

Racing Heart and Sweaty Palms

What Influences Users' Self-Assessments and Physiological Signals When Interacting With Virtual Audiences?

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Abstract. In psychotherapy, virtual audiences have been shown to promote successful outcomes when used to help treating public speaking anxiety. Additionally, early experiments have shown its potential to help improve public speaking ability. However, it is still unclear to what extent certain factors, such as audience non-verbal behaviors, impact users when interacting with a virtual audience. In this paper, we design an experimental study to investigate users' self-assessments and physiological states when interacting with a virtual audience. Our results showed that virtual audience behaviors did not influence participants self-assessments or physiological responses, which were instead predominantly determined by participants' prior anxiety levels.

Keywords: Virtual Audience, Public Speaking, Physiological State

1 Introduction

Interactive systems that use virtual agents are becoming increasingly common as tools to train social skills or mitigate social phobias. Virtual audiences, collections of virtual agents situated in a virtual environment that simulate a public speaking situation, are an instance of such interactive systems that have been proposed for treating public speaking anxiety and for improving public speaking ability. Clinical trials have shown that virtual audiences can be beneficial for treating public speaking anxiety as part of a larger psychotherapy treatment [9, 8]. In a previous study, we investigated whether they could also be beneficial in improving public speaking skills; we found that interactive virtual audiences led to positive training outcomes while simultaneously receiving high ratings of engagement [3].

Early experiments have shown that virtual audiences displaying different behaviors can affect the level of anxiety participants experience [7]. However, it is only recently that the perception of virtual audience behaviors was systematically investigated [5, 2], and it is still unclear exactly what affects a user's self-efficacy and psychological state when interacting with virtual audiences, in particular to what extent those are influenced by virtual audience behaviors. In this paper, we present an experiment where we exposed participants to virtual

audiences varying their behavior through the course of the participants' presentations. We investigated the impact of audience behaviors and users' prior levels of public speaking anxiety on their self-assessments and physiological signals.

2 Experimental Study

We recruited 28 participants (14F, 14M) from a pool of students and interns working at our institute during the summer 2016. These participants performed public speaking presentations in front of a large LCD screen showing a life-size audience. Before the experiment, they filled out a demographics questionnaire and the Personal Report of Confidence as a Speaker (PRCS) [6]. The participants were recorded through a variety of sensors: a webcam (centered on their face for monitoring facial expressions), a Microsoft Kinect and a microphone. Additionally, an Empatica E4 wristband¹ was used in order to capture participants' electrodermal activity (EDA) and heart rate (HR).

The participants' task was to realize 4 impromptu presentations. Before each presentation, the participant was given a list of controversial topics (*e.g.* "The two-party system makes the USA ungovernable"), accompanied by suggestions of figures and talking points related to the topics. After selecting one topic, the participant was given 5 minutes to prepare notes and was then instructed to make a 5 minutes presentation about this topic in front of a virtual audience. We used the Cicero virtual audience system, which can express various levels of audience arousal and valence through audience non-verbal behavior [2]. During each of those presentations, the virtual audience was configured to behave following a fixed set of four valence trajectories. The set of trajectories constituted the experimental condition, and was randomly chosen within a set of 6 conditions. For instance, in the *HNHL* condition, the audience started in a high valence state, gradually changed its behavior to display a neutral valence after 45 seconds (*HN*), then back to positive (*NH*), and finally ended in a low valence state (*HL*). Each of the trajectories lasted for 45 seconds. Between each trajectory, a 5-second pop-up appeared on the screen, asking the participant to give a self-rating of their performance with a hands gesture (holding out the number of fingers corresponding to their self-rating on a 5-scale). After the first 3 minutes, the audience then picked trajectories randomly, and continued behaving until the participant was finished.

3 Results

In this section, we describe the statistical analyses we conducted on the collected data to explore four research hypotheses.

H1a: self-assessments are affected by audience behavior - For this analysis, we group participants' self-assessments based on which audience trajectory they follow (*e.g.* *HL* is group 1, *NL* is group 2, *etc.*). For all 6 trajectory

¹ <https://www.empatica.com/e4-wristband>

types, mean scores were in the $[3.46, 3.74]$ interval with standard deviations in the $[0.89, 1.03]$. There were no statistically significant differences between group means as determined by one-way analysis of variance (ANOVA) comparing the effect of the audience trajectory type on self-assessment scores ($F(5, 408) = 1.40, p = 0.22$). This result indicates that the audience behavior did not seem to alter the participants' self-assessments, therefore we reject **H1a**.

H1b: self-assessments are affected by anxiety - We conduct additional analyses to try to identify whether participants' public speaking anxiety levels, obtained by using their answers to the PRCS questionnaire, influenced their self-assessments. From the PRCS questionnaires, we extract one anxiety value ($prcs \in [0, 1]$) per participant, and we group participants into 3 groups depending on their public speaking anxiety levels: low-anxiety group ($prcs \leq 0.33$, self-assessments: $Mean = 3.93, SD = 0.83$), mid-anxiety group ($0.33 < prcs \leq 0.66$, $Mean = 3.42, SD = 0.85$) and high anxiety group ($0.66 < prcs \leq 1$, $Mean = 2.78, SD = 0.89$). An ANOVA showed that the effect of prior anxiety on self-assessments was significant ($F(2, 411) = 48.07, p < 0.001$). Post-hoc t -tests showed a significant difference between the three different group pairs: **H1b** is confirmed (Low and Mid: $t(349) = 5.7, p < 0.001$. Low and High: $t(288) = 9.5, p < 0.001$. Mid and High: $t(218) = 5.0, p < 0.001$).

H2a: participants' physiological states are affected by audience behavior - We realize correlation analyses between physiological features and the audience behavior trajectory. We assign an integer ($\in \{-2, -1, +1, +2\}$) to the audience trajectories according to the valence change they correspond to; for instance, the trajectory *HL* corresponds to a strong negative change and is assigned -2 . We computed a number of physiological features, such as the mean and standard deviations of the raw EDA and HR signals, as well features extracted from these with specialized software [1, 4], such as features of the phasic component of the skin conductance response, and heart rate variability features. We did not find any significant correlations between the audience trajectory valence integers and any of the physiological measures we collected. All the correlation coefficients were found to be inferior to 0.05, with $p > 0.3$. Thus, **H2a** is rejected.

H2b: participants' physiological states are affected by public speaking anxiety - We conduct further correlation analyses to determine whether participants' self-reported public speaking anxiety was related to variations in users' physiological signals. We found significant negative correlations between anxiety scores and questionnaire answers and physiological features. The more anxious participants felt a lower arousal while interacting with the audience than less anxious participants, confirming **H2b**. Additionally, we found significant negative correlations between HRV and anxiety scores, *e.g.* for *RMSSD* (Root Mean Square of the Successive Differences), a common measure of HRV: $\rho = -0.27, p = 0.000$. This is unsurprising, as HRV is related to stronger emotional regulation capabilities, which presumably would lead to lower apprehensions about public speaking and perhaps higher enthusiasm to participate in a public speaking situation.

4 Conclusion

The results of our study show that our virtual audience stimuli were unable to have a significant impact on the participants, both on the level of their self-assessments, and physiological signals. Instead, we found that the prior level of public speaking anxiety had a strong effect on the self-assessments of speakers, validating. On the physiological level, while the audience's behaviors did not affect the participants, we found that the participants that displayed higher self-assessments were significantly more aroused. Both those results indicate that most of the variation in user experience when interacting with our virtual audience stimuli were determined by participants' public speaking anxiety levels. It is unsurprising that more confident participants could be more likely to attribute higher scores to their presentations. Finally, we observed that more anxious participants experienced less physiological arousal. An interpretation of this result could be that they were more withdrawn from the interaction compared to confident subjects who would perhaps engage more enthusiastically with the system.

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