

Augmented reality-based physical activity promotes self–other overlap in Japanese college students

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Abstract:

Problem statement Empathy is an essential ability that enables understanding of others' emotions and promotes the self–other overlap. Physical activity can increase empathy, particularly when combined with augmented reality (AR) systems, which appear to provide additional advantages. Although empathy promotes self–other overlap, the effects of AR-based physical activity on self–other overlap remain unexplored. **Purpose** This study investigated the impact of AR-based physical activity on self–other overlap. **Approach** A total of 36 second-year Japanese college students (26 males, 10 females) from two universities participated in the study. All participants followed the same protocol because the study was integrated into the physiology class within the university curriculum. The study was performed during the 11th to 13th sessions of this class. Participants completed the Japanese version of the Inclusion of Other in the Self Scale (IOSS), which assesses psychological overlap with students from the other university. Assessments were performed after remote lectures delivered *via* media in the 11th session (pre), the 12th session (post-lecture), and after participation in an AR-based physical activity session during the 13th session (post-AR). **Results** Participation in AR-based physical activity significantly increased IOSS scores among college students, while the remote classroom lecture delivered *via* media had no effect on self–other overlap (pre vs. post-lecture: $p > 0.9999$, pre vs. post-AR: $p = 0.0003$, post-lecture vs. post-AR: $p = 0.0011$). **Conclusion** Engaging in AR-based physical activity improves self–other overlap among college students. These findings highlight the potential of AR-based interventions to promote social interaction.

Keywords: Educational tool, Empathy, Physical activity, Self–other overlap

Introduction

Empathy is a fundamental human ability that enables the recognition and understanding of others' emotions, and it is essential in self–other overlap (Cialdini et al., 1997; Ioerger et al., 2019). This overlap is a key mechanism in identity formation and the maintenance of interpersonal relationships in social contexts (Decety & Jackson, 2004; Preston & de Waal, 2002). Therefore, empathy is an essential factor in supporting human well-being.

Physical activity has been recognized as a promising intervention for enhancing empathy. Previous studies highlight its beneficial effects, especially through sports participation, in improving social skills (Bedard et al., 2020; Steca et al., 2018). Moreover, our studies indicate that empathy in young adults can be shaped by engagement in physical activity (Shima, Jesmin, et al., 2021b, 2021a, 2022; Shima, Tai, et al., 2021). Physical activity also contributes to fostering self–other overlap, a key component of social connectedness (Cody et al., 2022; Zumeta et al., 2016). Thus, optimizing physical activity programs have the potential to further enhance self–other overlap, promoting stronger interpersonal understanding and social bonds.

Leveraging extended reality (XR) technologies—including virtual reality (VR), augmented reality (AR), and mixed reality (MR)—is a promising method to facilitate exercise in various environmental conditions while potentially enhancing self–other overlap. XR-based communication has proven effective in strengthening social interactions (Dong et al., 2013; Rogers et al., 2022). Its applications are rapidly growing across fields such as sports science and education, enhancing human capabilities (Fernández-Batanero et al., 2024; Kaźmierczak et al., 2024; Le Noury et al., 2023). Notably, AR-based group exercises have been shown to stimulate oxytocin secretion—an important neuropeptide related to empathy—more effectively than solitary exercise (Shima et al., 2024). Therefore, XR-based interventions may be effective tools for fostering self–other overlap and enhancing social connectedness.

In Japan, an initiative has been established in which two geographically distant universities collaborate to form a unified Faculty of Education, known as the Cooperative Faculty of Education. Within this faculty, remote instruction using media is employed, and enhancing interaction between students from both institutions remains a key challenge. This study investigates the effects of AR-based physical activity, performed as part of a

college class within the Cooperative Faculty of Education, on self-other overlap. Not all students actively participate in the exercise owing to the class structure; some only observe and are also included in the study. Because previous studies show that observing sports can promote social bonding (Guo et al., 2024), the hypothesis is that participation in AR-based physical activity will enhance self-other overlap with students from the other university.

Materials and methods

Participants

Thirty-six second-year Japanese college students (26 men and 10 women), aged 19–20, participated in the study. Among them, 20 were from University A, and 16 were from University B. The study received approval from the Utsunomiya University Ethical Review Board for Medical Research Involving Human Subjects (ethical number H23-0012).

Experimental diagram

All participants adhered to the same protocol because this study was integrated into a physiology class, which is a key part of the Cooperative Faculty of Education curriculum. The physiology course comprised fifteen 90-min sessions, held weekly. The study was performed during sessions 11 through 13. Sessions 11 and 12 consisted of remote lectures delivered *via* media, while session 13 included AR-based physical activity as part of the physiology exercise. The experimental framework is depicted in Fig. 1.

During the remote lectures in sessions 11 and 12, students from the two universities participated in a 15-min discussion. In session 13, three students from each university engaged in a cycling exercise using AR technology, while the remaining students observed and assisted with biochemical data collection. The class instructor was male.

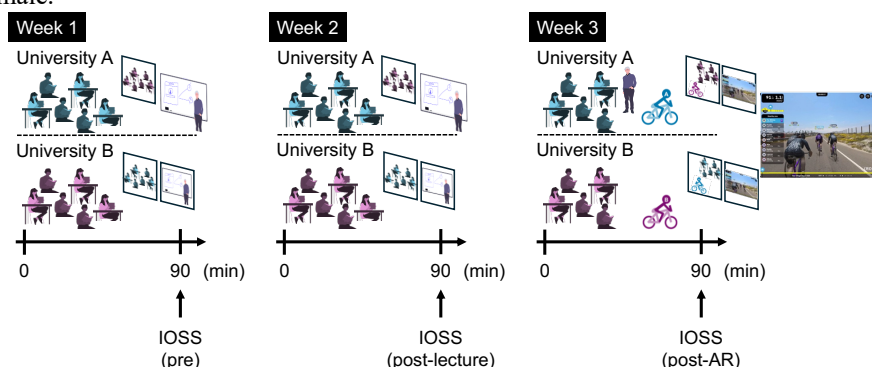


Fig. 1. Experimental diagram. The current study was conducted during sessions 11 to 13 of the physiology course within the Cooperative Faculty of Education curriculum. Sessions 11 and 12 consisted of remote lectures delivered via digital media, whereas session 13 incorporated AR-based physical activity as part of the physiology practicum. Following each session, participants completed the Japanese version of the Inclusion of Other in the Self Scale (IOSS).

AR-based physical activity

AR-based cycling races served as the physical activity in this study. The races were performed using the SmarT Turbo KAGURA (LST9200, MINOURA Co., Ltd., Japan) combined with the ROUVY application (VirtualTraining Co., Ltd., Czech Republic). Three students from each university participated, completing three races in total, each lasting approximately five minutes.

Questionnaires

The participants completed the Japanese version of the Inclusion of Other in the Self Scale (IOSS) (Aron et al., 1992; Vyrastekova, 2021) after each session. The IOSS uses a 7-point Likert scale (Fig. 2), where the left circle represents the participant and the right circle represents students from the other university. Participants chose the response that best represented their perceived relationship with students from the other university. A higher score reflects a greater degree of self-other overlap.

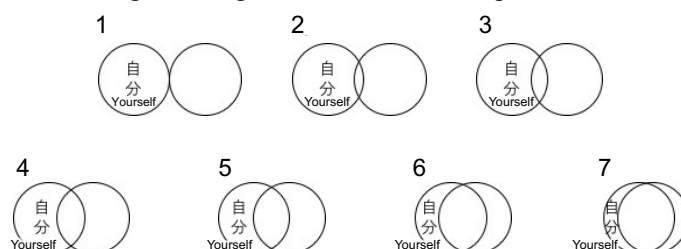


Fig. 2. The Inclusion of Other in the Self Scale. The left circle means the participant (yourself), and the right circle means students from the other university. Participants were asked to select the option that best described their relationship with students from other universities from a list of seven predefined choices.

Statistical analysis

Nine of the 36 participants were excluded for missing more than one session or submitting incomplete questionnaires. Therefore, data from 27 participants (19 men and 8 women; 15 from University A and 12 from University B) were analyzed. The analysis was performed using Prism version 10.4.1 (MDF, Tokyo, Japan). Comparisons used repeated one-way ANOVA followed by Tukey's multiple comparisons test. Statistical significance was set at $p < 0.05$.

Results

As shown in Fig. 3, participation in AR-based physical activity significantly increased IOSS scores among college students, while the remote classroom lecture using media had no effect on these scores ($F_{(1.40, 36.42)} = 16.41, p < 0.0001$; pre vs. post-lecture: $p > 0.9999$; pre vs. post-AR: $p = 0.0003$; post-lecture vs. post-AR: $p = 0.0011$).

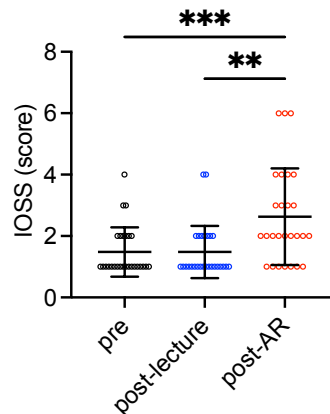


Fig. 3. Changes in self–other overlap among college students during the class. Data are presented as mean $\pm$ SD with individual values (black: pre, blue: post-lecture, and red: post-AR), males: $n = 19$, females: $n = 8$. ** $p < 0.01$, *** $p < 0.001$.

Discussion

In this study, we investigated the impact of engaging in AR-based physical activity on self–other overlap among college students. Our results demonstrated that participation in AR-based physical activity led to a significant increase in IOSS scores among the students.

Physical activity has been shown to enhance self–other overlap (Cody et al., 2022; Zumeta et al., 2016), which is consistent with the findings of this study (Fig. 3). Previous research has shown that AR-based physical activity can increase oxytocin secretion (Shima et al., 2024), a hormone associated with promoting empathy (Geng et al., 2018). Although this study did not directly compare AR-based physical activity with other forms of exercise, AR-based interventions may serve as valuable educational tools in collaborative settings between geographically distant universities. Additionally, in this study, only 6 of the 27 participants actively engaged in the exercise, while the remaining 21 observed the activity and participated in biochemical data collection during the AR-based physical activity. Because observing sports has been shown to promote social bonding (Guo et al., 2024), participating in this AR-based practice may help strengthen interpersonal connections even for those who did not physically participate in the exercise.

In contrast, the remote classroom lecture delivered via media did not result in an improvement in IOSS scores (Fig. 3). Although the lecture included a 15-min discussion between students from the two universities, simple verbal interaction may be insufficient to enhance self–other overlap (Koudenburg et al., 2017). These results suggest that shared exercise experiences may be more effective in promoting psychological overlap.

This study has several limitations. First, it did not consider the potential effects of other events, such as additional classes, which might have influenced the outcomes. This indicates the need for a more comprehensive evaluation of the curriculum's overall impact on self–other overlap. Second, the study did not analyze specific physical activity regimens, including intensity and duration. Previous studies show that light-intensity exercise can positively affect empathy (Shima, Kawabata-Iwakawa, et al., 2022), underscoring the importance of further detailed investigations. Third, teacher–student interactions were not assessed. Because teacher feedback may contribute to changes in adolescent empathy (Shima & Suzuki, 2024), it could act as a moderator of self–other overlap. Future studies should address this factor to improve understanding.

Conclusions

Our findings indicate that participation in AR-based physical activities enhances self–other overlap among college students, regardless of physical distance. On the other hand, the remote classroom lecture, which involved physical distance, had no significant effect on self–other overlap among college students. These results demonstrate the utility of AR-based physical activity in educational contexts and highlight the potential of AR-based interventions in promoting social interaction and strengthening interpersonal connections.

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Conflicts of interest

The authors declare no conflict of interest with any financial organization regarding the material discussed in this manuscript.

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