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► **To cite this version:**

Marion Ristorcelli, Emma Gallego, Kévin Nguy, Jean-Marie Pergandi, Rémy Casanova, et al.. Investigating the impact of a virtual audience's gender and attitudes on a human speaker. ACM International Conference on Multimodal Interaction (ICMI) - Workshop SAMIH (Social Affective Multimodale Interaction for Health), Oct 2023, Paris, France. 10.1145/3610661.3616128 . hal-04194953

HAL Id: hal-04194953

<https://hal.science/hal-04194953>

Submitted on 14 Sep 2023

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Investigating the impact of a virtual audience's gender and attitudes on a human speaker

Marion Ristorcelli
marion.ristorcelli@lis-lab.fr
LIS, CNRS, Aix-Marseille University
Marseille, France

Emma Gallego
emma.gallego@etu.univ-amu.fr
LIS, CNRS, Aix-Marseille University
Marseille, France

Kévin Nguy
kevin.nguy@etu.univ-amu.fr
LIS, CNRS, Aix-Marseille University
Marseille, France

Jean-Marie Pergandi
jean-marie.pergandi@univ-amu.fr
ISM, CNRS, Aix-Marseille University
Marseille, France

Rémy Casanova
remy.casanova@univ-amu.fr
ISM, CNRS, Aix-Marseille University
Marseille, France

Magalie Ochs
magalie.ochs@lis-lab.fr
LIS, CNRS, Aix-Marseille University
Marseille, France

ABSTRACT

Public speaking anxiety is a common social phobia in the general population, particularly among young adults. This social skill is essential for professional integration. However, few solutions have been developed to train people in public speaking. The research has shown that Virtual Reality tools can be used to improve public speaking performance. To vary the difficulty of the training, virtual audiences expressing different social attitudes may be simulated. However, only few research works have explored the impact of audience's gender on the user experience. In this article, we propose to investigate the impact of simulated social attitudes and of the gender of the virtual audience on subjective measures reflecting the user experience during a public speaking task. We describe an experimental study in which 41 participants were asked to speak in front of a virtual audience with a neutral, positive or negative social attitude. The gender of the virtual audience varied: only males, only females, or mixed-gender agents. After each speech, users assessed the audience's attitudes, self-report their emotions and their ease of public speaking in front of the audience. The results reveal that an audience with a positive attitude and composed of at least one female virtual agent is perceived as more positive and induces more positive emotions.

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; *Redundancy*; *Robotics*; • **Networks** → *Network reliability*.

KEYWORDS

Virtual Reality, Social Skills, Social Attitudes, Virtual Audience, Gender, Speaking Task, Public speaking anxiety

ACM Reference Format:

Marion Ristorcelli, Emma Gallego, Kévin Nguy, Jean-Marie Pergandi, Rémy Casanova, and Magalie Ochs. 2023. Investigating the impact of a virtual

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ICMI '23 Companion, October 9–13, 2023, Paris, France

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ACM ISBN 979-8-4007-0321-8/23/10...\$15.00

<https://doi.org/10.1145/3610661.3616128>

audience's gender and attitudes on a human speaker. In *INTERNATIONAL CONFERENCE ON MULTIMODAL INTERACTION (ICMI '23 Companion)*, October 9–13, 2023, Paris, France. ACM, New York, NY, USA, 5 pages. <https://doi.org/10.1145/3610661.3616128>

1 INTRODUCTION

Social anxiety disorder (SAD) is a common disorder affecting around 2.3% of the population in Europe [22]. According to the DSM V (Diagnostic and Statistical Manual of Mental Disorders), the SAD corresponds to the avoidance of social interactions due to the fear of being judged negatively. One of the most common social phobias is public speaking anxiety [19, 20]. In the literature, it is defined as the fear of public speaking associated with the onset of anxiety symptoms such as tremors or memory blanks [20].

Young people often experience higher social anxiety levels than older adults during public speaking [17], potentially affecting their professional integration [29]. In addition, the younger generations are increasingly exposed to oral presentation situations (e.g., the "grand oral du baccalauréat"¹) and several studies have shown the inequality between the gender when it concerns the apprehension of public speaking [24]. That's why, effective, easy-to-use social skills training tools are needed to address these challenges.

In the specific field of social computing, a number of simulation systems have been developed for training in public speaking [4, 8, 12, 14, 31]. In these systems, the users practice public speaking presentations in front of virtual audiences populated by virtual agents. Such a simulation environment presents several advantages: it is standardized, more available than an expert, and can be customized (adapting the location and audience's behavior). Concerning the devices, some recent research works have shown that virtual reality (VR) environments are particularly powerful to help users to improve their social skills but also to treat public speaking anxiety in therapy [1, 20, 32]. In VR, the patients have the illusion of being in front of a real audience. If patients are exposed to an audience several times through virtual reality exposure therapy (VRET), they reduce their anxiety during the public speaking [20].

In VR public speaking training systems, to vary the difficulties of the speaking task, the researchers simulate virtual agents with different social attitudes. The social attitude is characterized by the nonverbal behavior of the virtual agents. Several research works have shown that users perceive different attitudes of the virtual

¹<https://eduscol.education.fr/729/presentation-du-grand-oral>

audience depending on the nonverbal behavior of the virtual agents [9, 10, 13, 16, 30, 33]. For instance, virtual agents who shake their head, avoid looking at the speaker, lean back, frown or use their phone are perceived as an audience with a negative attitude; while virtual agents who look at the speaker, nod and lean forward are perceived as a positive audience. These social attitudes have an impact on the user experience. In particular, it has been shown that negative audience generates greater anxiety and discomfort for the user than positive one [30]. The representation of social attitudes differs in the different works. For instance, in [30], the virtual audience could simulate hostile, friendly or neutral social attitudes based on the model of social attitudes proposed in [2]. These two attitudes relate to the valence dimension used by [11] to build the different social attitudes of the audience. Valence can be viewed as a positive or negative attitude. In our experiment we consider only 3 social attitudes: neutral, negative and positive.

The gender of the virtual agents composing the audience may also have an impact on the user experience. Virtual agents are perceived differently depending on their appearance and particularly depending on their gender (detailed state of the art in [3]). Since gender stereotypes persist in human-machine interactions, the male virtual agent is perceived as more powerful [26], more expert [26] and more knowledgeable [5] than a female virtual agent that is perceived as more likable [26] and more attractive [23]. In learning environments, this perception of gendered virtual agents has an impact on the learners' performances but also on the learners' self-perception and self-efficacy [3]. The impact of the gender of the virtual audiences is generally not taken into account in existing research works. Some existing virtual audiences consider only male virtual agents [13, 30], others consider a few female agents in their virtual audience [6, 25, 27, 28] and finally relatively few consider a mixed number of male and female virtual agents [15, 16]. Whereas some studies have measured the impact of the users' gender [21, 30], as far as we know, no research works have evaluated the impact of the *gender of the virtual audience* on the user experience. In this paper, we propose to fill the gap by investigating the impact of the gender of the virtual audience on users in terms of perceived social attitudes, ease of speaking, but also emotional experience. For this purpose, we conducted a VR experiment in which users address audiences that vary in social attitude and gender.

2 A VIRTUAL REALITY PLATFORM FOR A SPEAKING TASK TRAINING

We developed a virtual reality platform consisting of two virtual agents in a meeting room. In order to vary the gendered appearance of the virtual agents, we have created 6 different virtual agents: 3 females and 3 males. All agents were thirty years old and Caucasian (Figure 1). The virtual agents could display different non-verbal behaviors to express different social attitudes, independently of the user's performance. For instance, in our experiment, a positive social attitude is defined by a seated virtual agent, torso leaning forward with a positive facial expression and nodding frequently. For the neutral social attitude, the virtual agent behaves in the same way as before, but its facial expression is neutral and the probability of nodding is lower. For the negative social attitude, the virtual agent could look behind him/her, shake his/her head but

also talk with the other agent, answer a phone call or use his/her cell phone, all with a negative facial expression.

3 THE EXPERIMENT

In this study, we aimed at assessing the impact of the virtual audience's attitude and gender on the user experience. In our experiment, the user experience is evaluated through self-report questionnaires about the three following aspects: (1) perception of the virtual audience's social attitude (e.g. if the virtual audience is perceived as pleasant, dissatisfied, attentive, annoyed), (2) self-report of ease of public speaking, and (3) emotions felt. In this study, we then investigate the two following hypotheses:

H1 - Effect of the virtual audience's social attitude: Participants perceive the audience more positively, feel more positive emotions, and feel more comfortable speaking in front of an audience with a positive social attitude than one with a negative attitude.

H2 - Effect of the virtual audience's gender: Participants perceive the audience more positively, feel more positive emotions, and feel more comfortable speaking in front of an audience composed of females than an audience composed of males.



Figure 1: Screenshot of the virtual reality room with a pair of mixed-gender virtual agents with a negative attitude during the presentation.

3.1. Participants. We recruited 41 students, including 19 women and 22 men at XXX University (20.44 ± 3.36 years).

3.2. Measurements. In order to evaluate the users' perception and their emotional and speaking experience, we used the following post-experience questionnaires:

The Self-Assessment Manikin (SAM). The Self-Assessment Manikin (SAM) is a well-known nonverbal pictorial assessment technique that directly measures pleasure, arousal and dominance associated to a person's emotion [7]. It consists of three questions rated on a 5-point Likert scale. The user indicates her/his current emotion for each dimension. In our experiment, we used the sum of the responses to this questionnaire after each speaking task to measure the impact of the virtual audience on the emotions felt by the users. *The Personal Report of Confidence as a Speaker (PRCS).* The Public Report of Confidence as a Speaker (PRCS) is a widely used questionnaire to assess fear of public speaking. In our experiment, we used the French version of the PRCS which consists of 12 questions (e.g. "I am in constant fear of forgetting my speech") to measure the ease of public speaking [18]. We asked the users to answer these questions by selecting a value on a 5-point Likert scale ranging from "not at all" to "a lot". The participants filled the questionnaire

after each speaking task to evaluate the impact of the virtual audience on her/his self-impression of ease of public speaking. We then consider the average score on all the questions.

Questionnaire on the user's perception of the virtual audience. This questionnaire consists of 9 affirmations to measure the users' perception of the virtual audience. We assess the following dimensions: satisfied, agreeableness, comprehension, attention, enjoyable and interest. One example of affirmation is "I found the virtual agents attentive to my presentation". Using a 5-point Likert scale, the participants filled the questionnaire after each speaking task. The final score is computed by subtracting the sum of the answers to the negative questions to the sum of answers to the positive questions.

3.3. Protocol. A within-subjects design was used for this study. We consider 3 conditions, one for each social attitude (positive, negative and neutral). To avoid an effect of the emotions potentially triggered by the positive or negative social attitude, the participants always started the experiment with the neutral condition. The positive and negative condition are then counterbalanced. In each condition, the participants presented them-self three times with each pair of virtual agents: 2 females, 2 males or 1 female and 1 male. We counterbalanced the order of the pair of agents presented to the users. Finally, each saw all the conditions and all the pair of agents. Note that the nonverbal behavior of the agents differ across the conditions, but not across the gender.

The participants first filled a demographic questionnaire to gather general information (gender, age, parents' socio-professional category, field of study, frequency of use of virtual reality devices and job interview experience). Then, before starting the public speaking task, they also filled the PRCS [18] and the SAM [7] questionnaires (Section 3). The task consist in introducing yourself for 9 different jobs. Before each presentation, the experimenter provided a paper description of the job for which participants were to apply. Then, the participants had all the time they need to prepare their speech. When they were ready, the participants were equipped with the Oculus Quest virtual and placed in the virtual environment (Section 2) with the virtual agents corresponding to the assigned condition. They performed their speech in front of the virtual audience for a maximum of 3 minutes. After the presentation, participants took off the headset, filled out the SAM, PRCS and a perceptive questionnaire using a touchpad and continue the experiment.

4 RESULTS

In order to test our hypotheses (Section 3), we considered 2 independent variables (IVs: the virtual audience's social attitude and gender) and 3 dependent variables (DVs: the user's perception, felt emotions and ease of public speaking). The Shapiro-Wilk test showed that the distribution of the perception, SAM and PRCS scores differed significantly from the normality. Consequently, we used a non-parametric Friedman ANOVA test to measure the main effects of the IVs on the DVs. Then, we used a Conover's post-hoc test to further investigate the difference between each modality for each IV that reveals a main effect. Finally, we measured simple effects to identify for each IV that reveals a main effect whether there is an effect when combining each modality of the first IV with each

modality of the second IV. In this study, we were attentive to counterbalance the participants' gender and we found no significant effect of the participants' gender on DVs.

In this section, we note the social attitude *SA* and thus distinguish the three social attitudes as follows: *SA+* for the positive social attitude, *SA-* for the negative social attitude and *SA_n* for the neutral one. We also note *FeVA* for the pair of female virtual agents, *MaVA* for the pair of male virtual agents and *MxVA* for the pair composed of one male and one female virtual agent.

4.1 The perception of the virtual agents' social attitudes

Impact of virtual agents' social attitude. The statistical tests show that the perception score is significantly different between *SA+* ($M = 6.56$, $SD = 3.90$) and *SA-* ($M = -7.73$, $SD = 3.46$) and between *SA_n* ($M = 4.32$, $SD = 4.17$) and *SA-* ($p < 0.001$). Indeed, the *SA_n* and *SA+* are perceived more positively than the *SA-*. However, there was no significant difference between the *SA_n* and *SA+*. In other words, these results show that *participants perceive positive and neutral audiences as more positive than negative ones.*

Impact of virtual agents' gender. Simple effects analysis showed that the perception score was significantly different according to the gender of the virtual agents when speaking to a virtual audience with a *SA+* ($X^2(2) = 7.32$; $p < 0.05$). The post-hoc test showed that, in the context of virtual agents with a *SA+*, the *FeVA* pair ($M = 7.32$, $SD = 3.97$) was more positively perceived than the *MaVA* pair ($M = 5.61$, $SD = 4.02$, $p < 0.05$). In other words, *in the SA+ condition, the FeVA are more positively perceived than the MaVA whereas they displayed the same nonverbal behavior.* However, the other conditions do not significantly differ from each other.

Finally, these results show that, firstly, the nonverbal behavior displayed by the virtual audience enable us to simulate a positive and negative attitudes. Moreover, the gender of the virtual audience has a significant impact on the perception of the social attitude. More precisely, a virtual audience composed of only female agents are perceived more positively when they displayed a positive social attitude than a virtual audience composed of only male agents with the same positive behavior. Note that the gender of the virtual agents impact only the perception of the positive social attitude.

4.2 Emotions felt by users

Impact of virtual audience's social attitude. The analysis shows a main effect of the virtual agents' *SA* on the users' emotions ($\chi^2(2) = 24.23$; $p < 0.001$). The post-hoc test revealed significant differences for the SAM score between the *SA+* ($M = 3.17$, $SD = 0.66$) and *SA-* ($M = 2.79$, $SD = 0.60$) conditions ($p < 0.05$). More precisely, the participants *felt more pleasant emotions facing an audience with a SA+ than facing an audience with a SA-*.

Impact of virtual audience's gender. The simple effects analysis and the post-hoc test showed that the emotions felt, reflected by the SAM score, were significantly different for the *MxVA* pair condition ($M = 3.28$, $SD = 0.61$) than the *MaVA* pair condition ($M = 3.02$, $SD = 0.72$) in *SA+* condition ($\chi^2(2) = 6.53$; $p < 0.05$). More specifically, the *MxVA* pair makes the participant feel slightly more pleasant emotions than the *MaVA* pair in the *SA+* condition only. However, the other conditions did not significantly differ from each other.

In other words, *the participants felt more positive emotions facing an audience composed of one female and one male than an audience composed of two males.*

Finally, these results show that, the social attitude, and in particular, the positive social attitude of the audience has an impact on the users' emotions. The emotional experience is more positive in front of a virtual audience displaying a positive attitude than in front of a virtual audience with a negative one. Moreover, the gender of the virtual audience has a significant effect on the users' felt emotions when they display a positive attitude.

4.3 The ease of public speaking

Impact of virtual agents' social attitude. The Friedman ANOVA test shows a main effect of the virtual agents' SA on the self-reported ease of public speaking ($\chi^2(2) = 45.44$; $p < 0.001$). The post-hoc test reveals that the *PRCS score obtained by the participants was significantly different between both the SA+ ($M = 1.98$, $SD = 0.69$) and SA- ($M = 2.36$, $SD = 0.74$) and between the SA+ and SAn ($M = 2.44$, $SD = 0.68$, $p < 0.05$). However, no significant difference was found between the SAn and SA-. In other words, *the SA+ displayed by the virtual audience really facilitates the users' speaking compared to the SAn and SA-*.*

Impact of virtual agents' gender. The Friedman test revealed *no main effect of the virtual audience's gender on the PRCS score.*

Finally, these results show that participants feel more confident speaking in public with a positive virtual audience than with a negative or neutral one. However, participants didn't report feeling more confident in public speaking when speaking in front of an audience containing at least one female compared to an audience composed only of males, regardless of the displayed social attitude.

4.4 Discussion

Social attitude effect. First, we confirm our first hypothesis (H1). We have found an effect of the social attitude of the virtual audience on the user experience. Participants found the *positive audience to be more positive than the negative one*, confirming their perception of different social attitudes based on virtual agents' non-verbal behavior. They also reported *feeling more positive and confident in front of a positive audience*. These results are consistent with those of [30], where participants' anxiety was also higher in front of an audience with a negative attitude than in front of an audience with a positive attitude. It is also consistent with previous works [10] that show that a person who feels more comfortable speaking in public also finds the task more enjoyable. In our study, participants were more comfortable to speak in front of a positive audience and also reported more pleasant emotions in this condition.

Regarding the *neutral social attitude*, we also find some interesting results. The neutral audience was also perceived as more positive than the negative audience. However, we found no difference in perception between the positive and neutral audience. This could be because the behaviors of the neutral audience were identical to those of the positive audience, differing only in animation probabilities. The differences between the two conditions were maybe not enough pronounced to be distinguished. Concerning ease of public speaking, participants didn't feel more comfortable speaking in front of an audience with a neutral attitude compared

to speak in front of an audience with a negative attitude, in contrast to the results obtained by [30]. Indeed, the authors found a higher level of anxiety in participants when they spoke in front of a negative audience compared to when they spoke in front of a neutral audience. This discrepancy can be explained by the nonverbal behavior adopted by the virtual agents in the neutral condition. In [30], they used completely static virtual agents with neutral facial expressions, whereas in our study, the neutral audience behaved similarly to the positive audience, but nodded less often. This difference in research highlights the need to clarify what a neutral audience is in terms of behavior.

Gender effect. We partially confirm our second hypothesis (H2). We found an effect of the gender of the virtual audience on at least two dimensions of the user experience. Specifically, the pair of female virtual agents was perceived as more positive than the pair of male virtual agents, whereas the virtual agents (male and female) displayed the same behavior. This is consistent with some research works that indicates that female agents are perceived as more attractive and likable than male agents regardless the behavior in a 2D environment ([5, 23, 26]). They also reported feeling more positive emotions in front of a mixed virtual audience than in front of a male audience.

Concerning the ease of public speaking, the results show no significant effect of the gender of the virtual audience on the self-reported comfort in public speaking. This may be explained by the number of virtual agents in the audience (only 2). It would therefore be interesting to increase the number of virtual agents to study the effect of gender on self-reported ease of public speaking. This study is complementary to the study conducted by [30]. Indeed, the author found an effect of the participants' gender on the measured level of anxiety. Female participants obtained a higher anxiety score than males when speaking in front of an audience composed only of male agents. In our study, we focused on the effect of the gender of the virtual audience due to a lack of scientific literature on this topic. However, future research could also take into account the gender of the participants and the virtual audience to determine, for instance, whether females' participants experience higher anxiety in front of a male audience than in front of a female audience.

5 CONCLUSION

In this article, we've explored the impact of a virtual audience's social attitude and gender on the user experience during a speaking task. Given that most of the virtual audiences are composed of male virtual agents, this kind of study is more than essential. The results show that social attitude has more impact than gender on the user experience. However, even with only two agents, the results of the perceptive study reveal statistically significant effects of the gender on the perception of social attitudes and on the user's felt emotions. The next step is, of course, to extend the virtual audience to confirm the results on a larger virtual audience.

These findings will be used in the final application to vary the difficulty of the task in a public speaking training system, but in future work we plan to investigate the effect of audience gender by increasing the proportions of female and male virtual agents in the audience. We also aim at studying the impact of the gender of the participant in interaction with the gender of the virtual audience.

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