

Effects of Nonverbal Communication of Virtual Agents on Social Pressure and Encouragement in VR

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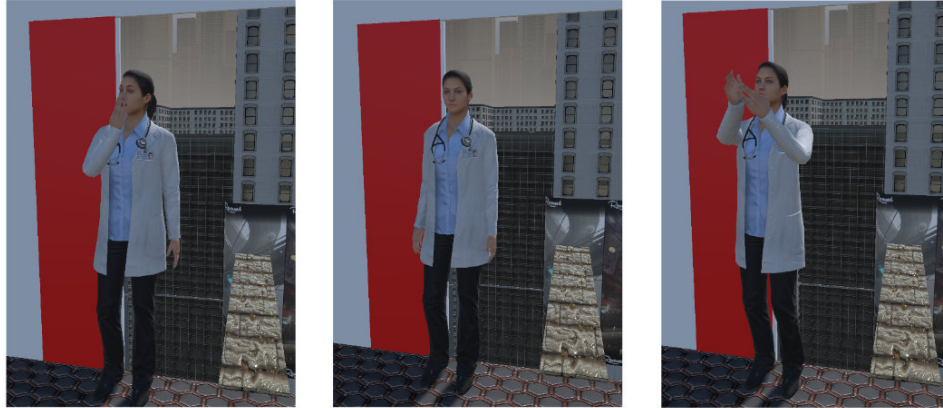


Figure 1: We exposed participants to virtual agent nonverbal communication animations while they had to perform body exercises on a virtual plank. Animations were either imitating positive, negative, or neutral nonverbal communication patterns. Left: Agent performing a yawn as negative behavior animation, Mid: Agent performing an idle animation, Right: Agent performing a clapping animation as positive behavior animation.

ABSTRACT

Our study investigated how virtual agents impact users in challenging VR environments, exploring if nonverbal animations affect social pressure, positive encouragement, and trust in 30 female participants. Despite showing signs of pressure and support during the experimental trials, we could not find significant differences in post-exposure measurements of social pressure and encouragement, interpersonal trust, and well-being. While inconclusive, the findings suggest potential, indicating the need for further research with improved animations and a larger sample size for validation.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Empirical studies in HCI; Human-centered computing—Human computer interaction (HCI)—Intelligent Virtual Agents

1 INTRODUCTION

Nonverbal communication refers to the behavioral elements of human-to-human messages besides spoken words [2]. It serves as a communication channel to convey intentions, consciously or subconsciously, within social interactions.

Previous research has demonstrated that human-like behavior animations of virtual agents in Virtual Reality (VR) can evoke emotions in participants [6]. However, there has been limited exploration into the effects of nonverbal communication animations of virtual

agents on participants in challenging situations, specifically regarding subjective felt social pressure, positive encouragement, trust, well-being, and manipulation. For this reason, we conducted an experiment involving a virtual agent expressing nonverbal communication patterns. The nonverbal patterns were either of 1) positive, 2) negative, or 3) neutral nature. The nonverbal agent animations were expressed towards the participants while they had to perform body exercises on a virtual plank in a fear-inducing high-rise environment in VR. This allowed us to investigate whether participants experienced and were influenced by encouragement and social pressure induced by an agent during a potentially fear-inducing task.

2 THEORETICAL BACKGROUND

Nonverbal communication, conveyed through eye contact and facial expressions, communicates emotions and intentions, profoundly impacting trust and relationships in human interactions. Social cues can manipulate people to conform to social norms. Failure to comply may lead to exclusion, something people try to avoid [3]. Negative or positive actions from group peers, such as applauding, influence behavior and attitudes and guide individuals' responses to their surroundings and relationships [4]. Using virtual agents to express nonverbal communication by animation has proven to impact users. For instance, a virtual agent offering alcohol in VR persuaded participants to accept the drinking despite being in a withdrawal therapy [9]. As seen in relationships, nonverbal communication patterns can be used to inflict social pressure [1] or encouragement [7].

3 METHOD

We varied the nonverbal behavior patterns of agents, classifying them as positive, negative, and neutral, thereby serving as our independent variable. The challenging setting was a fear-inducing virtual high-rise environment. Within this environment, we created two identical rooms. The first room, enclosed and situated at ground level, was

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designated for the interpersonal trust measurement. The second room was located on a high-rise building and had opened doors as well as a walkable plank over the edge of a high-rise building as displayed in Fig. 1. The design is inspired by the plank experiment from Usoh et al. [10]. In the lab, the participants moved across a cardboard dummy plank, experiencing the sensation of wind from a fan to increase the sensation of being on a plank at the edge of a high-rise building. Participants completed a task involving three light body exercises (looking around at the end of the plank, kneeling, and standing on one leg) for 15 seconds at the end of the plank. To ensure that the participants observed the nonverbal communication patterns of the agent, they had to look toward the agent's direction before the exercises started.

The agent and respective animations were sourced from the *Microsoft Rocketbox Library* [5]. To create animations eliciting social pressure or encouragement, we referred to nonverbal communication literature [3]. During an experimental trial, the agent demonstrated exercises on the plank's edge, accompanied by nonverbal communication animations until participants completed the exercises.

To detect social pressure and encouragement, participants responded to a questionnaire containing statements about the agent's behavior, rating them on a 7-point Likert scale (1 = *Not at all* to 7 = *Totally*).

As pressure and encouragement can influence a subject's trust towards a second person, we evaluated changes in interpersonal trust. Participants participated in the "Investment Game" before and after observing the agent's animations [11]. Also, we investigated the influence of nonverbal animations on trust by utilizing the "Trust in Automated Systems Survey" [8] questionnaire.

Finally, we investigated whether nonverbal communication influenced the overall behavior state of the participants. Behavior change was measured using questionnaires assessing the participant's well-being after the exercise, subjective manipulation score, and behavior manipulation, including the time needed to step on the plank.

4 RESULTS

We conducted ANOVAs to analyze our measurements. Thirty female participants (*Mean age* = 22.97, *SD* = 2.63) were involved in this study. No significant differences were observed concerning the animation condition on social pressure, $F(2, 27) = 1.225, p = .309$. Similarly, we found no significant difference for encouragement, $\chi^2(2) = 4.294, p = .117$. Despite the insignificant results, some participants reacted verbally to the agents in the negative condition indicating an experience of pressure to perform the exercises on the plank. Vice-versa, some participants reported a supportive feeling in the positive condition.

No significant differences were found between the conditions concerning interpersonal trust changes in the Investment Game, $F(2, 54) = 0.739, p = .398$. Also, we found no significant differences on the Trust in Automated Systems Survey, $F(2, 24) = 2.474, p = .105$.

Regarding the animation condition and the time taken by participants to first stepping on the plank, no significant difference was found, $F(2, 27) = 0.941, p = .402$. Concerning the overall subjective manipulation score of the participants, no significant difference was observed, $F(2, 27) = 0.990, p = .385$. No significant differences between the condition groups were detected regarding the participants' overall well-being after the exercises ($F(2, 54) = 0.491, p = .615$) or their well-being near the agent, ($F(2, 54) = 1.315, p = .277$).

5 DISCUSSION

We found no significant differences between the animation conditions and the participants' felt social pressure and encouragement. This could be a result of the used animations set. The used animations set was configured by choosing animations from the *Microsoft Rocketbox library* with the help of nonverbal communication literature [3] and manually adjusting the animation loop in Unity. Flaws

in the loop, such as sudden changes in arm position, might have affected the overall quality and effectiveness of the nonverbal communication patterns. Additionally, the agent was not positioned at the center of the participants' view, potentially leading some participants to ignore the animations and focus on the body exercises, weakening their exposure to the nonverbal animations. While no conclusive effects were noted, participants showed indications of perceived social pressure and encouragement influenced by animations. Some participants indicated signs of felt pressure or support by the agent's behavior. A follow-up study with a larger sample size and enhanced animations is recommended for deeper insights.

6 CONCLUSION

Our study revealed no significant impact of specific nonverbal animations on participants' social pressure, encouragement, trust, well-being, or subjective manipulation. However, the participants' reactions suggested potential social pressure and encouragement depending on the experimental condition. Future research should consider employing refined animations, a more prominent positioning of the agent towards the participants, and a larger as well as more varied sample.

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