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The Effect of Previous Exposure on Virtual Reality Induced Public Speaking Anxiety: A Physiological and Behavioral Study

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Abstract

Public speaking anxiety (PSA) is defined as a strong distress when performing a speech in front of an audience, causing impairment in terms of work possibilities and social relationships. Audience behavior and feedback received during a speech are a crucial variable to induce PSA, affecting performance and perception. In this study, two different virtual reality public speaking scenarios were developed to investigate the impact of positive (more assertive) versus negative (more hostile) audience behavior regarding perceived anxiety and physiological arousal during performance. Moreover, the presence of any carry-over effect based on first experiences (positive vs. negative) was investigated by using a within–between design. Both explicit (questionnaires) and implicit physiological measures (heart rate [HR]) were used to assess participants' experience. The results confirmed the influence of audience behavior on perceived anxiety. As expected, negative audience elicited greater anxiety and lower experience pleasantness. More interesting, the first experience influenced the perceived anxiety and arousal during performance, suggesting some sort of priming effect due to the valence of previous experience. In particular, starting with an encouraging feedback scenario did not increase the perceived anxiety and HR in front of a subsequent annoying audience. This modulation did not appear in the group who started with the annoying audience, which clearly reported higher HR and anxiety during the annoying exposure compared with the encouraging audience. These results are discussed considering previous evidence on the effect of feedback on performance. In addition, physiological results are interpreted considering the role of somatic marker theory in human performance.

Keywords: virtual reality, public speaking anxiety, physiological arousal, audience behavior

Introduction

Public speaking anxiety (PSA) is defined as a strong distress when performing a speech in front of an audience,[1] which often involves fear of public speaking, speech alteration (i.e., speech disfluency[2]), mismatch between self-report and observer speech performance ratings (i.e., illusion of transparency[3]), avoidance behaviors,[4–7] and an increase of physiological arousal (i.e., increase of heart rate [HR][8–12]). According to Pull,[13] up to 70 percent of the general population reports a fear of speaking in public, which often causes impairment in terms of work possibilities and social relationships.[5,14] Importantly, cognitive factors would seem to play a crucial role in the development and maintenance of PSA.[15]

That is, negative mental schemas of the self and of public speaking situations might lead to a certain degree of misinterpretation about own social performance, increasing anticipatory anxiety regarding future social events.[16–20] By contrast, inducing positive experiences by means of encouraging feedback might help to increase a person's belief to overcome challenging tasks and reduce speaking anxiety.[21,22] Experimental studies that provided positive feedbacks during performance reported an increase of self-efficacy perception and performance in physical or cognitive tasks.[23–30]

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Nowadays, virtual reality (VR) is a useful tool to recreate public speaking experiences for the study of anxiety.[31–33] Within this field of research, an interesting and often manipulated variable capable of modulating anxiety concerns the audience feedback received during the speech.[33–36] That is, performing a public speech in front of an audience who approves would seem to reduce PSA.[37] Conversely, speaking in front of a noninterested audience increases anxiety.[38]

Thus, feedback received during a speech can increase or decrease PSA, based on its valence. It is, therefore, plausible to think that previously received encouragement by the audience might protect and reduce anxiety against later annoying (or less positive) public speaking performances. This would suggest that it is not only the feedback *per se* (received during the performance) to determine the perceived anxiety, but also the valence of the feedback received in previous experiences and the mental schemas that are built on the basis of them. Importantly, according to Damasio's[39] somatic markers hypothesis, negative or positive outcomes result in specific physiological markers stored in the brain.

These ''somatic markers'' are reactivated in subsequent experiences and are used to predict the outcome of performance and affect behavior, especially under conditions of high cognitive load.[14,40] Thus, in a public speaking situation, the arousal elicited by earlier experiences might contribute to determine negative or positive somatic markers that, in turn, might affect following performances and physiological responses.

The study aims to explore the presence of any carry-over effect (both positive and negative) generated by the first experience on PSA. Two public speaking tasks (characterized by encouraging vs. annoying attitude by the audience) were performed in VR, but the order of presentation was counterbalanced across participants.

Hypotheses

H1: Negative feedback scenarios induce more anxiety compared with the positive scenarios, in both physiological and self-report measurements.

H2: Carry-over effects of previous feedback are expected on the following performance.

H3: Notable differences in terms of experience evaluations (pleasantness and audience evaluation) are forecasted when positive and negative conditions are compared.

Materials and Methods

The study was conducted according to the ethical standards of the Declaration of Helsinki and was approved by the Department of Psychology, University of Milano Bicocca, local ethical committee.

Details given in Supplementary Data.

Participants

The sample size was calculated *a priori* using G*Power 3.1. A total of $N = 47$ participants aged between 18 and 53 years took part in the experiment (mean [M] = 26.8, standard deviation [SD] = 6.49). There were 32 women (68.1 percent) and 15 men (31.9 percent).

Anxiety assessment

State-Trait Anxiety Inventory. State-Trait Anxiety Inventory (STAI) is an anxiety self-assessment scale, composed of two subscales that measure transient and enduring levels of anxiety.[41,42]

Social Interaction Anxiety Scale. Social Interaction Anxiety Scale (SIAS) is a self-report questionnaire that measures the presence of fear during general social interactions.[43]

Social Phobia Scale. Social Phobia Scale (SPS) is a self-report questionnaire that measures anxiety in situations involving being observed by others.[43]

Measures

Physiological measurements

Heart rate. HR was measured continuously at 512 *Hz* through Procompt Infiniti 5 through a Blood Volume Pulse (BVP) Sensor. According to the length of each exposure, 6 minutes of interval was extracted and analyzed using Kubios HRV software. Beats per minute (bpm) was selected as a measure of the participants' stress-related sympathetic activity. High HR values indicate high physiological arousal.[8,9,44,45]

Self-report measurement. Four different fixed-point visual analog scales,[46] ranging from 0 (not at all) to 10 (extremely) were used to assess participant's subjective experience during the task:

- Sense of presence (*I felt like I was inside the environment shown)*
- Interest of the audience (*I had the feeling that the audience was listening to me*)
- Perceived anxiety (*How much anxiety did this experience evoke*)
- Experience pleasureless *(I found this experience pleasant)*

Materials

Hardware. The VR equipment used for the experiment included an Oculus Quest-2 head-mounted display, connected to a computer to increase video-rendering. Two VR environments were developed by means of Unity Game Engine: annoying audience versus encouraging audience. Each condition included four questions (pleasant vs. annoying) (Fig. 1). To obtain comparable difficult and length across the two sessions, the speech topics were two different cooking recipes (pumpkin–cheese rice and apple cake) (Fig. 2).

Procedures (Fig. 3; details given in Supplementary Data)

The experiment followed the sequence as follows:

- QUESTIONNAIRES
- SPEECH PREPARATION
- BASELINE
- FIRST SPEECH
- LIKERT
- SPEECH PREPARATION (2)
- BASELINE (2)
- SECOND SPEECH
- LIKERT (2)

FIG. 1. Audience during question & answer.

Around 10 minutes divided the first VR exposure to the second one

Data analysis

Statistical analyses were performed by Jamovi software using linear mixed-effects model (Satterthwaite approximation for *p*-value). A random coefficient was used for each participant (as ID intercept), whereas anxiety questionnaires score as covariate for anxiety self-report and baseline covariate in the HR analysis.[47] The 2×2 analysis of variance was performed with the main factors of audience feedback (encouraging vs. annoying) and Begin (positive vs. negative). In case of significant interaction effects, simple effect analysis was performed to evaluate carry-over effects.

Results

Behavioral results

Sense of presence. No main effect of Audience feedback ($p = 0.573$), Begin ($p = 0.228$), and of the interaction Audience feedback * Begin exposure was found ($p > 0.999$) with respect to sense of presence ($M = 6.44$, $SD = 1.84$).

Interest of the audience. A main effect of Audience feedback [$F(1, 46) = 7.18$, $b = 0.45$, $p = 0.010$, $R^2 = 0.02$)] was found. The interest of audience was perceived as greater in the encouraging audience (estimate = 0.45, $M = 6.80$, $SD = 0.25$) compared with annoying audience ($M = 6.30$, $SD = 0.25$). No main effect of Begin ($p = 0.566$) or interaction between Audience feedback * Begin ($p = 0.057$) was found.

Perceived anxiety. A main effect of Audience feedback [$F(1, 46) = 5.88$, $b = 0.58$, $p = 0.019$, $R^2 = 0.02$)] in perceived anxiety was found. The perceived anxiety was higher for the annoying audience (estimate 0.58, $M = 5.44$, $SD = 0.25$) than for the encouraging audience ($M = 4.85$). No main effects of Begin ($p = 0.401$) was found. Interaction Audience feedback * Begin ([$F(1, 46) = 4.32$, $b = 1.00$, $p = 0.043$, $R^2 = 0.02$)] was significant.

Simple analysis revealed contrast between annoying versus encouraging feedback in negative begin group: lower perceived anxiety for the encouraging feedback ($M = 4.80$, $SD = 0.36$, estimate = -1.08, $p = 0.003$) compared with annoying feedback ($M = 5.88$, $SD = 0.36$). Such difference was not present in positive begin group (encouraging audience: $M = 4.91$, $SD = 0.36$; annoying audience $M = 5.00$, $SD = 0.35$, $p = 0.808$) (Fig. 4).

FIG. 2. Audience during recipe speech.

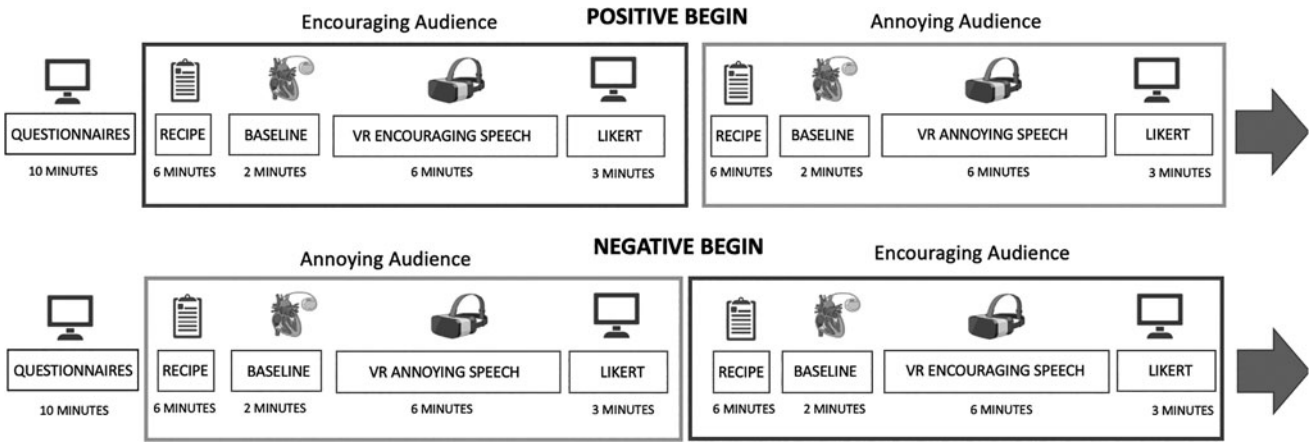

FIG. 3. Experimental timeline.

Experience pleasantness. A main effect of Audience feedback [$F(1, 46) = 5.66$, $b = 0.45$, $p = 0.021$, $R^2 = 0.02$)] on experience pleasantness was found. The pleasantness after encouraging audience ($M = 6.10$, $SD = 0.24$, estimate = 0.45) was greater than annoying condition ($M = 5.65$, $SD = 0.24$). No main effect of Begin ($p = 0.263$) or interaction Audience feedback * Begin ($p = 0.830$) was significant.

Physiological measures

HR mean. No main effect of Audience feedback [$F(1, 43.3) = 1.86$, $b = 1.08$, $p = 0.180$] or Begin [$F(1, 43.3) = 1.49$, $b = 1.74$, $p = 0.229$] on HR mean was found. A significant interaction effect Audience feedback * Begin [$F(1, 43.9) = 14.41$, $b = 6.06$, $p < 0.001$, $R^2 = 0.10$] on HR mean was found. Simple analysis revealed significant difference (estimate = 4.12, $p > 0.001$) only in the negative begin group comparing encouraging (83.5, $SD = 1.12$) and annoying feedback ($M = 87.6$, $SD = 1.12$). Moreover, considering the annoying feedback condition, significant difference related to the begin was found lower HR mean value in positive begin group ($M = 80.0$, $SD = 8.98$, estimate = −4.77, $p = 0.005$) compared with negative begin group ($M = 89.8$, $SD = 11.3$) (Fig. 5).

Discussion

The aim of this study was to investigate the impact of the audience's behavior during a VR public speaking task, as well as the presence of carry-over effects related to previous experiences, on self-reported evaluations and implicit (physiological) measures.

The results confirmed the impact of the audience's feedback on perceived anxiety during the public speaking exposure. In line with previous studies,[37,48] the annoying audience elicited stronger evaluations of anxiety than the encouraging audience. We also found that the previous feedback received affected following exposures. Participants who were first exposed to an encouraging scenario evaluated the following annoying scenario similarly to the previous scenario.

Those who started with the annoying audience, on the contrary, reported higher perceived anxiety after the annoying

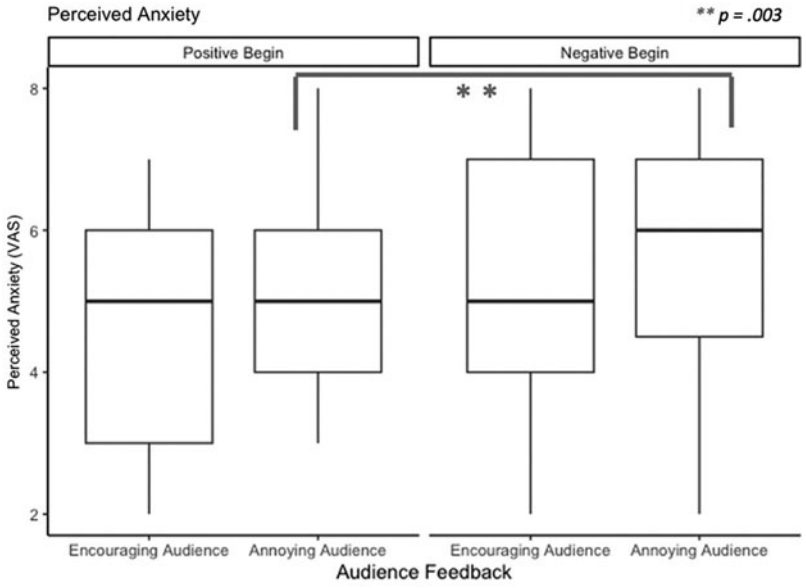

FIG. 4. Perceived anxiety for annoying and encouraging audience in positive versus negative begin group.

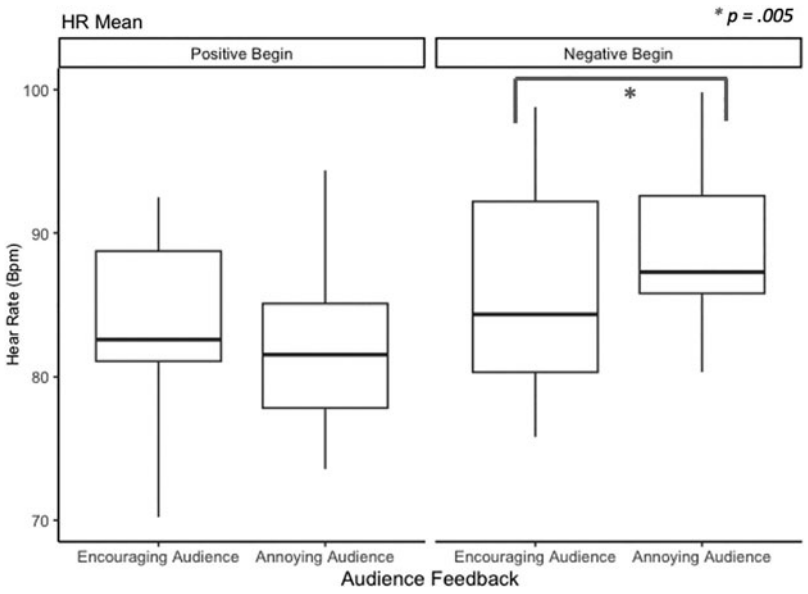

FIG. 5. HR mean for annoying versus encouraging audience in positive versus negative begin group. HR, heart rate.

scenario (compared with the encouraging audience). The effect of positive feedback was also found in terms of physiological arousal. During the annoying audience, the HR of participants who previously were exposed to positive scenario did not increase, and remained similar to that obtained while speaking in front of encouraging audience. On the contrary, an increase of HR was found in those who began with a negative feedback scenario, reporting differences in terms of HR across conditions (higher level for annoying audiences), like self-report anxiety evaluations.

The study confirms previous results obtained in other domains,[25,30,49] showing that initial positive feedback can affect the following performance and extend them to PSA. Such modulation is likely to be driven by the positive reward elicited by the verbal (e.g., congratulations) and nonverbal (e.g., nodding) interest exhibited by the audience. These findings might be discussed considering the somatic marker hypothesis.[39] Such theory suggests that specific experiences are linked within our brain as a form of memories to specific body states. This association can affect following experiences and evaluations.[39]

This might be the case in this experiment wherein the first interaction with an encouraging audience could have contributed to the creation of positive somatic markers, which in turn affected behavioral and physiological responses in the following task.[50]

To conclude, this study suggests, for the first time, the importance of the carry-over effect due to previous experiences on a following public speaking VR task. Future studies will need to investigate how prolonged (in terms of duration) positive or negative feedback has to be to consolidate or reverse previous negative experiences within a virtual stressful situation, such as public speaking,

Limitations of the study

To consolidate these results, the paradigm should be replicated with a cohort of participants with different personality traits, such as high anxiety traits, instead of low anxiety traits only. Moreover, PSA, as well as presence and social presence in VR, might be investigated by means of specific questionnaires. These questionnaires were not used in this study to avoid participants' fatigue across exposures. Unavoidably, the speech argument might affect differently each participant concerning speech preparation and also perceived anxiety.

As well, further studies will need to investigate carry-over effects for different emotions (positive vs. negative). Moreover, concerning physiological results, somatic markers are generally built and consolidated after repeated experiences, while in this study the participants were only exposed to one condition before the other. Further studies will then need to address this topic more explicitly.

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Supplementary Material

Supplementary Data

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