Empirical Validation of an Agent-Based Model of Emotion Contagion[1]

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Emotion contagion is a largely subconscious process where the emotions of people in groups become more similar as the result of the expression of those emotions themselves [1]. Emotion contagion encapsulates a number of processes that drive the formation of collective emotion in crowds that meet in-person as well as via media and online [2]. While the effects of emotion contagion in groups are often subtle, in some cases the effects can be extremely harmful to individuals and society. Every year there are outbreaks of mass panic and anger in crowds that cause injuries and deaths, of which the recent Astroworld stampede and riots at the US Capitol are examples that received much attention [3], [4]. Also hatred, anxiety, loneliness and depression have been suggested to be contagious [5]. Motivated by this, a number of computational models have been developed over recent years that are mostly aimed at the spread of negative emotions in large groups of people and their effect on behaviour, such as during evacuations [6]. In a literature review of agent-based mechanisms of emotion contagion, we concluded that empirical validation of these models of emotion contagion is lagging behind [6]. Moreover, most of the studies that did validate a crowd model against real people, compared the actions of people in videos to the actions of agents, like movement speed or direction [7], [8]. Since behaviour choices depend on numerous other factors besides emotion, this method provides indirect evidence for the validity of the contagion mechanism at best. Above all, establishing rigorous validation for models with emotionally interactive agents is important to eventually justify bridging the gap from scientific work to practical use cases, like for event planning, crowd management, warning systems and training purposes [9], [10], [11], [12]. We argue that this should include more direct validation for the spread of emotions in groups, not merely action patterns that hint at an underlying emotional state

What makes it challenging to validate a crowd model at the level of emotions, is the difficulty to collect detailed and reliable data about the emotional state of groups of people. Emotion, as well as entangled factors like personality, are generally seen as private, ethically limiting the data collection in the wild without informed consent. Also from a technical perspective, there is still an ongoing scientific challenge to reliably track the emotions of large groups of people in uncontrolled conditions [13], [14]. A notable exception can be found in the online crowd on public

1. van Haeringen, E. S., Veltmeijer, E. A., & Gerritsen, C. (2023). Empirical validation of an agent-based model of emotion contagion. *IEEE Transactions on Affective Computing*, *15*(1), 273-284.

social media [2]. There, people share their expressions and react to others with the knowledge that this will be public, usually in the form of text, images or videos, which can relatively easily be collected. However, without direct face-to-face interaction and regulating feedback, it is not clear how representative these forms of contagion are for the spread of emotion in real crowds [15]. An environment that potentially bridges this gap, is that of video calls. There, participants are used to their expressions being recorded and shared with others whilst interacting face-to-face, albeit via a screen.

To make a first step towards validation at the level of group emotions, the aim of the present paper is to compare agent-based simulations of emotion contagion against the emotional development of real participants in an experiment via a video call. The participants in this experiment play a competitive quiz in two teams via the video call, where the emotional state of each participant is annotated manually from the recorded video in small time steps. By modifying the composition of the virtual environment, different conditions are created with regard to the spread of emotions. These conditions include 1) virtually isolating the participants to disable emotion contagion, 2) virtually grouping the participant per team to allow contagion among agents with similar emotional stimuli, and 3) placing all participants in the same virtual space, allowing contagion among participants with conflicting emotional stimuli.

Since emotion contagion is believed to drive emotional similarity [1], we hypothesised that the participants become more emotionally similar over time when they are in the same virtual space, forming a collective emotion. In contrast, we expected this does not happen when they are virtually isolated. Further, we expected that winning a quiz round results in a positive emotion, while losing a round triggers a negative emotion. Since one team wins and the other loses, we hypothesised that when the participants are virtually grouped per team, the emotion converges within a team, and the difference between the teams increases. On the other hand, when the teams are virtually placed in the same space, we expected the emotions of all participants to converge to some degree, decreasing the emotional difference between the teams. Finally, based on literature that finds that there are larger constraints against the expression of negative emotions than most positive emotions in groups [16], we hypothesised a win is followed by relatively strong expressions of positive emotions, while a loss is followed by more diverse expressions that are weaker.

Congruent with our expectations, the combined results show that the emotional responses in the experiment converge in groups. While emotion contagion has been found to be operational in a broad range of environments [2], [17], to our knowledge, these results show the first tentative evidence for emotion contagion via video calls in groups. This is important because the video call environment offers the possibility to record the face-to-face exchange of emotion in groups in a controlled setting, thereby providing a way forward to empirically validate models of emotion contagion. Next, to empirically validate an agent-based model of emotion contagion, called DECADE, simulations were performed with conditions similar to the real experiment. Comparing the simulations to the real participants, we found that the agents reproduced many of the patterns that were found in the real participants. When emotion contagion was disabled in the model, the resemblance decreased substantially. However, while the relative differences among the conditions in the full model resembled the empirical study, in absolute sense there was a significant gap. The agents were emotionally more stable and similar to one another than the real participants. An explanation for this may be that the agents start each simulation emotionally neutral and only a single stimulus is considered per trial (winning or losing).

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