Joint Avatar Control in Virtual Reality and Its Effects on Self and Social Presence

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Abstract

As virtual environments become more common, more opportunities to create new kinds of social presence arise. In this paper, we describe the design and implementation of a game designed to enhance team-building through joint control of an avatar, leveraging synchrony between two players in a collaborative virtual environment (CVE). In this virtual reality (VR) game, participants drive the movement of a sea turtle hunting for jellyfish by their combined movements. Participants can play in one of two conditions--either seeing the environment from the first-person point of view of the turtle avatar, or from a third person perspective. We examine the effects of the conditions of these games on two measures of social presence, and the interaction of these measures with score in the game. We provide the code and instructions to implement the game, some preliminary qualitative data from a small pilot study, and discuss next steps.

Keywords: Synchrony, team-building, collaboration, avatars, virtual reality games, first-person perspective, third person perspective, many-to-one, joint avatar control

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Team-building is important for many groups, and teams trying to build rapport often use exercises that enhance nonverbal synchrony. Activities such as dancing together, or singing or marching in unison, are examples designed to build rapport by encouraging synchronous behavior (Lakens & Stel, 2011). Experimentally inducing synchronous nonverbal behavior has been shown to aid in building affiliation (Hove & Risen, 2009), and the ability to jointly act (Valdesolo, Ouyang & DeSteno, 2010).

However, creating the opportunity for such interactions, especially those in a business context, will often require participants to travel long distances in order to participate in person, so that they can leverage the full benefits of social presence. Virtual reality (VR) allows participants to experience a relatively high level of social presence, and could thus be a reasonable, and resource-sparing, alternative for face-to-face interactions. In addition, synchrony can be readily manipulated in a virtual environment (Tarr, Slater & Cohen, 2018). However, VR also allows for other advantages.

It is relatively easy to *transform* players' tracked movements in a CVE to change the nature of their social interactions (Bailenson, Beall, Loomis, Blascovich and Turk, 2004). Not only can participants control an avatar that looks very different from their own body, they can also complete tasks using a control schema that differs from the normal human template (Won, Bailenson, Lee & Lanier, 2015). In this game, we aimed to investigate how such novel embodiment might affect social closeness and social presence, and potentially lead to higher rapport.

In our game, participants must synchronize their movements to more efficiently jointly control an avatar—an example of "many-to-one" control in virtual reality that is, to our knowledge, novel. In this game, it is also possible to select whether participants view the game from the first person perspective (1PP); both seeing events from the perspective of the avatar they jointly control, or the third person perspective, in which participants can see their own and their partner's humanoid avatars which accurately reflect their movements, as well as the avatar of the sea turtle they jointly control. This offers a unique opportunity to create synchrony-based team-building interactions that are impossible in real life.

Below, we first describe the system and the way in which participants' scores were determined. We provide the source code. We then describe the measures of self-presence, social presence and social closeness that we used. Finally, we describe a pilot experiment, conclusions and next steps.

System

We designed and implemented a game, where players jointly control a sea turtle by "swimming" with their arm movements to collect jellyfish in an undersea world. The game was originally embedded in a networked virtual environment, High Fidelity (highfidelity.com, retrieved March 1, 2018), which enables users to interact from different locations, and is now being ported to the Unity platform for further testing. While the study was conducted in a controlled environment, the game could be applied by a broader user base as a team building exercise, especially distributed teams.

The game was developed to allow for future testing of four different conditions of game experience; crossing first and third person perspective, and one- or two-player conditions.

In the pilot study, participants first practiced the game in the first-person condition \ Participants then shared control of the turtle with a second user, a research assistant.

The turtle's speed was determined by the vector addition of the two users' arm movements, which reflects the degree to which users' movements are synchronous. The turtle's direction was determined by the combined vector of two users' body orientation.

First Person Perspective.

In this condition, users are embodied in the turtle avatar. They see over the turtle's head at its eye level, and their hand movements are reflected by the movements of the turtle flippers.

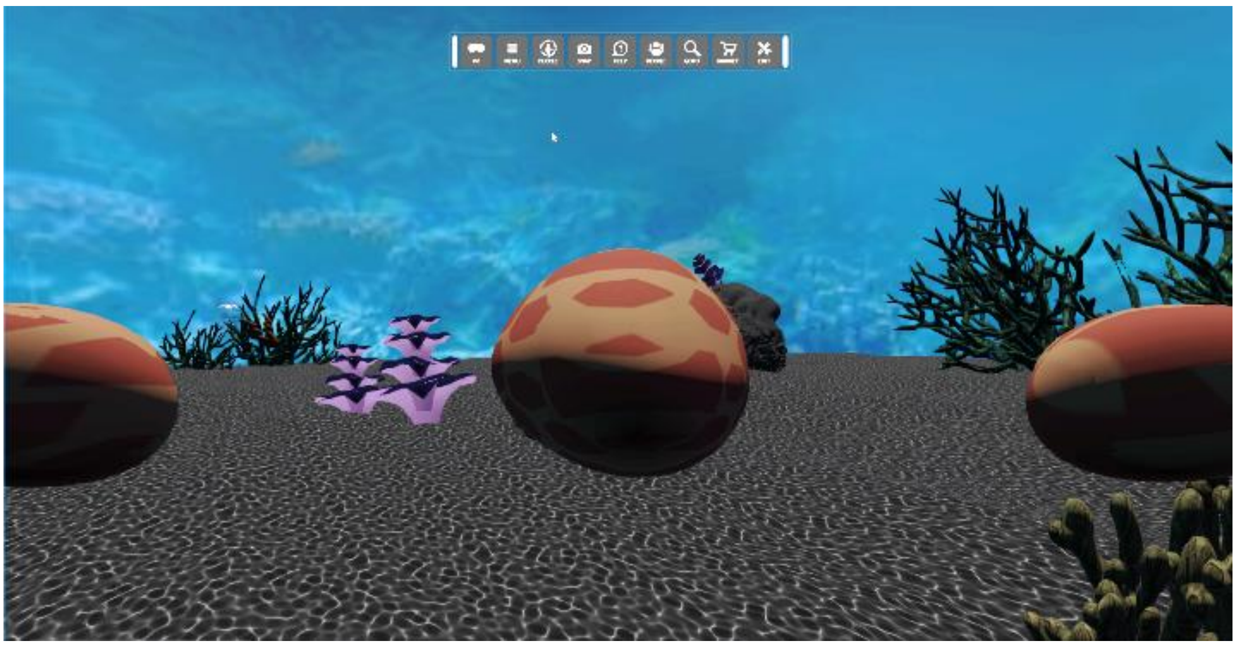

Figure 1. The turtle's head is shown in the center of the frame, and the flippers are shown at the frame edges.

Third Person Perspective.

In this condition, users have their own humanoid avatars. The viewpoint is not attached to the controlled turtle character; rather, users have independent viewpoints in spite of the turtle's position and orientation. The avatar is shown in the middle of the screen, and the turtle is shown in the distance. In the two player version, participants see their own avatar from the first person perspective and the other player's avatar to one side.

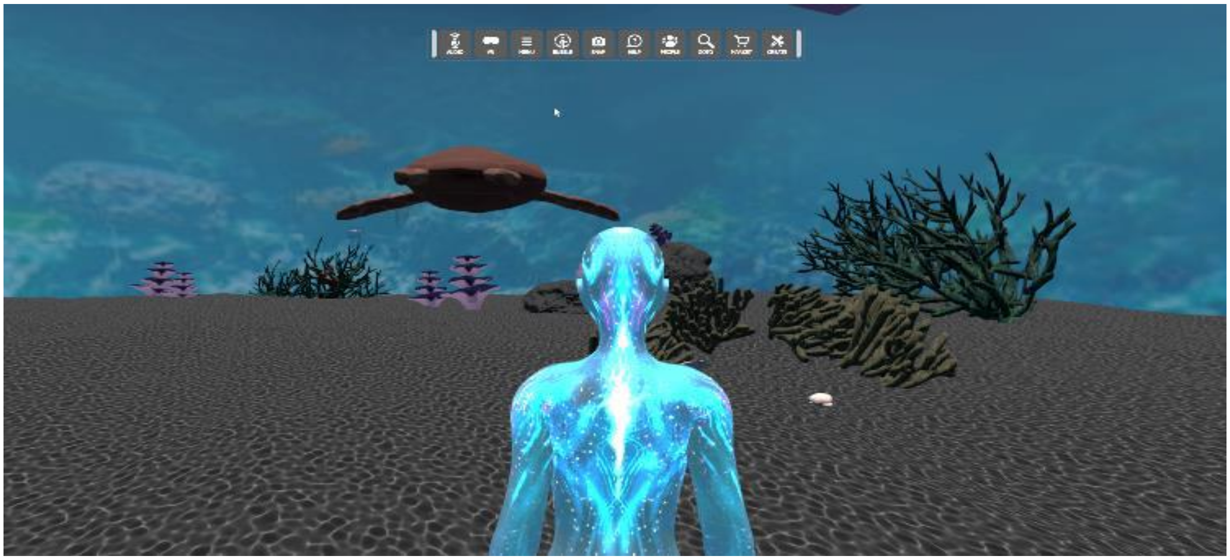

Figure 2: A view illustrating the third-person perspective, where a user can see both the turtle avatar, and the blue avatar of their teammate.

Calculations Performed at Each Frame.

1. Convert the two avatars' body yaw to radians to get the average. Convert the average yaw orientation to rotation and apply it to the turtle

2. For each avatar, subtract the vector of Left Hand Position and Right Hand Position from the vector of Body Position. Apply a coordinate transform to the two result vectors, rotating the coordinate by the yaw orientation of the avatar body.

3. Results from #2 are left hand's and right hand's relative positions to the avatar body in vectors. Subtract these vectors from vectors of hands' relative positions from last frame to get each hand's displacement. Use only displacements along Z-axis. Sum to combine two avatars'

left-hand displacements along Z-axis. Sum to combine two avatars' right-hand displacements along Z-axis.

4. Average left hand's displacement and right hand's displacement from Step 3. (We multiplied the average by 30 to get an appropriate speed along the Z-axis).

5. Read the turtle's current body rotation and convert it to orientation. Take the yaw orientation. Rotate the coordinate by the yaw orientation and get the turtle's velocity vector from the speed along Z-axis.

Implementation.

Our initial implementation used the platform High Fidelity (highfidelity.com, retrieved March 1, 2018) which does not allow shared use of avatars. To achieve shared control of the turtle, we assigned High Fidelity avatars to users and generated the turtle as an entity controlled by the avatars' movements. The game scripts process these movements to calculate and render the turtle's movements at a framerate of 30 fps.

Setting up the game does not require knowledge of computer programming. However, if using the High Fidelity version, familiarity with the platform is recommended. All scripts can be found in the GitHub repository link https://github.com/cornellvelnovel/SeaTurtle-on-HiFi along with a readme file for implementation.

Pilot Study: Methods and Materials

We recruited 19 participants to participate in the pilot study (13 women). Participants were randomly assigned to either the 1PP or the 3PP condition. Two participants were removed for technical failure, leaving eleven participants in the first person condition and six in the third person condition. Participants interacted with a research assistant as the second player.

Participants used the HTC Vive headset and hand controllers, and played the game in a virtual underwater world created using stock 3D models. In the game, participants' main task was to cooperatively control the sea turtle avatar to catch jellyfish. For each experiment, participants practiced in Single-Player mode, and then began the collaborative task, cooperating to catch all six jellyfish. For each experiment, there were three rounds, with six jellyfish available in each round. Participants then filled out a brief self-report questionnaire on simulator sickness, social closeness (liking and affiliation) and self and social presence.

In this study, we investigated the effects of the two-player first and third person perspective conditions on social and self-presence, social closeness, and the interaction of presence and score.

Measures

Score was calculated by summing the jellyfish captured over the three rounds (*M* = 15.24, *SD* = 2.75).

Self-presence was calculated by taking the average of five questions following Won, Bailenson, Lee and Lanier (2015). These questions were "If something happened to the avatar, it was happening to me; The avatar's body was my own body; I was in the avatar's body; The avatar was an extension of me; The avatar was me" (*M* = 2.51, *SD* = 1.02, *alpha* = .93).

Social presence was calculated by taking the average of four questions following Bailenson and Yee (2006) as follows: "I felt like the other students were present; I felt like I was in the same room with the other participant; I felt like the other participant was aware of my presence; I felt like the other participant was real." The initial alpha of these questions was .69, after "I felt like the other participant was real" was removed (*M* = 2.73, *SD* = 0.88), *alpha* = .74.

Social closeness was measured following Won, Shriram and Tamir (2017), averaging 17 questions on affiliation and liking. Questions were modified from Bogardus (1933), Kelley (1950), and Lakens and Stel (2011). These questions had an alpha of .94, a mean of 3.43, and a standard deviation of 0.69.

Results

While we must emphasize that the sample sizes were extremely small, we present the following summary statistics. Using t-tests, we found that participants suffered more simulator sickness in the first-person condition (M = 1.64, SD = 0.67) than in the third-person condition (M = 1.0, SD = 0), (t(10) = 3.13, p = 0.011). In addition, participants in the first person condition also caught a higher number of jellyfish across the three trials (M = 16.64, SD = 1.43) than did participants in the third person condition (M = 12.67, SD = 2.80), (t(3.24) =6.46, p = .016).

There were no statistically significant differences between conditions on social closeness (t(12.70) = 1.55, p = 0.147) or social presence (t(8.62) = 0.63, p = .543). However, there was a significant difference between conditions on self-presence, such that participants in the first person condition (M = 2.15, SD = 1.00) reported lower self-presence than those in the third person condition (M = 3.17, SD = .77), (t (12.9) = 2.34, p = .036). Further, while there was no main effect of condition on social closeness, there was an interaction such that in the first-person condition, social closeness was marginally *negatively* correlated with score, (r = -.55, p = .083), but in the third-person condition, social closeness was significantly *positively* correlated with score, (r = .84, p = .036).

Conclusion

We created a game that allows participants to experience two conditions in which their synchronous movements jointly control a single avatar to complete a simple task. In our pilot study, we found differences between conditions on simulator sickness and task success. Self-presence was also influenced by condition. Another interesting finding is that in the first-person condition, social closeness was negatively correlated with score, but in the third-person condition, social closeness was positively correlated with score.

Limitations

Our initial pilot study showed that, due to the considerable computational workload, the game might not function as expected with a slow network in High Fidelity. Thus, for further experimental work, we plan to use Unity as the platform for this interaction.

In addition, the sample size for this condition was very small, thus, to draw firm conclusions about the conditions, a second, pre-registered study must be run.

Finally, in this condition, two participants were previously acquainted with the research confederate, and could identify him by his voice. Future studies should compare the effects of this experience on participants who are acquainted and those who are strangers to each other.

Next Steps

While this small pilot study limits the conclusions we can draw, we propose that it has promise for future investigations of team interactions. In particular, we aim to investigate the role of acquaintanceship/friendship in these kinds of experiences. We also propose to investigate the movements of the participants in order to determine whether or not synchrony evolves differently over time in either condition.

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