

## **The mechanism of social stress induction in virtual environments.**

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In recent years, Virtual Reality (VR) has become an increasingly popular tool for social skills training. Including training for public speaking and job interviews situations. Despite encouraging results on the effectiveness of VR, we still don't fully understand how virtual reality leads to social stress. In my PhD project, we investigate this mechanism in order to provide designers with guidelines on how to design stress-inducing applications. To this end, we propose a model that aims to predict stress levels according to the situation.

**Additional Keywords and Phrases:** Social stress, virtual agents, social evaluation, computational model.

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### **1 INTRODUCTION**

Social skills are the verbal and non-verbal communication skills that help communicate and collaborate with others [8, 9]. These skills are needed to clearly articulate one's needs, to present and stand up in front of a public audience, to negotiate and achieve personal growth, or to convince an employer that we are the ideal candidate. Research shows that higher levels of social skills are correlated with higher levels of life satisfaction and negatively correlated with loneliness [1,2]. Not everyone has the same level of social skills: little practice and observation, mental health conditions and developmental disabilities can reduce the chances of acquiring these skills. In particular, people with social anxiety are less likely to engage in social interactions, giving them fewer opportunities to build skills and gain confidence. In fact, social situations can be overwhelming for people with social anxiety, and can activate autonomic bodily responses such as sweating, stuttering or muscle tension, leading to difficulty expressing themselves, rumination, and depression. These physical responses to a socially threatening situation constitute social stress. Social stress responses include increased heart rate, increased blood pressure, increased cortisol levels and many other responses. To reduce their intensity, health professionals suggest exposure therapies: by exposing the individual to anxiety-inducing but safe situations, the intensity of the body's responses decreases over time.

Virtual reality (VR) is one of the tools used to expose patients to a stressful situation and gradually reduce stress responses. Virtual Reality Exposure Therapy (VRET) shows promising results in the treatment of phobias such as the fear of heights [10], while other applications provide public speaking training, where the user can practice giving a presentation in front of a virtual audience. However, it is not clear how a virtual application for social skills training induces the stress required for the training. In our project, we investigate the ways in which virtual reality leads to higher levels of social stress and attempt to provide guidance to designers of social stress applications. We

also propose a model that can predict the level of stress induced by a particular situation. To do this, we map input factors describing the situation, such as the virtual agent's behavior towards the user, to corresponding levels of social stress.

The two main situations that we focus on are public speaking and job interviews. These situations cause stress when the individual feels under social evaluation. According to the social preservation theory [3], individuals experience stress when their self-image is threatened, and when their skills, abilities and qualities are questioned. Indeed, Dickerson et al. [4] conducted a meta-analysis showing that being under social evaluation such as public speaking, or job interviews leads to increased cortisol levels. This is not only limited to real-life situations, Kothgassner and al. [5] conducted a study in which participants performed a public speaking task in front of a real audience, a virtual audience, or an empty virtual lecture hall. The results showed that public speaking in front of virtual agents led to higher cortisol levels compared to the empty room, suggesting that virtual agents induced a sense of social evaluation.

When dealing with social stress, it is important to consider the differences between individuals and how they process social cues and social situations. For instance, individuals with social anxiety seem to process social cues with a bias towards negative cues, making them more sensitive to stressful situations [11, 13, 12, 19]. Other factors such as personal goals, beliefs or experiences may also influence the mechanism of stress induction [14, 15, 16, 17]. As a result, the same virtual situation may be perceived as stressful by some people, while others may find it very mundane

## **2 METHODOLOGY**

First, I conducted a literature review to identify important factors in the process of social stress induction in virtual reality. These factors included technological factors (i.e. factors that are related to technological configurations such as the display resolution), personal factors (i.e. factors related to the person, including personal traits and characteristics), and situational factors (i.e. factors related to the scenario such as the behavior of the virtual agent, its characteristics or the task). Based on this literature we propose a conceptual model that describes how these factors interact with each other and how this interaction affects the level of stress. We then conducted two experiments to test two different hypotheses of the model. We now plan to conduct a new experiment to test the third hypothesis. Later, we will try to integrate personal factors and translate the conceptual model into a computational model capable of predicting the level of stress by taking these factors into consideration.

## **3 MODEL OF SOCIAL STRESS IN VIRTUAL REALITY**

According to our model, the level of social stress depends on the interaction of three factors, namely the *virtual agent friendliness*, the *virtual agent's dominance*, and the *feeling of being evaluated*, as shown in Figure 1. A number of studies have shown that interacting with a hostile virtual agent is more stressful than interacting with a friendly virtual agent [18, 19, 20]. However, another study [25] found contradictory results, i.e., they found no effect of the virtual agent friendliness level on social stress. To explain this difference we hypothesised that social presence (i.e., the feeling of being there with a real person [21,22]) interacts with virtual agent friendliness (i.e., the level of affection expressed) on the level of social stress. We conducted a study to test this hypothesis and found an interaction between social presence and friendliness of the virtual agent on social stress levels. High social presence

was achieved by displaying the virtual agents in the virtual headset display and low social presence by displaying the virtual agents on a wall projection. High and low friendliness was operationalized by implementing friendly behavior (e.g., smiling, leaning forward) and low friendliness was operationalized by implementing hostile behavior (e.g., frowning, leaning backward). The results showed that only when social presence was high the hostile audience lead to higher stress compared to the positive audience, whereas when social presence was low we did not observe this difference.

The feeling of being evaluated is an important factor for social stress induction, specially when social evaluation is used as a stressor. Research shows that the mere presence of an individual is not sufficient [27] [26]. Therefore the feeling of being evaluated is essential for the induction of stress when social evaluation threat is used. *The feeling of being evaluated* seems to be the result of the interaction of three factors. First, there is social social presence. Research shows that without cues in the environment indicating that an attention is being paid to us, there is no sense of being evaluated [4][5]. To induce a high sense of being evaluated, the virtual environment should carry cues that we are in the presence of a social agent. The experiment that we conducted also supports this effect, it showed that only when social presence was high, virtual agents' behavior affected the user's level of social stress. The second factor influencing the feeling of being watched is the ability of the virtual agents to reflect. In fact, Muth et al. [24] asked participants to rate the degree to which they felt observed and the observer's ability to reflect. The observers were: a dog, an infant or an adult. The results showed a correlation between the feeling of being evaluated and the observers ability to reflect. Finally, other studies suggest that the feeling of being observed is related to the observer's gaze direction [23]. By observing the gaze direction and behavior, we may be able to infer the observer's attention.

In our next experiment, we investigate the effect of dominance in this model. We propose that interacting with a dominant virtual agent will lead to higher stress level because of the sense of losing control induced by the virtual agent. Indeed, Cundiff and al. [7] conducted a study showing that dominance plays a key role in social interactions and leads to higher stress when being under evaluation. They asked participants to interact with another person who had a dominant speaking style (e.g., speaking in an assertive and definitive manner) or a submissive speaking style (e.g., speaking in a less confident way). Results showed that dominant partners induced higher cortisol levels during a situation of social evaluation. We would like to test this hypothesis in the case of virtual reality and virtual agents. We expect that a negative evaluation from a dominant virtual agent lead to higher stress compared to a submissive virtual agent, but a positive evaluation from a dominant virtual agent will lead to a similar level of stress compared to a submissive virtual agent.

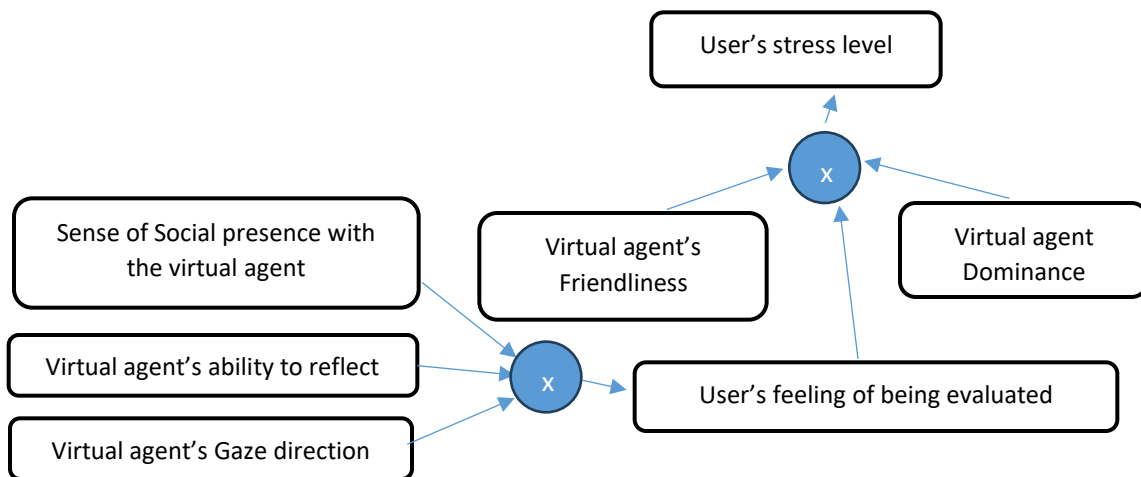


Figure 1: Model of social stress in virtual reality situations during socially evaluative tasks. X: interaction effect

#### 4 CONCLUSION

Our research attempts to identify the mechanism of stress induction in virtual reality. Although social stress is a complex mechanism involving a complex number of factors, our model draws attention to certain processes and factors that designers of social stress applications should consider. These include the sense of being evaluated and dominance, which have received little research attention in the area of social stress induction. The model can also be used to fine-tune the level of social stress induced in a virtual situation by adjusting the situational and technical factors. Our future perspectives are to include other personal factors in the model and then to translate this conceptual model into a computational model capable of predicting a level of stress based on input data. In this way, we can create systems that can adapt to each individual with different characteristics and traits.

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