Addressing Public Speaking Anxiety in Real-time Using a Virtual Public Speaking Coach and Physiological Sensors

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ABSTRACT

Oral presentations are important and challenging tasks that most people struggle with due to public speaking anxiety. Virtual agents have been shown to be effective communication skills training coaches and effective as virtual audiences for inducing anxiety in public speaking exposure therapy. To date, there are fewer research interventions, including virtual agents, that are designed to assist presenters manage their anxiety in real-time during presentations. Our research attempts to fill this gap by exploring ways in which technologies, including virtual agents, can help reduce anxiety during presentations. To help presenters manage their anxiety, we will design and evaluate an automated real-time framework for detecting public speaking anxiety and explore behavioral just-in-time techniques that presenters can use while presenting. Our automated framework will be guided by a physiological detection model, use a virtual agent as the user interface, and will assist presenters during their presentation.

CCS CONCEPTS

• **Human-Centered Computing** → Human Computer Interaction (HCI)

KEYWORDS

Virtual agents; oral presentations; public speaking anxiety; sensing; biofeedback

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1. INTRODUCTION

Oral presentations are challenging cognitive and communication tasks that can require a significant amount of training and presentation experience for presenters to feel confident and prepared. Public speaking anxiety is one of the causes for poor and ineffective oral presentations and the main reason why most people find this task challenging and undesirable [1]. Various technological interventions have been developed to aid in authoring, rehearsing and delivery of oral presentations. Some of these interventions include virtual agents designed to help presenters deal with public speaking anxiety before their presentations [2]. Often, most of these interventions require significant time commitment from presenters to prepare for their presentation using these technologies. Although there have been successful interventions in which virtual agents have collaborated with presenters in co-delivering their presentations to reduce public speaking anxiety [3], little work has been done to date on other kinds of interventions (including those with virtual agents) that aim to reduce anxiety during a presentation. Interventions for assisting speakers address anxiety during a presentation could potentially make an oral presentation task less dreadful, increase presenters' confidence, and improve the quality of their presentations.

Developing real-time interventions for dealing with anxiety during a presentation is a challenging endeavor. During an oral presentation, most presenters are in a high cognitive load state, and any task performance feedback provided to them may induce more anxiety [4] and negatively impact their presentation quality. Real-time interventions may be more effective if they are delivered based on a presenter's affective state and presentation context, and require minimal effortful processing of information.

In this research work, a framework for real-time anxiety detection will be developed and used to explore interventions for reducing anxiety during presentations. The real-time anxiety detection model will be based on physiological data and will be evaluated in a user study. A series of exploratory studies will be conducted to determine effective just-in-time interventions for reducing presenters' anxiety. We will integrate those interventions with the real-time anxiety detection model and evaluate the integrated framework in a user study. We have already conducted preliminary work in which a virtual agent counsels presenters before their presentation on how to deal

Figure 1: Sample EDA data collected from a participant in our preliminary study

with the anxious thoughts they experience related to public speaking. Our next steps include the development of just-in-time virtual agent-based interventions for public speaking anxiety, including interventions in which the agent nudges the presenter to perform certain anxiety reducing behaviors (e.g. taking a deep breath). Finally, we will conduct a summative evaluation to assess the appropriateness and effectiveness of these interventions in user studies.

2. RELATED WORK

In this section, we briefly review theories of public speaking anxiety and physiological processes associated with anxiety. We describe related research in detecting anxiety using physiological data, before highlighting related studies where virtual agents have been used in presentations.

2.1 Defining Public Speaking Anxiety

Public speaking anxiety (PSA) is the most common subtype of social anxiety and the No.1 fear experienced by most people in the United States [5, 6]. Often, public speaking is used as a method of discovering the antecedents, causes, and consequences of anxiety in most social anxiety studies [5, 7]. PSA can be conceptualized as both a trait - a general predisposition to experience anxiety in most situations [8] and as a state - anxiety experience in a particular situation [9], as pointed out by Bodie [7] in his review of PSA research. Some people are generally anxious about public speaking while other might experience it sometimes (depending on the setting) [7].

Public speaking anxiety, just like other stressful situations, can be explained within the three-system model originally proposed by Lang [10]. The three-system model proposes that anxiety is experienced in three systems: cognitive, physiological and behavioral [7, 10]. Presenters that have PSA often report negative self-focused cognitions (e.g., “*I am a horrible presenter. I am going to make mistakes*”) [4, 8], experience physiological arousal (e.g. increased heart rate) [11] and sometimes behaviors such as speech disfluencies and avoiding audience eye-contact [7, 8]. Most interventions for reducing public speaking anxiety typically target only one of the three systems, fewer interventions target two or all three systems [8].

2.2 Defining Public Speaking Anxiety

The cognitive dimension of PSA is typically measured using self-report instruments. The behavioral dimension is traditionally assessed using observers who record anxiety induced behaviors that manifest in the presenter [12]. With recent advances in technology, some of these behaviors (e.g. speech disfluencies) can potentially be automatically and objectively measured using

speech and vision processing tools. The physiological aspect of PSA is assessed using both self-report and objective physiological sensors [7]. In our work we will primarily focus on detecting physiological response to anxiety during presentation, but have also developed a virtual agent system that targets the cognitive aspect of PSA. We will use self-report measures to assess presenters’ cognitive and physiological anxiety before and after presentation and, in some studies, we will ask observers to assess the presentation quality.

The human physiological system, which includes the central, autonomic, and somatic nervous systems, is used to regulate the body’s response to stress [13] but researcher have mainly focused on studying the activation of the autonomic nervous system due to anxiety. Most validated physiological assessments of activation of the autonomic nervous system have focused on measures of electrodermal activity (EDA), e.g. sweat on palms, and cardiovascular response, such as heart rate. Recently, unobtrusive wrist sensors (such as the E4 sensor) have been shown to be as effective as traditional stationary electrocardiogram and finger skin conductivity sensors in measuring stress and anxiety [14]. In our work we will use the E4 wrist sensor [15] to collect real-time EDA and heart rate variability data for our anxiety detection model. Figure 1 visualizes differences in EDA when relaxing and presenting.

Research using physiological data for real-time anxiety detection in human-agent collaboration has received little attention in the human-computer interaction literature. Current research in this area has mainly focused on the application of real-time anxiety detection systems in gaming [16]. Fewer researchers, such as Rani et al. [17, 18] have explored robotic systems for anxiety detection. Rani et al. [18] proposes the use of multiple physiological indices and pattern recognition methods such as fuzzy logic and regression trees for real-time detection of anxiety. However, Rani et al. [18] work does not include an evaluation study of the proposed real-time robotic system for anxiety detection. In our work we will explore various pattern recognition techniques and use these techniques in the development of a real-time anxiety detection framework that uses physiological data for use in human-agent collaboration and to support just-in-time interventions for reducing anxiety.

2.3 Virtual Agents in Presentations

Studies using virtual agents in presentations have increased in recent years. These studies have shown that virtual agents can be effective in assisting speakers in preparation, rehearsal, and delivery of their oral presentations [2, 3, 19]. Some studies like those by Nijholt et al. [20], Matulic et al. [21] and Noma et al. [22] have explored how virtual agents can extend the capabilities

of the presenter in virtual space. A recent study by Trinh et al. [3] has extended the use of the virtual agent in the real world by designing a co-presenter agent. In an evaluation study, the co-presentation agent was associated with significant reductions in self-reported public speaking anxiety [3].

Other researchers have studied the effectiveness of virtual agents in communication skills training. These studies include one by Trinh et al [2], in which a robot coach was used to provide communication skills feedback to a presenter when rehearsing. Virtual agents have also been used as audience members to induce anxiety [22]. In some cases, the virtual audience has been used to provide non-verbal feedback in communication skills training [24]. In our work, we will explore other ways of using virtual agents for reducing public speaking anxiety and improving presentation quality.

3. RESEARCH APPROACH AND METHODS

We will conduct a series of studies aimed at meeting two core research goals:

1. *Designing a framework for real-time anxiety detection*

We will collect physiological data of presenters giving short presentations in a usability lab setting and then use the data to develop and evaluate a framework for real-time anxiety detection. The framework will be evaluated in two folds: 1) using machine learning model evaluation techniques then, 2) in user lab studies. Proposed studies are expounded in section 3.2.

2. *Identify effective interventions for reducing public speaking anxiety when anxiety is detected*

To meet this goal, first, we will investigate how an intelligent virtual agent can assist presenters manage their anxiety by coaching them on how to deal with anxious thoughts they may experience during a presentation. Second, through an exploratory user study, collecting qualitative and quantitative data, we will explore various just-in-time techniques that are effective in reducing anxiety during presentation. We will then study how an intelligent virtual agent can help presenters perform those helpful techniques while they are presentation. For example, the agent could nudge the presenter to perform suggested behaviors (e.g. taking a deep breath). We will evaluate the appropriateness and effectiveness of these just-in-time interventions (that use the real-time anxiety detection framework) in user studies.

3.1 Preliminary Work

To date, we have conducted a user study (Study 1) in which an intelligent virtual agent (shown in figure 2) coached presenters on how to deal with anxious thoughts they may experience during presentation, using cognitive-behavioral therapy (CBT) techniques. The virtual agent followed the cognitive restructuring process used by a clinical psychologist in developing rational replacement thoughts from a selection of maladaptive ones related to public speaking anxiety. To develop cognitive restructuring algorithm, we collected and analyzed a corpus of examples, generate by a clinical physiologist, and using natural language generation techniques produced

Figure 2. Virtual coach for public speaking anxiety used in study 1.

replacement thoughts. This cognitive restructuring algorithm was incorporated into a virtual coach that helps presenters address their public speaking anxiety. In a between-subject study, where the CBT virtual coach was compared to a social chat agent, the CBT coach led to significantly greater reductions in maladaptive thoughts associated with speech anxiety, as well as significantly less self-reported nervousness during presentation.

In this study we asked participants to wear a physiological sensor on their wrist throughout the study sessions. Using this sensor, we collected participants' heart rate and electrodermal activity data when: 1) they were relaxed, 2) rehearsing for their presentation, and 3) delivering their presentations. Additionally, we asked participant to view their videotaped presentations and use a continuous affect rating and media annotation software to indicate their affect (positive/negative) and when they felt anxious during the presentation. We are in the process of analyzing those physiological and affective data. Analysis of this data will inform the design of the real-time anxiety detection framework.

3.2 Proposed Work

Our proposed research plan has three evaluation studies as milestones.

3.2.1 Study 2: Evaluation of Real-time Anxiety Detection

Extensive research has demonstrated a relationship between electrodermal and cardiovascular activities with anxiety. Informed by the analysis of the physiological data collected in the first study, we plan to use features correlated with anxiety in developing a framework for real-time public speaking anxiety detection. The proposed anxiety detection model will be trained on physiological data of participants in both a relaxed state and an anxious state (during presentation) and will be used to determine when a presenter is physiologically responding to presentation anxiety. We will evaluate the accuracy model in detecting anxiety using additional participants who will be asked to deliver a presentation. We will record moments when a participant is anxious and in a presentation review activity we will assess if they would self-report as having experienced anxiety at the moments our model detected they were anxious. This study will also be used to determine presentation context

features (i.e. what the presenter is doing when they experience anxiety) that could be helpful in making the model robust and in designing personalized interventions.

3.2.2 Study 3: Real-time Interventions to Reduce Anxiety

In our third study, we plan to first explore different just-in-time techniques and interventions that can help presenters manage their anxiety during presentation, then determine which ones are most effective in reducing anxiety. Finally, we will investigate ways in which a virtual agent can nudge or persuade presenters to perform behaviors we determined are effective at reducing public speaking anxiety.

We are currently conducting a literature review of proposed just-in-time techniques, including biofeedback techniques used in stress and management, for dealing with anxiety. From this review we will select a subset of techniques to explore in a user study.

We will select the techniques that prove to be most effective from the exploratory study and in a subsequent user study examine how a virtual agent can persuade the presenter to perform these behaviors while presenting. In this study, we will also assess the effects of the agent on presenter's confidence, anxiety and presentation quality. Results of this study will inform the design on the final study in which we will integrate the anxiety detection framework.

3.2.4 Study 4: Summative Evaluation

The findings of study 2 and 3 will guide our fourth and final study. This study will involve the evaluation of a sensor-driven virtual agent in assisting presenters in performing the effective techniques determined in study 3. In this study, we will recruit participants to give a presentation in which they will evaluate the effectiveness of a physiological sensor-driven virtual agent in aiding them in public speaking anxiety management during presentation. We will assess if a just-in-time sensor-driven virtual agent that intervenes when a presenter's anxiety is detected is more effective at reducing their anxiety during a presentation compared to a non-sensing virtual agent. This study will answer questions related to when a sensor-driven virtual agent should interrupt the user when they are performing tasks that have high cognitive load and where they experience social anxiety (such as in presentations).

4. EXPECTED CONTRIBUTION

Our work to date has contributed to the design on a CBT-based public speaking anxiety virtual coach that can be integrated into current presentation tools, such as Microsoft's PowerPoint, and is accessible to many anxious presenters who might not have access to a social anxiety therapist. This work will also contribute to theoretical models on sensor driven real-time human-agent collaboration. This work will also further research in the design of real-time systems to reduce anxiety induced by cognitive and social tasks.

A broader contribution of this work is the development of tools and interventions that will increase the overall quality of oral presentations and improve public speaking experience by reducing anxiety and increasing speakers' confidence.

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