongly analogous to team training in a high risk dynamic environment. While it is always possible in VEs that there is significantly less perceived risk than in real life, it did appear that the game playing context selected was effective in engaging the participants. In addition, where collaboration was effective a strong sense of shared presence was reported and performances were improved. Also the behaviours observed during the experiment reproduce those of real life. This result leads us to believe that the construction of a shared dynamic VE with similar settings of the analysed game could be used for training collaborative naturalistic decision making skills.

While this is a preliminary result that could benefit from a more thorough analysis of the data, it does support the notion that social presence can be effective in maintaining a strong sense of physical presence.

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