Emotion Contagion in Avatar-Mediated Group Interactions[1]

Erik van Haeringen [0000-0002-7452-8399] and Charlotte Gerritsen [0000-0002-5911-6353]

Department of Computer Science, Vrije Universiteit Amsterdam, The Netherlands
cs.gerritsen@vu.nl

Applications where people socially interact with virtual humans have multiplied in recent years. Virtual humans can be applied autonomously, for example as customer assistants, teachers, influencers and artificial companions [1], [2]. In other applications, often referred to as the 'metaverse', people interact with other people, mediated by avatars that represent them [3]. While such applications are not yet widely available in society, recent studies have explored various use cases, for example in education and remote working [4], [5]. Although these uses could bring important benefits to society, it also raises the question how visually replacing people with their digital counter parts affects social processes in groups.

This study focusses on a social phenomenon known as emotion contagion, which is a collection of processes that often occur subconsciously via which the emotional state of people shifts towards the emotions expressed by others [6], [7]. The spread of emotions in groups therefore tends to converge the emotional expressions of its members, which can result in collective emotion. In case of virtual humans, studies have shown that people can recognise emotions expressed by virtual humans with a similar accuracy as expressions of real people [8], [9]. Others have found that emotions can also spread from virtual humans to real people [10], [11], [12]. However, much less is known about how real-time communication via virtual humans affects emotional processes in groups.

This work aims to examine emotion contagion in groups interacting via human-like avatars. Emotion contagion in the present study is equated to similarity in either the facial expression (facial movement as measured with action units) or the emotional meaning of facial expressions (human and machine annotations). To examine this, we build upon a method that was used to study emotion contagion in the context of group video calls by van Haeringen et al. [13]. In that study, participants play a quiz in two competing teams, where if one team wins, the other loses. By varying the group composition on the screen, emotional amplification was found when the stimulus (win/loss) was the same for everyone in the room, while emotional cancelation was found when opposite stimuli were introduced in the same room. Instead of showing the webcam footage directly to others in a virtual room, in the present study the webcam footage is used to animate an avatar in real-time. This shows the facial expressions and head movements of the participant to the other participants in the virtual room. Specifically, we use the facial action unit system (FACS), as measured with the OpenFace2 toolkit [14], to mimic the facial expression of the participant on the avatar. We hypothesise that the measured action units contain a large part

1. Haeringen, E.S., van and Gerritsen, C. (2024). Emotion Contagion in Avatar-Mediated Group Interactions. In proceedings of the 12th International Conference on Affective Computing & Intelligent Interaction. IEEE Xplore.

of the emotional information expressed by the participant. This method has the benefit that it does not reduce the complexity of the context-specific expressions to a basic set of emotions, as would be the case if automated emotion detection or manual emotion selection were used to inform the expressions of the avatar [15]. By projecting the measured action units directly on the avatar, emotions should theoretically be allowed to flow in the group in a similar manner as during a webcam-mediated video call. However, since errors in measuring or display are likely to hamper this process, we expected expressive avatars to lead to stronger emotional convergence than non-expressive avatars, but weaker contagion than in regular video calls. To test this, trials are performed with and without mirroring the expressions of the participants on the avatar, using an experiment based on the methodology by van Haeringen et al. [13]. To measure contagion, similarity in action units and emotion labels are analysed, by post-trial annotating the filmed facial expressions of the participants with manual and automated methods. Moreover, by measuring the gaze of the participants with eye trackers, we zoom in on the visual pathway for emotion contagion at the dyadic level.

While we hypothesised emotion contagion would drive emotional convergence at the group level and in gaze pairs, the results show that the opposite may have taken place. Looking at the avatars of others was related to a decrease in similarity of facial expressions and emotional content of those expressions, compared to before the gaze. This was found both with and without mimicking avatars, yet more negative expressions were present in the control condition compared to the avatars that mimicked expressions.

The absence of emotion contagion can be caused by a number of reasons. The cause could be that the mimicked expressions were not sufficiently measured or replicated to be contagious. Another option is that the projection of facial action units on the avatar needs improvement. And a third explanation for the absence of emotion contagion could be that body motion plays an important role in emotion exchange in computer-mediated communication while only head movements were mimicked by the avatar. Whatever the reason, the study shows that communicating via avatars can disrupt social processes and that it is therefore important to do more dedicated research into this before it is widely applied.

References

1. Sung, E., Han, D.I.D., Choi, Y.K., Gillespie, B., Couperus, A., and Koppert, M. “Augmented digital human vs. human agents in storytelling marketing: exploratory electroencephalography and experimental studies,” Psychol Mark, 2023, doi: 10.1002/MAR.21898.
2. Loveys, K., Sagar, M., Pickering, I., and Broadbent, E. “A digital human for delivering a remote loneliness and stress intervention to at-risk younger and older adults during the COVID-19 pandemic: randomized pilot trial,” JMIR Ment Health, vol. 8, no. 11, p. e31586, Nov. 2021, doi: 10.2196/31586.
3. Nowak, K.L. and Fox, J. “Avatars and computer-mediated communication: a review of the definitions, uses, and effects of digital representations,” Review of Communication Research, vol. 6, pp. 30– 53, 2018, doi: 10.12840/ISSN.2255-4165.2018.06.01.015.
4. Kye, B., Han, N., Kim, E., Park, Y., and Jo, S. “Educational applications of metaverse: possibilities and limitations,” J Educ Eval Health Prof, vol. 18, 2021, doi: 10.3352/JEEHP.2021.18.32.

5. Šimova, T., Zychova, K., and Fejfarova, M. "Metaverse in the virtual workplace," Vision: The Journal of Business Perspective, vol. 28, no. 1, pp. 19–34, Jun. 2023, doi: 10.1177/09722629231168690.
6. Kleef, G.A. van, Heerdink, M.W., and Homan, A.C. "Emotional influence in groups: the dynamic nexus of affect, cognition, and behavior," Current Opinion in Psychology, vol. 17. Elsevier B.V., pp. 156–161, Oct. 01, 2017. doi: 10.1016/j.copsyc.2017.07.017.
7. Goldenberg, A. and Gross, J.J. "Digital emotion contagion," Trends Cogn Sci, vol. 24, no. 4, pp. 316–328, Apr. 2020, doi: 10.1016/J.TICS.2020.01.009.
8. Cerda, L., Graziani, P., and Del-Monte J., "Emotional valence recognition on virtual, robotic, and human faces: a comparative study," J Technol Behav Sci, vol. 6, no. 1, pp. 151–158, Mar. 2021, doi: 10.1007/S41347-020-00172-5.
9. Amorese, T., Cuciniello, M., Vinciarelli, A., Cordasco, G., and Esposito, A. "Synthetic vs human emotional faces: what changes in humans' Decoding Accuracy," IEEE Trans Hum Mach Syst, vol. 52, no. 3, pp. 390–399, Jun. 2022, doi: 10.1109/THMS.2021.3129714.
10. Wu, Y., Babu, S. V., Armstrong, R., Bertrand, J. W., Luo, J., Roy, T., & Fasolino, T. Effects of virtual human animation on emotion contagion in simulated inter-personal experiences. *IEEE transactions on visualization and computer graphics*, *20*(4), 626-635, 2014.
11. Tsai, J., Bowring, E., Marsella, S., and Tambe, M. "Emotional contagion with virtual characters," in Proceedings of the 11th International Conference on Autonomous Agents and Multiagent Systems – Volume 3, in AAMAS '12. Richland, SC: International Foundation for Autonomous Agents and Multiagent Systems, 2012, pp. 1193–1194.
12. Volante, M., Babu, S. V., Chaturvedi, H., Newsome, N., Ebrahimi, E., Roy, T., and Fasolino, T. Effects of virtual human appearance fidelity on emotion contagion in affective inter-personal simulations. *IEEE transactions on visualization and computer graphics*, *22*(4), 1326-1335, 2016.
13. Haeringen, E.S., van, Veltmeijer, E.A. and Gerritsen, C. "Empirical validation of an agent-based model of emotion contagion," IEEE Trans Affect Comput, 2023, doi: 10.1109/TAFFC.2023.3272031.
14. Baltrusaitis, T., Zadeh, A., Lim, Y.C., and Morency, L.P. "OpenFace 2.0: facial behavior analysis toolkit," Proceedings - 13th IEEE International Conference on Automatic Face and Gesture Recognition, FG 2018, pp. 59–66, Jun. 2018, doi: 10.1109/FG.2018.00019.
15. Baker, S., Waycott, J., Carrasco, R., Kelly, R. M., Jones, A. J., Lilley, J., and Vetere, F. Avatar-mediated communication in social VR: an in-depth exploration of older adult interaction in an emerging communication platform. In *Proceedings of the 2021 CHI conference on human factors in computing systems* (pp. 1-13), 2021.