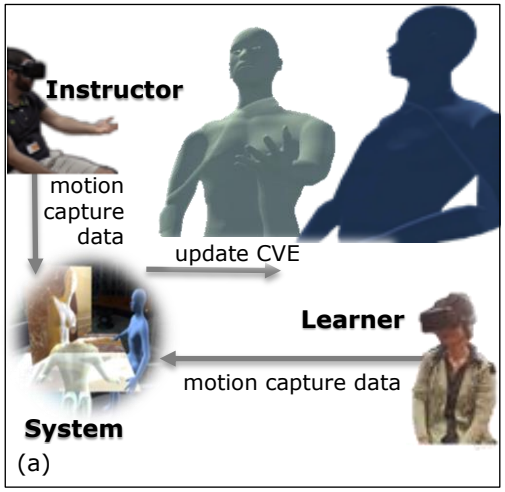
Quantifying Social Behaviors Affecting Interpersonal Relationships in a Collaborative Virtual Environment



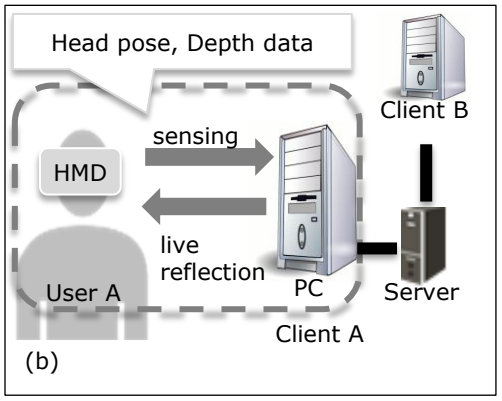


Figure 1: (a) Overview of our CVE, (b) System configuration.

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Abstract
This paper reports on our ongoing study that aims to enable a user to build an interpersonal relationship in a collaborative virtual environment (CVE). We draw on the "Equilibrium theory" and other existing research to define requirements for the system, such as the capability of the user to adjust their bodily distance from others to control interpersonal relationships. Then, we developed a prototype CVE and applied it to provisional English learning classes in which an instructor and a learner had an English conversation. Our experiment with the system indicates that English learners in the CVE (learners' avatars) could adjust their body parts and upper body postures but could not adjust their gaze attention to control their interpersonal relationship with the remote English instructor in the CVE (the instructor's avatar).

Author Keywords
Social embodied interaction; affectively intelligent technology; collaborative virtual environment (CVE).

ACM Classification Keywords
H.5.3. Information interfaces and presentation (e.g., HCI): group and organization interfaces, computer-supported cooperative work.

Research questions

Q1: Which types of relationship control behaviors are used or not used in the CVE compare to the actual face-to-face setting?

Q2: How do the users adjust their behaviors in the CVE when they are assigned a particular intention of relationship control (e.g., approaching, avoiding)?

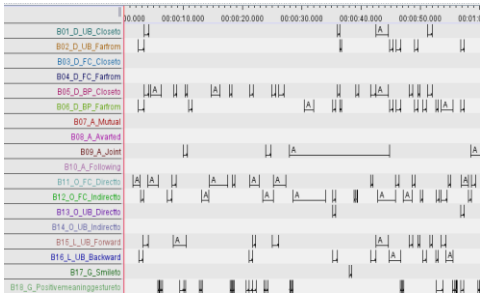

Figure 2: Annotated behaviors (The initial one minute for one participant).

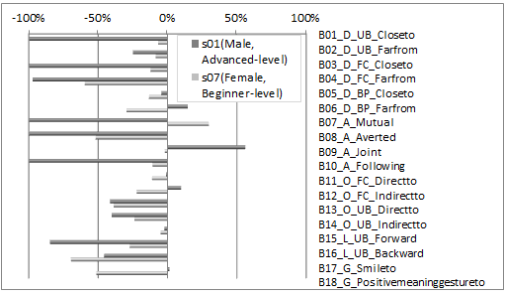

Figure 3: Time ratio of each type of behavior in CVE setting compared with the real setting (For example -100% for B01 of S01 means that S01 did not perform B01 behavior in the CVE setting, and +15% for B06 of S01 means that S01 performed B06 behavior in the CVE setting 15% longer in total during the task).

Introduction

In this study, we aim to provide a collaborative virtual environment (CVE) which allows users to build interpersonal relationships with other users. Especially, we focus on social behaviors that are observed in interpersonal relationship building/maintaining/break-up [1]; we call these behaviors as *relationship control behaviors*.

This paper reports our ongoing study to design a CVE that supports relationship building. We defined requirements for the system by drawing on the "Equilibrium theory" [2] and other prior research. The main contributions of this study are to introduce our CVE design which is capable of interpersonal relationship building, and to introduce the extensive analysis method of social behaviors, such as body posture and bodily distance from others, for building interpersonal relationships in the CVE. Our research questions are twofold, Q1 and Q2, shown in the left box.

"Equilibrium theory" applied to a CVE

The developed CVE was designed to allow users to perform relationship control behaviors in the same way they would in face-to-face interactions. "Equilibrium theory" explains humans' reciprocal/compensatory changes in gaze, interpersonal distance, and smiling, for adjustment from an unbalanced equilibrium level to preferred levels of intimacy. We selected relationship control behaviors based on prior research [2] [3] [4] [5] [6] when implementing our CVE [1]. Table 1 shows the types of relationship control behaviors. B11 to B14 are also considered as important conversational cues in conversation analysis [7]. Note that, in the remainder of this paper, we abbreviate each behavior using a prefix number of the name, e.g., B01 means B01_D_UB_Closeto.

Figure 1 shows an overview of our CVE and system configuration. The system captures users' motions using Oculus rift DK2 (https://www.oculus.com/) and Kinect v2 (https://developer.microsoft.com/en-us/windows/kinect). Relationship control behaviors from B01 to B16 will be calculated from these sensors. As an application of our CVE, we implemented an English learning scenario between an instructor and a learner.

Name	Behavior
B01_D_UB_Closeto	upper body moves closer to I
B02_D_UB_Farfrom	upper body moves away from I
B03_D_FC_Closeto	face moves closer to I
B04_D_FC_Farfrom	face moves farther away from I
B05_D_BP_Closeto	body parts (e.g., head) move closer to I
B06_D_BP_Farfrom	body parts (e.g., head) move away from I
B07_A_Mutual	gaze each other (including body)
B08_A_Averted	avert his/her gaze attention from I
B09_A_Joint	gaze at the same object with I
B10_A_Following	follow I's gaze
B11_O_FC_Directto	face orients to I's side
B12_O_FC_Indirectto	face orients away from I's side
B13_O_UB_Directto	upper body orients to I's side
B14_O_UB_Indirectto	upper body orients away from I's side
B15_L_UB_Forward	upper body lean forward from the previous position
B16_L_UB_Backward	upper body lean backward from the previous position
B17_G_Smileto	Smile
B18_G_Positivemeaninggesture	positive gesture (e.g., nod)

Table 1: Types of relationship control behaviors. "I" denotes "interlocutor."

Experiment overview

Participants: 10 English learners (5 males and 5 females. Non-native English speakers each categorized as beginner, moderate, or advanced-level). English instructor (1 male, native English speaker) was a confederate.

Methods: In one 5 minutes English lesson, the learner and the instructor had an English conversation class in face-to-face (real setting) or CVE setting. One task consisted of one English lesson followed by filling out questionnaire form. A learner had 6 tasks in total. The order and number of real and CVE setting were counterbalanced.

Contents: Movie and picture slides. A movie provided English conversation examples in a restaurant. We divide this movie into 3 parts, welcome, order, and pay. Each part was a few minutes long. Prior to every 2 tasks, the learner saw one of the movie parts. During the tasks, the learner and the instructor could see a slide which consists of images captured from the movie and subtitled dialogues of those scenes.

Procedure: In each task, he/she was/was not requested to adjust relationship control behaviors as follows:
- Approaching
- Avoiding
- No request

The order and number of these requests were counterbalanced.

Experiment

We conducted 60 English lesson tasks to compare user's relationship control behaviors between real and CVE settings. To collect relationship control behaviors, we asked each learner to adjust his/her relationship control behaviors with an English instructor. We showed participants a piece of paper explaining types of relationship control behaviors in Table 1 as examples of adjustment of behaviors for "approaching"/"avoiding." When the participant was requested "approaching", he/she adjusted his/her behaviors as if he/she wanted to make a closer bond with the English instructor. Also when he/she was requested "avoiding", he/she adjusted the behaviors as if he/she did not want to make a bond with the English instructor.

To analyze relationship control behaviors, we recorded the participant's behaviors using a video camera and annotated his/her movements using video annotation software, ELAN (https://tla.mpi.nl/tools/tla-tools/elan/). Figure 2 shows an example of annotated relationship control behaviors.

Preliminary Results

[Behaviors seen in the CVE setting]

Figure 3 shows each behavior's time ratio in the CVE setting compared with the real setting for two participants, S01 (advanced level) and S07 (beginner level). In the CVE setting, S01 did not perform B01, B03, B04, B07, B08, B10, and B16 as he did in the real setting. As for S07, her behavior ratio for B04, B08, B17, and B18 were low. Especially S01 did not use the movement of the upper body (B03, B04) and face (B01), and adjustment of gaze (B07, B08, B10) at all. Decreasing gaze adjustments was also observed for other learners in CVE setting especially when they were focused on the contents. In such situations, he/she did not move his/her eye gaze toward the instructor. Note that although the ratio of B09 for S01 is large, it was because the instructor proactively adjusted his gaze towards the same object that S01 was gazing.

Consequently, as compared to the real setting, we decided to focus on B02, B05, B06, B11, B12, B13, B14, and B15 as the behaviors possible to be used for relationship control in the CVE (Q1). In the rest of this paper, we mainly focus on these 8 behaviors.

[Approaching and avoiding]

We then investigated what kind of relationship control behaviors the participant did in the real and CVE settings. Figure 4 shows the time ratio of participant S01's behaviors during a task in "no request" and "avoiding" conditions. For both in real and CVE settings, the time ratio of B06, B11, B13, and B14 showed major differences between avoiding and no requested conditions. Figure 5 shows the time ratio of participant S07's behavior during a task in no requested and approaching conditions. For both real and CVE settings, the time ratio of B05, B06, and B14 showed major differences between approaching and no requested conditions. Comparison of Figure 4 and Figure 5 shows that B11 was used both in avoiding and approaching conditions similarly.

We compared the differences between approaching and avoiding regarding B05, B06, B13, and B14 in the CVE setting in order to see how users adjusted their behaviors in different intentions of relationship control (Q2). Figure 6 shows the cumulative percentage of behavior time regarding changes in the location of the body parts: mainly head position (B05, B06). In the

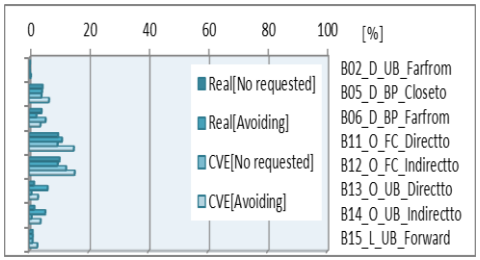

Figure 4: Time ratio of each type of behavior S1 formed one task.

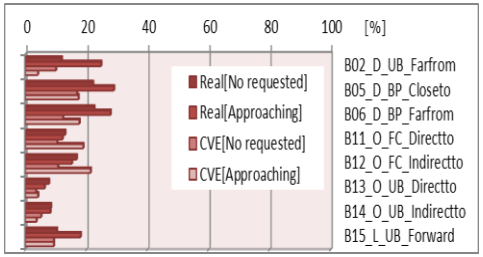

Figure 5: Time ratio of each type of behavior S07 formed one task.

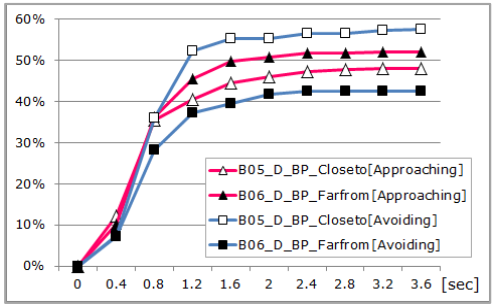

Figure 6: Cumulative percentage of behavior time B05 and B06 (data on each time slot is averaged. N=3).

avoiding condition, there was a difference between B05 and B06 in terms of the time length of a behavior he/she conducted. In this case, we saw a lot of movements where he/she positioned his/her head closer to the instructor while looking off from the instructor. B13 and B14 had similar tendencies. In avoiding interactions, there are few slower movements when he/she changed his/her upper body direction toward the side of the instructor, compared with toward the opposite side of the instructor.

Discussion and conclusion

We implemented our CVE based requirements induced from the "Equilibrium theory" and other prior research. Our CVE enabled the learners to adjust their behavioral parameters such as gaze attention, leaning, distance, orientation, and gestures.

Our preliminary results revealed that body posture, the location of body parts (B05, B06) and direction of the upper body (B14), are important cues to show the adjustment of relationship control behaviors in light of approaching/avoiding intentions. We assume that some of the participants compensated for missing social signals in our CVE by using other available behavioral cues in order to build interpersonal relationships.

In this experiment, some learners did not look at the instructor so much. Consequently, we are considering to implement additional support to share a user's body posture –not only the head posture- to reflect his/her intention of relationship control.

For the next step, we will further investigate which behaviors are important for not only human-human but also human-machine relationship building.

Acknowledgements

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