A-Vibe: Exploring the Impact of Animal-form Avatars on Students' Connectedness and Social Presence through Delivering Honest Signals in Live Online Classes

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Abstract. The outbreak of the coronavirus pandemic has made online video conferencing a common delivery method of education worldwide. Research has shown that students in online learning environments often experience isolation and alienation, a situation which can be improved by increasing their social presence. In this study, A-Vibe, a non-real-time animal-form avatar system has been created to transform the user's current honest state into a customised animal form, thereby contributing to the user's social presence and connectedness in the online learning environment. The results of this study provide important insights and ideas on the impact of introducing animal-form avatars on students' connectedness and social presence in live online classes.

Keywords: Avatar, Live online class, Honest signal, Connectedness, Social presence

1 Introduction

The coronavirus pandemic has made online video conferencing a common mode of education delivery worldwide [42]. While e-learning platforms like Microsoft Teams or Zoom have provided useful advantages, the shift to online education has posed several challenges, e.g., the loss of structure and routine, as well as changes in social connections [36]. The occurrence of online learning instruction results in students missing out on opportunities to interact or share their backgrounds with the teacher and other students [12]. In the USA, a majority of undergraduate and graduate students identified the absence of peer interaction and communication as the primary challenge in adapting to online education [44].

Compared with physical face-to-face interaction, communicating through video conferencing-mediated tools is an artificial experience [22]. The physical separation creates a barrier to communication as these mediated systems lack "media richness" and support for both verbal and non-verbal communication [5].

Research [40] suggests that increasing social presence, the level to which one is perceived as "real" in mediated communication, can address the isolation and detachment experienced by learners in online learning environments. Rourke et al.

[38] further identified the importance of developing social presence to establish online learning communities. Learners' ability to establish satisfactory a social presence is crucial in the online learning environment [8]. However, limited empirical evidence is available on learners'

connectedness within their communities [41], highlighting the need for further research on connectedness and presence in online learning environments.

In this study, A-Vibe, a non-real-time animal-form avatar system, was introduced to video conferencing communication. It transforms the student's current honest state into a vivid, customised animal form, thereby attempting to amplify subtle physical and non-verbal signals. An experiment was conducted to explore and evaluate connectedness and social presence using A-Vibe. The objective of this study is to investigate the impact of animal-form avatars in the live online class environment on students' connectedness and social presence through the delivery of honest signals. As such, the following research question is proposed: What are the effects of introducing animal-form avatars that can transmit honest signals to live online classes on students' connectedness and social presence?

2 Related Work

2.1 Online Education

Online education in higher education has experienced exponential growth recently [30], yet it may not be a complete substitute for the face-to-face mode [16]. Learners have to interact with other learners and experts in online education. This presents one of the challenges of online education: the lack of real-time interaction, which can negatively affect students' basic psychological needs [9], [23]. Research shows that computer-mediated communication creates a time-space shift that reduces communication, weakens social connections, and increases isolation [6-7]. Software that facilitates real-time online video connections is constantly developing, allowing teachers and students to conduct live online classes.

2.2 Social Presence

Social presence, as described by Short et al. [43], refers to the degree of salience of the other person in the interaction and the interpersonal relationships that ensue. Short et al. [43] observed that computer-mediated communication fails to relay vital audio and visual cues from face-to-face communication, leading to reduced potential for developing a high level of social presence. According to this view, the social presence in an online learning environment is less than that in a traditional face-to-face classroom. Short et al. [43] identified intimacy and immediacy as the two core components of social presence, which are closely related [31] and determined by both verbal and non-verbal signals [20]. The ability of a medium to convey information about these cues affects its degree of social presence [11].

Garrison et al. [17] have extended the traditional definition of social presence to "the ability of participants in a community of inquiry to project themselves socially and emotionally, through the medium of communication being used". This social presence can be developed and fostered as individuals in the mediated environment are able to "make up" for lost social cues [45], e.g. expressing moods by using emoticons and displaying humour can affect the perception of social presence [39], [45]. Importantly, social presence is the result of interactions among social participants (i.e. students-students, student-instructors) in an online learning environment [18-19], [33]. The study by Liu et al. [28] presented evidence which showed that social presence is vital to maintaining

a high degree of online social interaction as a significant predictor of course retention in the online education environment.

Social presence is closely related to "connectedness", which has been classified as a form of psychological involvement by Biocca et al. [3]. Ijsselstejn et al. [25] have shown that these two concepts are complementary in the awareness system. Rettie [37] pointed out that connectedness' is potentially useful in the analysis of communication. In this study, connectedness is studied together with social presence as a related concept.

Networked Minds Measure. Biocca et al. [4] identified three essential dimensions of social presence, which they term "Co-Presence", "Psychological Involvement", and "Behavioral Engagement", with corresponding empirically-determined factors. The Networked Minds Measure of Social Presence (NMMSP) questionnaire consists of multiple items for each of these three factors. It proposes a rough hierarchy among the dimensions of social presence and measures the extent to which individuals feel interconnected through networked mediated interfaces [4]. This approach is consistent with other conventional subjective measures of social presence but promises a relatively high degree of reliability in cross-media comparisons.

2.3 Honest (Unconscious) Behaviour

The unconscious mind was defined by Freud [14] as a pool of thoughts, memories, urges and feelings outside of human consciousness. According to Hua and Fei's [24] study of behaviour on interaction design, unconscious behaviour is the representation of unconscious needs based on long-term life experience, psychology, instincts, and emotional influences. Unconscious behaviour may therefore be an important factor in determining demands [26]. Honest signals are considered those that are not processed consciously or are not controllable [30]. Pentland's study [35]focused on "influence, mimicry, activity and consistency" as honest human signals measured by the timing, energy, and variability of the interaction. The experiment observes that people use combinations of honest signals in real life rather than using them individually [35]. In this study, the honest signals served as part of the system design rather than the objects being measured.

3 A-Vibe Design and Experiment

3.1 Design

Platform overview. Microsoft Teams has been chosen as the reference live online class platform for the study as it supports both synchronous and asynchronous online learning [34], providing a well-integrated educational space.

The animal models used in this study were launched by Live2D and PrprLive. Live2D is a software technology that creates dynamic expression into an original 2D illustration and is utilized for a wide range of applications [47]. Prprive is a Live2D live broadcast support software. It enables high-frame-rate Live2D animation with high-performance facial capture [1]. Open Broadcaster Software (OBS) Studio, a free open-source broadcaster software, was used in this study for creating scenes made up of multiple sources as a virtual camera. Specifically, it allows the animal models to be layered on top of the webcam source and then displays the designed scenes. Lastly, Face Analysis (Visage|SDK live), a software development kit developed by the company Visage Technologies AB [13], was used as one of the criteria for assessing participants' emotions in the experiment.

A-Vibe system. Humans can usually explain the emotions of both themselves and animals through the study of facial expressions, gestures, and postures that share a common origin in life [24]. Previous studies suggest that human empathy for animals can transfer to empathy for other humans [46], leading to increased engagement in social interactions when using animal-form avatars. Taking these findings into consideration and inspiration from the theory of "Honest Signals" [35], the A-Vibe system was built. It is important to note that "Honest" state refers to inner real emotions rather than the emotions displayed and observed directly. The use of animal-form avatars is intended to preserve privacy while conveying the individual's honest state, thereby raising the issue of the relationship between the avatar and the learner's sense of self. It should be noted that these animal avatars utilize sample data owned and copyrighted by Live2D Inc., and is created at the authors' sole discretion in accordance with Live2D's terms and conditions [29].

When the user starts the system and chooses one avatar, it presents an idle state. Apart from the real time facial tracking output, seven different moods of the avatars are animated: idle, laughing, sweating, questioning, surprising (shocking), nodding, and clapping. Each animation is triggered by manually pressing the corresponding key on the keyboard. The animation time lasts about three seconds. Pressing the "1" key on the Numpad returns the avatar to the default state immediately.

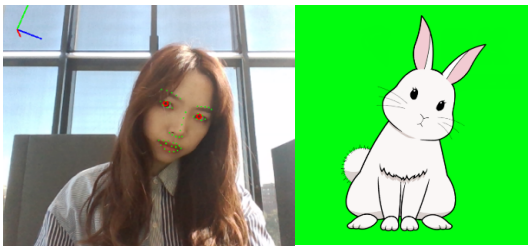

Fig. 1. Examples of interaction with users: (a) tracked face, (b) animated avatar

In OBS the different video sources are combined into one cohesive scene, which is turned into a virtual camera so that Microsoft Teams can use it as the input for the camera. Two scenes were created in OBS, which can easily be switched between: (1) Live video output and avatar (LA), and (2) avatar (AO).

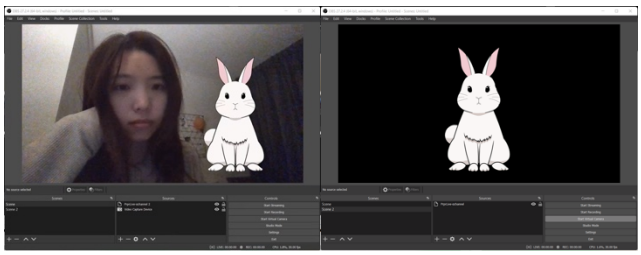

Fig. 2. Two scenes in OBS: (a) LA, and (b) AO (idle/default status of one of the avatars)

3.2 Participants

The participants of the study comprised a total of 16 master's students (mean (M) ± standard deviation (SD) age 24.3 ± 1.40) experienced in online education and studying at Eindhoven University of Technology. The sample was equally divided between males and females. Participants' ages ranged from 22 to 27, with four individuals in the 22-23 age group, six individuals in the 24-25 age group, and six individuals in the 26-27 age group. Purposive sampling, a non-probability sampling

method, was used in the study since it allows researchers to decide which samples will best represent the main audience based on their prior knowledge. Purposive sampling is "used to select respondents that are most likely to yield appropriate and useful information" [27].

3.3 Procedure

The experiment took place in a room with a pre set-up A-Vibe system. Prior to the experiment, participants had received a digital consent form and were briefed on the purpose of the study and the experimental procedures involved. Participants also completed a brief demographic survey that included a question on their level of cooking experience on a scale of 1 to 5 since the class was about cooking.

The experiment consisted of sequential steps: Preparation, Tutorial, Trial 1, Trial 2, Trial 3, and Post-questionnaire. Each participant spent about 50 minutes in total. Participants first selected a preferred avatar from ten options and completed a 3-minute tutorial. They then participated in three trials, one for each situation: face-to-face (FtF), Avatar (AO), and Live Avatar (LA). In the FtF situation, the participant and the experimental assistant were in the same room, while in the other two, they were in separate rooms connected via the online video conferencing interface in Microsoft Teams.

The study was designed as a within-subject experiment, and the order of the three experimental conditions was randomly assigned. In every trial, there were common steps: "Watching video" - "Performing task" - "Survey". Participants watched a 5-minute instructional video about cooking with the experimental assistant. Immediately after the video, they had 2 minutes to describe the steps in making the dish taught in the video with the assistant. At the end of each trial, participants completed a survey, and after all three trials, they filled out a post-questionnaire.

In the AO and LA conditions, participants were in the same room as the experimenter when "Watching video". The experimenter manipulated the participant's avatar based on human observation and Face Analysis results. The participant's inputs had priority over the experimenter's in controlling the animations. During the "Performing task" and "Survey" steps, the experimenter left the room.

3.4 Measures

The survey conducted after each of the three trials consisted of three self-report instruments: (1) The Inclusion of Other in the Self (IOS) Scale [2]; and (2) Semantic differential questionnaire (SDQ) [43]; (3) the NMMSP [3] to measure participants' degree of connectedness and perceived social presence. To minimize the possibility of response bias, the order of the questionnaires for each participant was randomised. The experiment concluded with a post-questionnaire consisting of two general and three open-ended questions aimed at assessing potential customer acceptance of the A-Vibe system and gathering qualitative data, respectively.

The Inclusion of Other in the Self Scale. The IOS scale [2], is a seven-step, interval-level scale used to measure "a person's sense of direct interconnectedness with another". It is a reliable measure of the subjective closeness of a relationship in psychological terms [15], which is used to evaluate the level of closeness of the participant with the experimental assistant after each round of test. In the

IOS scale, participants select the picture that best describes their relationship and each diagram represents a different degree of overlap between two circles (see Figure. 3 below).

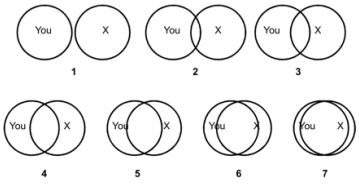

Fig. 3. The IOS scale [15]

Semantic Differential Questionnaires. Short et al. [43] suggested that the semantic differential technique [32] is the primary subjective method used to measure social presence using seven-point bi-polar scales. Eight bi-polar pairs were selected from Short et al.'s SDQ to measure participants' perceived social presence. Four bi-polar pairs were used to measure the presence of social richness. Another four were used to measure the aesthetic sensibility of the media.

Networked Minds Measure of Social Presence. All thirty-eight items of the NMMSP were used in the study to detect the difference between face-to-face and mediated interactions in the level of perceived social presence. The items target the experience of the mediated interactions as the main criterion [3].

4 Results

4.1 Reliability Analysis

A reliability statistical analysis of all items was performed using Cronbach's coefficient alpha. The alpha scores for the factors in SDQ were found to be sufficient (> 0.6). However, for both "Corrected item-total correlation (CITC)" and "Cronbach's alpha if item deleted", "Impersonal-personal" obtained a failing value and therefore was removed. In the NMMSP, the factors "Mutual awareness", "Mutual assistance" and "Dependent action" reached an insufficient alpha score (< 0.6) thus being excluded from further analysis.

1.1 Means Comparison

The mean value and standard error of the degree of connectedness, measured by the IOS scale can be seen in Fig. 4(a) below. The mean values of every condition were compared in an analysis of variance with the FtF, AO, and LA situations as a within-subject factor. The main effect of the situations was significant for connectedness ($F=3.634$, $p=0.034<0.05$). ANOVA post-hoc tests were then performed for multiple comparisons. The connectedness mean score for FtF ($M=6.25$, $SD=1.00$) was significantly higher than that for LA ($M=4.92$, $SD=0.87$, $p=0.035$). No significant differences could be found between FtF & AO and LA & AO.

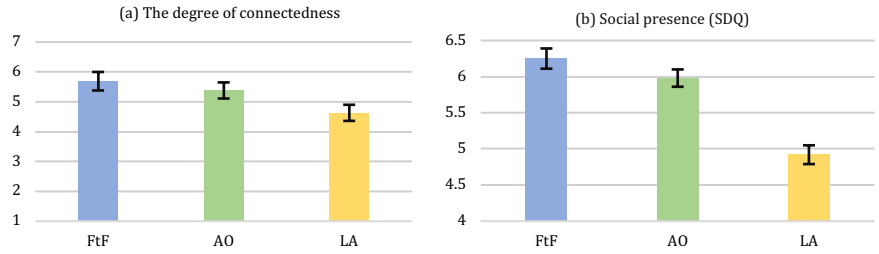

Fig. 4. (a) Mean differences and standard errors in the connectedness factor, measured by the IOS scale (Y-axis starts at 1); (b) mean differences and standard errors in the social presence factors, measured by SDQ (Y-axis starts at 4)

The mean values and standard errors of social presence, measured by SDQ, are shown in Fig. 4(b). The mean values of all situations were compared in an analysis of variance with FtF, AO, and LA as a within-subject factor. The main effect of situations was significant for social presence ($F=16.219$, $p=0.012$). ANOVA post-hoc tests were then performed for multiple comparisons. The social presence means score for FtF ($M=6.25$, $SD=1.00$) was significantly higher than that for LA ($M=4.92$, $SD=0.87$, $p=0.017$). Measured social presence for AO was significantly higher than that for LA ($p=0.038$). No significant differences could be found between FtF and AO. The results show that social presence is higher in the FtF situation than in the video conferencing situations. The avatar alone supports a higher sense of social presence than when the real-time video and avatar show up together.

The mean value and standard error of social presence-aesthetic appeal, measured by SDQ, can be seen in Fig.5 below. No significant differences could be found in any of the factors of NMMSP. Therefore, no conclusions can be drawn from this questionnaire.

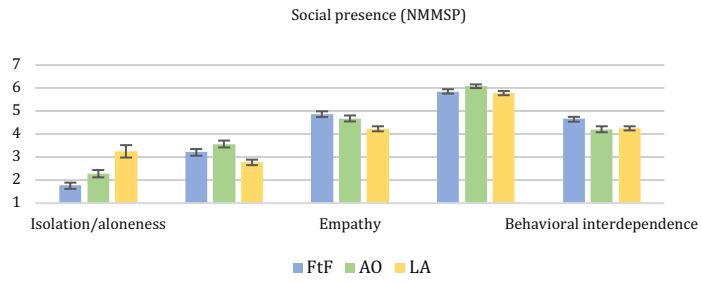

Fig. 5. Mean differences and standard errors in the social presence factors, measured by NMMSP

4.2 Analysis of Variance

To assess whether these differences were due to the group means differences related to the topic of the video (cooking), a one-way analysis of variance was chosen to analyse the impact of prior cooking experience ($M=3.1$, $SD=0.68$) on mean values of the IOS scale and SDQ. The results of this analysis ($p>0.05$) showed that the samples with different cooking experiences do not show significant differences for all group mean differences. This implies that the volatility of the data from the samples shows consistency and no variability. It can therefore be inferred that the results of connectedness and social presence measured in this study were due to the different experimental situations.

4.3 Potential Customer Acceptance

A-Vibe gained positive responses in terms of the participants' desire for future use, highlighting its potential. Out of the 16 participants, 14 (87.5%) responded affirmatively, while 2 (12.5%) responded negatively to the question: "Would you use or utilize the system in the future? And why?" Participants who answered "yes" generally mentioned the cute animal forms, which positively impacted their learning and increased their interaction with peers. However, Participant 8, who responded negatively, pointed out the system's occasional distractions. Participant 15, another negative respondent, explained: "I feel like it is more engaging than just voice, but it could not replace seeing someone's actual face for me". This is asking for richer information to be provided by the system. Overall, the system achieved a good grade: 7.4 (M) ± 1.20 (SD) (on a scale of 1–10).

4.4 Insights into the Avatar System

Understanding of the avatar. Ten participants (62.5%) saw the avatar as themselves in the experiment as the representation of the avatars matched their changing moods. Participant 2's answer noted that the avatars of the experimental assistants conveyed emotions well, which brought about the feeling that "the avatars were representing us to communicate to each other." Four participants (25%) identified the avatar as their pet. Interestingly, Participant 1 said: "I have a cat at home, so I always relate this cat avatar to my own cat when I interact with it." Another participant who also chose the cat avatar thought it is just a "cat" and wrote, "I really like cats so in my eyes it is a really cute 2D cat." Participant 15 thought the avatar was "just a cartoon character" and did not feel a connection to it.

Privacy aspects. The answers to the question, "Do you think the animal avatar format protects your privacy? And why?" provided the following results: nine (56.25%) yes and seven (43.75%) no, along with reasons. Those who agreed stated that the anonymity of the avatar in the AO situation protected their privacy while still enabling interaction. However, Participant 7 noted that "it's fun to see my 'honest' state in the form of an animal but at the same time I can say it's not me". Regarding the participants who answered no, some said they did not care; some raised doubts about it. As they pointed out, in the LA situation, the live video is still presented, so there is no perceived protection of privacy in essence. In addition, Participant 12 felt that using multiple cameras and facial analysis software in a real online classroom setting was intrusive. Participant 22 reported feeling uncomfortable, even with their real state was represented through the visual language of the animal avatar.

Richness of content. The last optional question was: "Is there anything else you would like to share? A number of comments were made about the content presented by the system. Participant 4 proposed incorporating personalized text for speech bubbles to integrate text-based messaging. Participant 12 suggested adding a frame between avatars and live video in the LA situation, while another participant desired a background for the avatar, such as grass or sky. Customisable avatar backgrounds were also preferred by participants in the AO condition. Participants 1, 3, 4, 9, and 10 expressed a desire for more emotionally expressive animations. However, one participant noted that the current honest design could be confusing and suggested that conveying real-time emotions would improve communication.

5 Discussion

Considering the difficulty of detecting honest signals and reflecting them to the avatars, the alternative chosen for this study differs from the detection of unconscious signals in the original definition. Assessing the degree of honesty of honest signals was not included in the measurement of this study. The value of this study lies in the measurement of the connectedness and perceived social presence, rather than in the deep analysis of honest signals. However, this does affect the user experience as the response to the question about "privacy" and the participants' understanding of the avatar shows that the avatar system did not really raise the issue of the relationship between the avatar and the self.

The IOS scale measured results showed that connectedness was the gold standard in the face-to-face situation, while it was not significantly associated between AO and LA. However, participants reported a facilitative effect of this system on interaction, which further promotes connectedness.

By using SDQ, it has been successfully found that differences not only between the face-to-face and the LA situation but also between the two mediated situations themselves in terms of the social presence scale. This result supports one of the hypotheses in Christie's study [10] that the social presence dimension can distinguish between different variations of the same mediated system, which in this study is videoconferencing. The semantic difference measures also suggest that the AO situation is more capable of supporting an elevated sense of social presence than the LA situation in video conferencing. The concept underpinning AO videoconferencing was confirmed as it also had positive effects on the user's social presence in terms of aesthetic appeal. Overall, the experiment result shows that this avatar system can potentially influence the degree of connectedness and social presence. However, NMMSP did not elucidate how social presence was influenced by different situations. Future evaluative studies should be carried out by trying other questionnaires, as well as adding some objective or physiological measures.

Limitations and Future Work. The current study had a small sample size of only 16 participants, and so results are not generalisable. Future work should recruit more participants and further explore the interactions between lecturers and students by applying the designed avatar system to real online lectures. Comparing the proposed AO and LA situations with real-time video only is also a direction for future research.

Additionally, the results were subject to the human factor. The performance of the experimental assistant who repeatedly participated in the experiment (whose performance was not considered in the data analysis) was not guaranteed to maintain the same level every time, and both proficiency with the content of the experiment and his fatigue level could affect participants' experience. The way of capturing and transmitting "honest" state output in the experiment should be improved in the future, for example, by using tools like biosensors or sociometer-like sensors to sense the real states and reflect them to the avatars [21], [35]. However, privacy and ethical aspects must be kept in mind when deciding what tools to use, and they should be easy to use and accessible from the user's perspective while maintaining the suitability and marketability of the system.

It is worth noting that while animal forms were chosen as the preferred design option in the current study, other possibilities should be considered in future research, such as abstract or humanistic representations, to provide a more comprehensive understanding of how different avatar designs affect user engagement and emotional expression. Additionally, a comparison with

other visual aids such as emojis as an expression of emotion could be an interesting avenue for further research.

6 Conclusion

The results showed that the degree of connectivity and social presence increased from the mediated communication LA situation to the AO situation and face-to-face communication. Although face-to-face was rated the highest in the IOS scale and SDQ, AO showed excellent performance, and participants reported that the animal-form avatar increased their enjoyment and encouraged interaction. However, further investigation is needed of the definition and transmission of honest signals in the system.

A-Vibe was well-liked by participants and gained good potential customer acceptance, but some criticism was noted. The introduction of the animal avatar in live online classes may lead to distractions for students, and the non-real-time presentation caused confusion for some users. Importantly, the system design and functionality leave much room for improvement.

Overall, it can be claimed that the research and development of animal avatars in live online classes are of great value for the students' connectedness and social presence. This study confirms the potential for video conferencing-mediated communication to perform at a good level of social presence compared to face-to-face communication, which is in line with Swan's [45] findings. It is hoped that this research can bring meaningful insights to researchers in the field of remote education, and contribute to more enjoyable video conferencing communication in future live online classes.

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