Changes of Self-Others Relation by Synchronizing Facial Expressions

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Abstract

In our study, we address conflicts between individuals and groups, such as cyberbully on social media, as a challenge related to the distinction between the self and others. To address this issue using technology, we propose the concept of introducing facial synchronization in the virtual realm as a means to manipulate the boundary between oneself and others. We designed an experiment using Cyberball that simulates an ostracism environment, effectively partitioning the boundary between the self and others. This task was conducted in Virtual Reality (VR), with the agent's facial expressions synchronized with those of the participant. Our findings indicated a reduction in feelings of alienation within the ostracism environment. This discovery has potential implications for communication media, particularly in enhancing interfaces for individuals who may experience exclusionary behavior on social media.

Keywords: Social stress; virtual reality;facial mimicry;social support; self-other boundaries;

Introduction

In modern cyber media, exemplified by social networking services (SNS), communication has undergone a transformation, transcending the constraints of physical reality. These platforms facilitate effortless video calls with distant relatives and friends and foster connections with individuals never encountered in the physical world. Additionally, the metaverse's emergence (Weinberger, 2022) introduces the enticing prospect of engaging in immersive communication within virtual spaces, bridging the gap between digital and physical realities while instilling a sense of body ownership.

The removal of physical communication constraints or the introduction of new physical (body) constraints in virtual space allows individuals to partake in rich and fulfilling experiences within a social community of peers who share similar interests and tastes (Lin & Lu, 2011). However, a potential drawback is highlighted connections among people with shared preferences may lead to echo chambers, reinforcing beliefs and attitudes within the participating community (Cinelli, De Francisci Morales, Galeazzi, Quattrociocchi, & Starnini, 2021). Notably, on Twitter, anonymity can amplify racist opinions (Criss, Michaels, Solomon, Allen, & Nguyen, 2021).

Echo chambers is just one challenge in the cyber-space landscape; daily internet searches are also biased by filter bubbles, tailoring results according to individual preferences (Dahlgren, 2021). The development of echo chambers and filter bubbles prompts exclusive behavior towards those with different attributes, leading to conflicts like cyberbullying or group polarization (Iandoli, Primario, & Zollo, 2021).

This paper addresses these individual and group challenges by highlighting the importance of "self/other boundaries" in the relationship between oneself and others. To manipulate these boundaries using information technology, the concept of introducing facial synchronization to others in cyber-space is proposed. Facial expressions, effective in conveying emotions in real-world communication, are routinely emulated through emoticons in cyber communication. Turning on the camera in video communication has also been considered to enhance engagement (zoom, 2022). Furthermore, in a developing metaverse, manipulation of self and others' displays will be possible (Osawa, 2014).

Numerous studies delve into the social psychological impact of facial expressions. For instance, a study grounded in the facial expression feedback hypothesis revealed that altering one's face slightly in a mirror can manipulate mood (Yoshida, Tanikawa, Sakurai, Hirose, & Narumi, 2013). The expectation is that deforming one's own face can lead to an improvement in mood.

Furthermore, studies on mirror neuron systems (Rizzolatti & Craighero, 2004) and neonatal imitation (Meltzoff & Moore, 1989) exhibit that synchronizing facial expressions with others is a fundamental mechanism underlying human social intelligence. Based on these findings, we consider that synchronizing facial expressions blurs the boundary between self and others in communication, fostering an increased sense of belonging to one's own group. Consequently, it is hypothesized that synchronization of facial expressions, particularly when an individual experiences exclusionary behavior from others, has the potential to diminish negative feelings such as alienation. To scrutinize the alterations in the self/other boundary associated with facial synchronization, we leveraged the task called Cyberball (Williams, Cheung, & Choi, 2000). This microworld task, commonly utilized in social psychology, is specifically designed to explore the dynamics of exclusion from groups.

Related Studies

In this section, we first present research related to the theoretical background of this study. Then, previous studies related to the experimental problem set in this study are described. Following that, we delve into studies related to the methods

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used to change the boundary between self and others. At the end of this chapter, we present the objectives of this study based on the findings from previous research.

Emotional Role of Facial Mimicking

Emotional role of facial synchrony has been considered having a postive effect like the chameleon effect, unconscious mirror neuron effects (Chartrand & Bargh, 1999). There are also studies relatiog "facial mimicry." Unlike the Matched Motor hypothesis of action mimicry, the study by Hess and Fischer (2013) reveals that emotional imitation involves perceiving relevant emotions, considering the partner's background. The introduction of facial imitation amplifies perceived similarity, likability of the other person, and contributes to enhanced emotional understanding.

Previous experiments focused on eliciting imitation through facial synchronization, fostering favoritism toward others (Higashi, Isoyama, Sakata, & Kiyokawa, 2021). For instance, participants synchronizing facial expressions in a video call exhibited smoother communication and increased willingness to continue talking, accompanied by more smiles. This study suggests that facial synchronization not only changes perceptions but also blurs the boundary between self and others.

Experimental Tasks to Experience Emotions in Social Situation

There are experimental tasks focusing on group and individual exclusion. One example is Cyberball, which has been used in studies of ostracism and acceptance. The experiment conducted by Williams et al. (2000) used Cyberball to compare exclusion effects in the virtual and real worlds. The experiment showed that the same effects of real-world exclusion can occur in the Internet society as in the real world.

Delving further into the neural responses associated with Cyberball-induced exclusion, Eisenberger, Lieberman, and Williams (2003) utilized fMRI to observe blood oxygenation level-dependent responses (BOLD) in participants' brains. The findings revealed heightened activity in the anterior cingulate cortex, a brain region linked to physical distress, when participants experienced exclusion. This neuroscientific evidence underscores that Cyberball-induced exclusion can evoke responses to those encountered in real-world distressing situations.

Distress in Cyberball occurs even when it is explicitly stated that the other players are not real people but agents controlled by a computer. Zadro, Williams, and Richardson (2004) conducted experiments in which the Cyberball was performed with a computer and a condition in which the task was performed as if it were a person. Zadro et al. reported that there was no significant change in the experimental results when the task was performed with a computer agent and when the task was performed with a person.

Recognizing the emotional toll of Cyberball-induced alienation, efforts have been made to explore methods for alleviating such feelings. Hermann, Skulborstad, and Wirth (2014) conducted a study that involved participants writing about people they trusted in the form of an essay before engaging in Cyberball. While this approach showed promise in reducing alienation, it was not universally effective, particularly for participants with attachment concerns.

The Self-Other Boundary in VR

The social psychological effects of Virtual Reality (VR) have been examined by many studies. Ma, Sellaro, Lippelt, and Hommel (2016) conducted an experiment in which a virtual self face was generated and posted to participants. The researchers observed that the participants mood improved when their own faces were transformed into smiling faces and displayed. This is due to the instantaneous imitation of the virtual face and the contagion of emotion. The results suggest that viewing oneself from a positive perspective contributes to improving one's mood.

In another experiment, participants were given the ability to fly like a superhero in VR to experience helping behavior (Rosenberg, Baughman, & Bailenson, 2013). This experience reinforced the concept of superheroes and induced helping behavior in the real world. Thus, it has been shown that helping behavior in VR has an impact in the real world.

Several researchers conducted Cyberball in VR space (Kassner, Wesselmann, Law, & Williams, 2012; Stallmann et al., 2022; Kano & Morita, 2020). Among them, Kano and Morita (2020) examined the effects of VR in an inverted cyberball where the role of the participant is switched to one of the ostracising agent. The results showed that the use of VR created a sense of embodiment by moving the arm, making it easier to notice the exclusion situation; it can be considered that the use of VR increased the sense of motor and physical subjectivity, creating an environment in which participants could concentrate on the task.

Objective

The purpose of this study is to investigate the effects of facial synchronization on self/other boundaries using cyberball as a task. As described in the second section, it has been shown that the names of loved ones and people one can rely on in a Cyberball environment reduces alienation. Facial synchronization has also been shown to have a positive effect on communication. However, the effect of facial synchronization has not been examined in this task. Therefore, we setup an experiment where participants participate Cyberball with virtually introduced facial synchronization.

The sense of alienation in Cyberball is thought to lead to the perception that the self is not a member of the group. Synchronizing the facial expressions of self and others in Cyberball is thought to blur the boundary between self and others in interpersonal relationships, increase one's sense of belonging to the group, and reduce negative emotions.

Evaluation on the Facial Synchronization

A preliminary experiment was conducted to evaluate the facial synchronization method used in the study. In the exper-

Table 1: AU and SRanipal Correspondence Table

AU(action unit)	SRanipal
AU01	Eye_Left_Left, Eye_Right_Left
AU02	Eye_Left_Right, Eye_Right_Right
AU04	Eye_Left_Down, Eye_Right_Down
AU05	Eye_Left_Up, Eye_Right_Up
AU12	Mouth_Smile_Left, Mouth_Smile_Right
AU15	Mouth_Sad_Left, Mouth_Sad_Right
AU17	Mouth_Ape_Shape

iment, participants observed the facial synchronizing agent introduced in the later part and evaluated question items relating the effect of facial synchronization.

Methods

Participant In this study, an experiment was conducted on 26 participants (19 males and 6 females). The average age of the participants was 20 years old.

Materials HTC VIVE PRO[1] and Vive Facial Tracker[2] were used as the hardware for facial synchronization. HTC VIVE PRO is a VR device that can acquire information around the eyes. The Vive Facial Tracker is a device that can acquire information around the mouth in real time. We used SRanipal[3], a facial expression recognition software that reads the participant's facial expressions and moves the avatar according to 30 facial expression categories. The avatar was created using Blender[4] with a square face and blue color. The position of the eyes and mouth of the face were implemented to follow the Golden Ratio (Pallett, Link, & Lee, 2010).

The width of each part (eyebrow, eye, and mouth) were determined to follow "Human Body Dimensions Database 1991-92 (Kouchi & Mochimaru, 2005)". For facial expressions, we used the Action Unit (Ekman & Friesen, 1984) based on the SRanipal classification. The correspondence between the SRanipal categories and Action Units (AU) used in this study is shown in Table 1. Following these correspondence, the obtained values of the SRanipal is converted to the AU values whose maximum position is presented in Figure 1. The experimental environment was built using Unity[5]. The avatar's facial expressions were moved within the range of the shape key.

Design We conducted a comparison between the aforementioned facial synchronization condition and a random control condition in which the avatar's facial expression changed randomly every 1.5 seconds. These two conditions were established as a between-participants factor. Each condition consisted of 13 participants, resulting in a total of 26 participants.

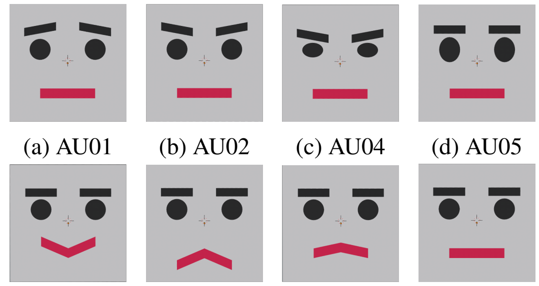
[1]HTC VIVE PRO: https://htcvive.jp/item/99HASZ017-00.html

[2]https://www.vive.com/jp/accessory/facial-tracker/

[3]https://developer.vive.com/resources/vive-sense/eye-and-facial-tracking-sdk/tutorials/sranipal-getting-started-steps/?site=kr

[4]https://www.blender.org

[5]https://unity.com/



(a) AU01 (b) AU02 (c) AU04 (d) AU05

(e) AU12 (f) AU15 (g) AU17 (h) Fixed

Figure 1: Facial expression generated by the maximum AU value setting

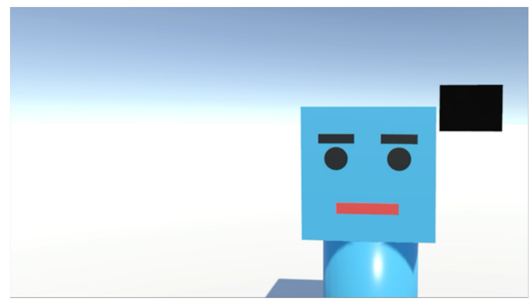


Figure 2: Screen for evaluating the facial synchronization.

Procedure After the participants wear the VIVE devices, they faced the agent in a VR environment. The screen displayed the agent and a black screen next to it (Figure2). The background was white.

Following the participants' wearing of the VIVE devices, they were positioned in a VR environment facing the agent. The screen displayed the agent and adjacent black screen for showing scripts (see Figure 2). The background was set to white.

After the experimenter instructed the participants to "move your face freely while looking at the screen," the following instructions to make one of the emotion category were displayed in white letters on the black screen to the right of the avatar ("Make a smile/angry/sad/supprise face"). These instructions were based on the previous study on the feeling of synchrony (Nakazato et al., 2014). This instruction was switched every 15 seconds. After the task was completed, a questionnaire was conducted as described below.

The questionnaire was constructed based on the previous study (Ma et al., 2016), which is presented on Table 2. Those questions can be classified into perceived ownership (Q1-1 and Q1-2), perceived appearance similarity (Q1-3 and Q1-4), perceived agency (Q1-5 to Q1-9), and mood (Q10). Unless otherwise stated, all questions were rated on 7-point scales (where 1 = not at all, and 7=very much so)

Result and Discussion

The results obtained from the questionnaire are shown in Figure 3, where the Weltch's t-values are shown in the bottom of

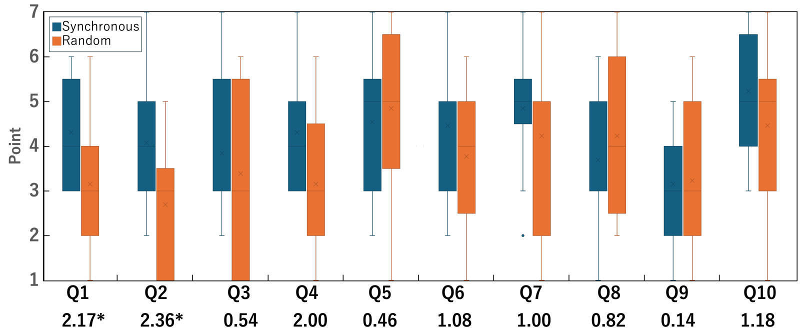


Figure 3: Results of the evaluation of facial synchronization. The numbers under the horizontal labels indicate F statistics.

Table 2: Questions for the evaluation of facial synchronization.

Q1-1.	I felt like the face on the screen was my own face
Q1-2.	It seemed like I was looking at my own reflection in a mirror
Q1-3.	It seemed like the face on the screen began to resemble my own face
Q1-4.	It seemed like my own face began to resemble the face on the screen
Q1-5.	It seemed as though the movement I saw on the face on the screen was caused by my own movement
Q1-6.	The face on the screen moved just like I wanted it to, as if it was obeying my will
Q1-7.	Whenever I moved my face, I expected the face on the screen to move in the same way
Q1-8.	It seemed like my own face was out of my control
Q1-9.	It seemed the face on the screen had a will of its own
Q1-10.	I feel I am happier than I was before the manipulation

the label. From the figure, we can confirm the significant difference between Q2 and Q3, indicating the effect of facial synchronization on the perceived ownership.

Experiment

Objective

We examine the impact of facial synchronization in Cyberball to intervene in the boundary between self and others in cyber space.

Methods

Participant Twenty-four Shizuoka University undergraduate students (18 males and 6 females) majoring in engineering and informatics participated. The participants were paid 1,500 yen for their cooperation in the experiment.

Environment The equipment used in the experiment and the method of facial synchronization were the same as in the evaluation experiment. The screenshot of Cyberball is shown in Figure 4, where two agents are faced with the participant. At the game, the agent receives a ball and throws it to the participant or the other agent. When the participants received the ball, they throw it by moving their arm holding Vive controller. During the game, the agents' faces tracked the position of the ball.

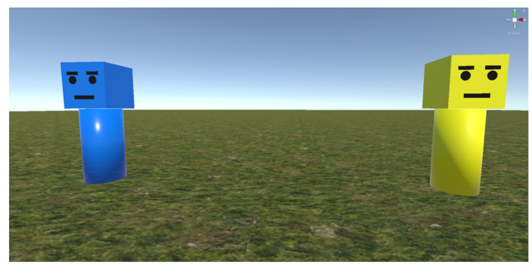


Figure 4: Cyberball Environment

Design To analyze the effect of facial synchronization on the participants' states, we set up a 2 [synchronization: synchronous vs. fixed (between-participant)] $\times$ 2 [ostracism: inclusion vs. ostracism (within-participant)] factorial design. In the synchronous condition, the facial expressions of the two agents were synchronized with those of the participants while the agents' faces in the fixed condition did not move from the (h) in Figure 1.

The color of the agents was designed so that the two agents were paired, referring to the hue color circle. The right side was designed to be red or yellow, and the left side was designed to be green or blue, as seen from the participants. In each combination, the order of the two between-participant and within-participant conditions and the agent color were counterbalanced, resulting in a total of eight possible combinations. For each combination, three participants were assigned.

Procedure The participant engaged in the two tasks of Cyberball. Before them, they performed a test play to practice the operation. The test play also served the purpose of calibrating parameters of facial expressions.

The task was performed for 5 minutes in both agent conditions. In the inclusion condition, one participant and two agents played a normal ball tossing game. In the ostracize condition, the first minute was the same as in the inclusion condition, and then the participant was excluded from the agents for 4 minutes. A questionnaire was conducted after the completion of each task.

Table 3 displays the items of the questionnaire. These

Table 3: Questions for mitigating ostracism.

Q2-1.	What percent of the throws were thrown to you
Q2-2.	To what extent were you included by the other participants during the game
Q2-3.	I felt poorly accepted by the other participants
Q2-4.	I felt as though I had made a "connection" or bonded with one or more of the participants during the Cyberball game
Q2-5.	I felt like an outsider during the Cyberball game
Q2-6.	I felt that I was able to throw the ball as often as I wanted during the game
Q2-7.	I felt somewhat frustrated during the Cyberball game
Q2-8.	I felt in control during the Cyberball game
Q2-9.	During the Cyberball game, I felt good about myself
Q2-10.	I felt that the other participants failed to perceive me as a worthy and likeable person
Q2-11.	I felt somewhat inadequate during the Cyberball game
Q2-12.	I felt that my performance [e.g., catching the ball, deciding whom to throw the ball to] had some effect on the direction of the game
Q2-13.	I felt non-existent during the Cyberball
Q2-14.	I felt as though my existence was meaningless during the Cyberball game
Q2-15.	Rate the current mood: bad/good
Q2-16.	Rate the current mood: sad/happy
Q2-17.	Rate the current mood: tense/relaxed
Q2-18.	Rate the current mood: aroused/not aroused
Q2-19.	I felt angry during the Cyberball game
Q2-20.	I enjoyed playing the Cyberball game
Q2-21.	How much did you like the other players
Q2-22.	How much did the other players like you

Table 4: Results of the manipulation check (Q2-1).

	Synch	Fixed
Inclusion	58.36% (22.13)	50.45% (16.84)
Ostracize	8.00% (5.76)	10.36% (7.65)

items were selected following a previous study that investigated the effects of ostracism (Zadro et al., 2004). The questionnaire includes items for manipulation checks (Q2-1 and Q2-2), ratings on the feeling of belonging (Q2-3 to Q2-5), control (Q2-6 to Q2-8), self-esteem (Q2-9 to Q2-11), and meaningful existence (Q2-12 to Q2-14). Mood was also assessed with four bipolar questions (Q2-15 to Q2-18). Additionally, the questionnaire included four ancillary variables (Q2-19 to Q2-22). Items other than manipulation check were rated on 9-point scales, where 1=not at all and 9=very much so.

After the completion of the two tasks of Cyberball, the participants also answered whether or not they had noticed the facial synchronization, and then to rate the degree to which the agent's facial expression was synchronized with their own face on a four-point scale.

Result

Table 5: Results of the manipulation check (Q2-2).

	Synch	Fixed
Inclusion	2.90 (1.44)	2.27 (1.03)
Ostracize	8.00 (1.41)	8.27 (0.61)

Manipulation Check We initially assessed the functionality of Cyberball in this experiment, aligning with previous research. Tables 4 and 5 display the averages (standard deviation in parentheses) for Q2-1 and Q2-2, respectively. For each table, we conducted a 2×2 ANOVA. Concerning Q2-1, a significant main effect was observed for ostracism ($F(1,20) = 169.83$, $p < .01$), while the main effect for synchronization ($F(1,20) = 0.25$, $p > .05$) and the interaction between the two factors ($F(1,20) = 2.19$, $p > .05$) were not significant. Similarly, ANOVA on Q2-2 demonstrated a significant main effect for ostracism ($F(1,20) = 208.46$, $p < .01$), with no significant main effect for synchronization ($F(1,20) = 0.25$, $p > .05$), and no significant interaction between the two factors ($F(1,20) = 1.40$, $p > .05$). These outcomes affirm the effectiveness of the ostracism manipulation in the current experiment.

Awareness of Facial Synchronization To assess the participants' awareness of facial synchronization, a chi-square test was conducted on the final questionnaire item, specifically, the question regarding whether or not participants were aware of facial synchronization. The analysis revealed a significant difference ($\chi^2(1) = 9.18$, $p < 0.01$) in responses between the two conditions: in the synchronous condition, 12 participants were aware, and none were unaware, while in the asynchronous condition, 4 participants were aware, and 8 participants were unaware. Consequently, the synchronization condition demonstrated an impact on participants' awareness in relation to the ostracism situation.

Effect of the Facial Synchronization on Mitigating Ostracism To focus on the effect of facial synchronization, the rated scores for each participant on each item were subtracted from the inclusion condition to the ostracism condition. The calculated score is presented in Figure 5.

We calculated Welch's t-values for independent questions (Q2-15, Q2-16, Q2-17, Q2-18, Q2-19, Q2-20, Q2-21, Q2-22). The other questions for the rating of the belonging, control, self-esteem, meaningful existence are related to alienation caused by ostracized situation. Therefore, we grouped those questions to conduct 3 [question items] × 2 [synchronization vs. fixed] mixed design analyses of variance (ANOVAs). In the figure we reported F-values for the main effect of the synchronization (the left numbers) and the interaction between the items and the synchronization (the right numbers). Among the items presented in the figure, we found a main effect of synchronization in the rating of control ($F(1,22) = 4.57$, $p < 0.05$) and a significant difference between the conditions for Q2-21 ($t(18) = 2.793$, $p < 0.05$).

Discussion

The hypothesis that facial synchrony reduces feelings of alienation in the ostracism condition found support in questions related to "control," indicating that subjects felt more in control of themselves in the ostracize condition compared to the fixed condition. However, the results of Q2-21 were not

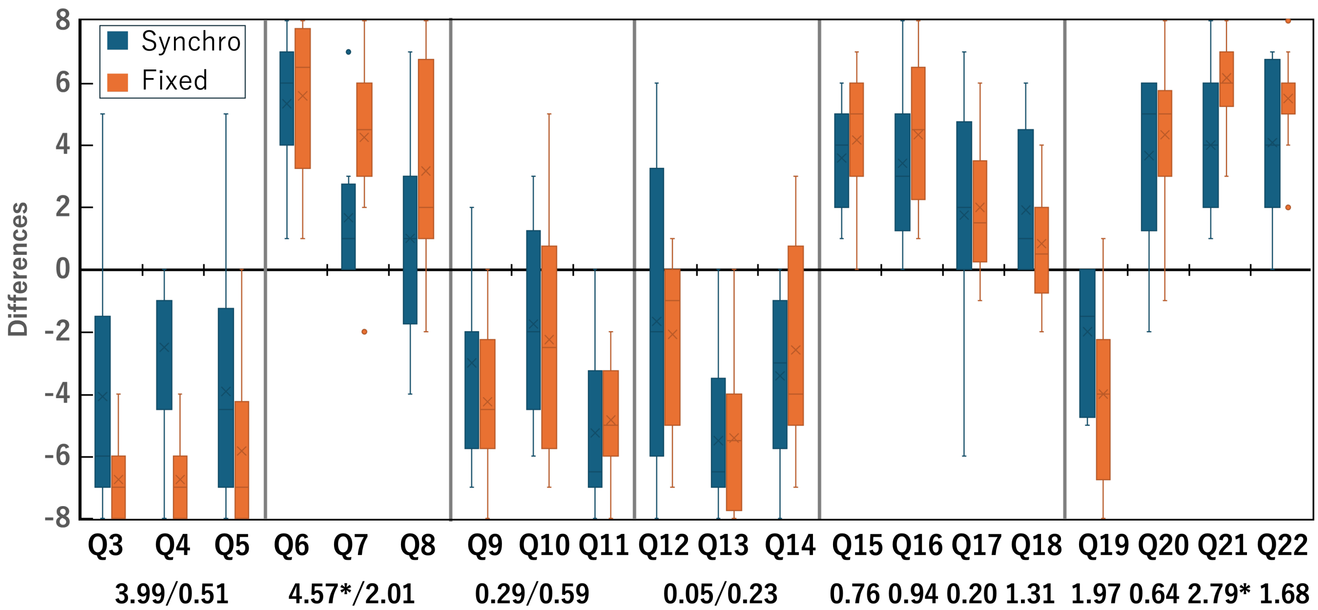


Figure 5: Results of the experiment. The numbers under the horizontal labels indicate F statistics.

as predicted, revealing that participants preferred fixed-face agents over face-synchronizing agents. Regarding this result, we have confirmed that the main reason of the difference were from the inclusion condition.

The results can be viewed as changes in the boundary between self and others. In the inclusion condition, the facial synchronization caused the participants to distrust the agent. This may be due to the fact that the agent is perceived as a stranger. In most of the previous studies on facial synchronization, verbal communication was used (Raja, Laohakangvalvit, Sripian, & Sugaya, 2021; Higashi et al., 2021). In contrast, in this experiment, the agent plays ball-tossing game. In such a situation, there is a possibility that the agent is recognized only as the other person. Therefore, we believe that the presence of facial expressions may clarify the boundary between self and others and cause a sense of aversion.

Conclusion

This study controlled the relation between self and other to mitigate alienation caused by ostracism situation. The result of the experiment indicates the effect of facial synchronization, suggesting that the virtually introduced facial manipulation has an effect on reducing the feeling of alienation. This blurring of the boundary between self and others is thought to have increased the sense of belonging to one's own group. We consider that such a technology can be used in the future interface to realize harmonious digital society.

However, the effect of facial synchronization is limited. To promote the effect, we need to improve this technology. In the current experiment, it is possible that the agent's face may not well be recognized when it operates as facial synchronization with the participant. In fact, the average score of the question about the degree of synchronization in the final questionnaire was not so high. This is due to the fact that the avatar has been simplified to make it less human than the original human AU. Therefore, in order to improve the accuracy of facial synchronization, it may be worth to consider to make the model more human-like or to devise ways to make the user notice the facial synchronization.

Another limitation of the present study pertains to the control condition. In the control condition, the facial expressions of the two agents remained static, which makes it difficult to confirm the effect of facial synchronization. There is a possibility that the observed reduction in alienation might be caused solely by the fact that the agents' facial expressions were in motion, rather than being a consequence of their facial synchronization. Therefore, future experiments should consider including additional conditions in which facial expressions move randomly to distinguish the effects more precisely.

The results of this study may provide new methods and approaches in social communication and communication. In this study, facial synchronization was shown to reduce feelings of alienation when a person is excluded from a group. We believe that this finding will contribute to the design of future communication media. For example, we believe that improving the interface of the recipient of exclusion from exclusionary behavior caused by echo chambers on Social networking sites can improve the psychological resilience of the individual.

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