

# You'll be Great: Virtual Agent-based Cognitive Restructuring to Reduce Public Speaking Anxiety

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**Abstract**—Public speaking is an essential task for success in many careers, yet fear of public speaking makes this an undesirable activity for most people and negatively affects the quality of many presentations. Cognitive behavioral therapy is an effective tool for helping people overcome social anxieties disorders, including public speaking anxiety. However, most people do not engage in this therapy for public speaking anxiety, due to time constraints and other barriers. We present a virtual coach that uses cognitive behavioral therapy techniques to help presenters restructure irrational thoughts associated with public speaking anxiety. The design of the virtual coach was informed by an analysis of a corpus of cognitive restructuring examples generated by a clinical psychologist. In a between-subjects experiment comparing the virtual coach to a control condition, the virtual coach was shown to be significantly better at reducing thoughts associated with speech anxiety and improving a presentation experience for speakers.

**Index Terms**—embodied conversational agents, intelligent interactions, virtual agents, cognitive behavioral therapy, natural language generation, public speaking anxiety

## I. INTRODUCTION

Public speaking anxiety (PSA) is the most prevalent subtype of social anxiety and is the No.1 fear experienced by the public in the United States [1], [2]. In a survey of 803 college students, over 35% expressed a need for PSA counseling [3]. Speakers that have PSA often experience negative self-focused thoughts (e.g., “the audience will think I’m stupid if I make a mistake”) [2], [4], physiological arousal (e.g. increased heart rate) [5] and behaviors such as speech disfluencies and avoidance of audience eye-contact [4], [6].

Cognitive-Behavioral Therapy (CBT) is the most commonly used and most successful psycho-social treatment for Social Anxiety Disorders, such as fear of public speaking [7]. Cognitive-behavioral models of social anxiety propose that anxiety arises from inaccurate beliefs about potential dangers in social situations, negative predictions about possible outcomes, and biased processing of events that occur in social situations [7]–[9].

A central tenet of CBT is that many negative emotions and mood disorders arise from maladaptive, irrational thoughts and beliefs. CBT holds that if these internalized maladaptive thoughts can be replaced with more rational thoughts, it will lead to reductions in emotional distress and negative emotions, such as fear [4, 6, 10]. The process by which irrational thoughts are identified and more rational equivalents derived is

called “cognitive restructuring” and is a central process in CBT and an important skill employed by CBT counselors. Cognitive restructuring involves the identification of common patterns of irrational thoughts (such as catastrophizing) analyzing and disputing the basis of these thoughts and replacing them with more rational equivalents. For example, someone who has public speaking anxiety may think that “I’m going to stumble over my words and my presentation will be horrible.” but upon reflection may realize that “My presentation might not be horrible if I rehearse, and even if I stumble the audience will probably understand.” If they are able to replace their irrational thought with the more rational one (e.g., through rehearsal, or linking the rational thought to trigger conditions), it can reduce their fear and anxiety related to public speaking. In our work, we have automated the cognitive restructuring process used by a therapist in developing rational replacement thoughts for a selection of maladaptive ones related to public speaking anxiety. Our methodology involved collecting and analyzing a corpus of examples and using natural language generation techniques to produce the replacement thoughts. We incorporated this cognitive restructuring algorithm into a virtual public speaking coach that helps presenters address their public speaking anxiety. In this paper we describe our development process, the cognitive restructuring algorithm and the coach, and a randomized evaluation of the system to determine whether it leads to reductions in maladaptive thoughts and anxiety in public speaking.

## II. RELATED WORK

### A. Virtual Agents for Cognitive Behavioral Therapy

Virtual agents have been used successfully for a variety of health coaching and counseling interventions. They have been shown to have generally positive results in providing health counseling in areas including preconception care [14], chronic disease care [10], and mental health [11]–[13]. Recently, virtual agents have been effectively used to deliver CBT to patients with mental disorders [14], depression [13], [15], and anxiety in particular [15]. Fitzpatrick, et al. [15] evaluated an automated text-based agent mirroring the CBT process in delivering counseling to college students with depression and anxiety, demonstrating that it significantly reduced depressive symptoms after two weeks. In the context of CBT for public speaking anxiety, virtual agents have mainly been used for



Fig. 1. Virtual coach for public speaking anxiety

public speaking exposure, in which the agents simulate virtual audiences [16]–[18]. In our study we explore the efficacy of a virtual therapist that uses CBT techniques to help presenters restructure irrational thoughts associated with public speaking anxiety.

### B. Virtual Agent in Presentations

In recent years, there has been an increase in studies that use virtual agents in oral presentations, including the use of agents to help deliver information. In one effort a virtual agent was used to deliver manually-authored speech on behalf of the presenter [19], and in a more recent study by Trinh, et al. [20], a virtual agent was developed to co-present with a human presenter. The evaluation of the virtual co-presenter agent system reported that the agent led to significant reductions in public speaking anxiety and increases in speaking confidence for non-native English speakers [20].

In public speaking skills training, virtual agents have been used as virtual audiences [18], [21], [22], with some of these agents providing non-verbal feedback based on the presenter's performance [23]. Other studies have researched the use of virtual agents and robots [24] as coaches for communication skills training [25]. In these efforts, the virtual coaches were shown to significantly improve presentation quality [24] and interviewing performance [25], suggesting that a virtual agent can be an effective public speaking coach.

## III. VIRTUAL COACH FOR PUBLIC SPEAKING ANXIETY

We developed a virtual agent CBT counselor to coach presenters on how to address public speaking anxiety. The counseling sessions follow the CBT framework for social anxiety, which includes four main components: psycho-education, cognitive restructuring, exposure, and homework [2]. CBT interventions typically involve multiple sessions with a therapist. Our intervention is delivered in two sessions with the agent, focusing only on anxious feelings related to a specific upcoming presentation, as opposed to public speaking in general. At the beginning of the first counseling session, the agent conducts a brief psycho-education in which she explains the relationship between anxious thoughts, emotions, and physiological reactions [2]. Following this, the primary

focus of the session is on cognitive restructuring. In the second session the virtual coach reviews anxious thoughts and cognitive restructuring strategies discussed in the first session. Then shares the helpful thoughts that were generated in the first session, for the participant to review. In the next sections, we present an overview of the system architecture and a description of the core component of the CBT virtual counselor.

### A. Virtual Coach Architecture

Our virtual coach, named “Angela”, is a 3D animated embodied conversational agent (Fig.1). Angela uses synthetic speech generated to communicate, with her language driven by a hierarchical network-based dialogue engine and template-based text generation for most utterances (except for cognitive restructuring - see the next section). User response is obtained via multiple choice selection of utterance options, displayed on the screen at the end of each agent utterance, updated at each turn of the conversation. Angela can also display nonverbal communicative behaviors including: eyebrow movement, facial expressions (such as smiles and concerns), directional gazes, head nods, posture shifts, and different hand gestures, including contrastive for comparison, deictic gestures (e.g. pointing to an image displayed on the screen) and beat gestures for emphasis. Most of these nonverbal behaviors are automatically generated using the Behavior Expression Animation Toolkit (BEAT) [26].

### B. Cognitive Restructuring with a Virtual Coach

Cognitive restructuring is the principal component of CBT, and involves examining thoughts about feared situations. CBT models [9], [27] propose that anxiety arises from inaccurate beliefs about feared situations, destructive prediction about outcomes of the situations, and irrational processing of events that occur during the situations [7]. In cognitive restructuring, the counselor aims to teach individuals how to: 1) identify negative, maladaptive thoughts associated with feared situations [28]; 2) challenge these negative thoughts; and 3) come up with alternative thoughts that are rational [7].

Our CBT virtual coach guides presenters through the process of identifying irrational thoughts that they may have about public speaking, assists them in challenging these thoughts, and derives alternative thoughts that are more helpful (Fig. 1). When interacting with the coach, presenters express anxious thoughts that they have by choosing from a list of common negative thoughts about public speaking. The coach then describes why the thought is unhelpful and, with a set of questions that she poses to the presenter, she works with the presenter to challenge the irrational thoughts. From the presenter's responses to the questions, the virtual coach generates rational thoughts that are customized to the presenter, using Natural Language Generation (NLG) techniques. The coach repeats this process twice, by focusing on two irrational thoughts that the presenter might have. We now describe the virtual agent's alternative thought generation component that is developed based on the NLG pipeline described by Reiter, et al. [29].

TABLE I  
IRRATIONAL THOUGHT CHALLENGING QUESTIONS

Anxious Thought: <i>If I make a mistake, the audience will think I'm stupid</i>	
Disrupting Questions	Examples of responses generated
How sure am I that what am thinking will happen?	<i>I'm 50% sure I will make mistakes because I didn't have enough time to prepare.</i>
What evidence do I have for what I am thinking?	<i>I often judge people negatively when they make mistakes.</i>
What evidence do I have against what am thinking?	<i>They might not think I am stupid because making some mistakes when presenting is normal.</i>
What is the worst that could happen?	<i>The audience will have a negative view of me.</i>
How can I cope if the worst case happens?	<i>I will focus in the fact that, I do not know the audience, so their opinion does not matter.</i>

1) *Corpus Generation*: We collaborated with a clinical psychologist who uses CBT to treat patients with depression and anxiety to develop a corpus of examples of irrational thoughts and associated restructured thoughts regarding public speaking. This expert provided written samples of alternative thoughts that we used in the content determination process. From a literature review of public speaking anxiety, we generated a list of automatic thoughts that presenters with public speaking anxiety frequently have [2], [9], [30], [31]. We also selected a set of 5 questions, shown in Table I, that therapists use to challenge irrational thoughts [2], [32], and the clinical psychologist generated a sample of possible responses that people with anxiety would have. Additionally, the psychologist provided 49 written samples of alternative rational (restructured) thoughts based on responses to the questions in Table I.

2) *Content Determination*: In NLG, content determination is the process of determining what messages or information should be included in the generated text [29], in our case, the generated alternative thought. We analyzed our corpus, using the corpus-based procedure for domain modeling and message definition proposed by Reiter, et al. [29]. We broke down each example into its constituent sentences and then segmented each sentence into a set of phrases that correspond to distinct message types that we identified. We then grouped these message types into 3 message classes: 1) **validation**; 2) **viable alternative scenario**; 3) **actionable solution** for the worst-case scenario. Table II shows examples of these message classes.

TABLE II  
EXAMPLES OF MESSAGE CLASSES FOR ALTERNATIVE THOUGHT EXTRACTED FROM OUR CORPUS

Message Class	Examples
Validation	There is a small chance I will forget my presentation because I did not have a lot of time to rehearse.
Viable Alternative Scenario	However, I am familiar with the topic, so I might not forget.
Actionable Solution for Worst-case Scenario	If my worst-case scenario happens, I will focus on what I learned from the situation and come up with a plan for the future.

3) *Document Structuring*: Document structuring in NLG is concerned with ordering and structuring of the information to be conveyed [29]. From the corpus analysis, we observed that in most examples, validation messages preceded the other message classes. Therefore, we structured the generated thoughts such that validating presenters' responses and feelings

preceded viable alternative scenarios and coping techniques for worst-case scenarios. Previous research has shown that anxious people tend to focus on destructive predictions of outcomes [7]. Thus, we generate two types of alternative thoughts: one that includes the validation message that was to be conveyed via speech and another that focused on alternative scenarios and ways of coping with worst-case scenarios, that was displayed on a document that the virtual coach held up and pointed at. (Fig. 2). The structure of the generated thoughts can be seen in the examples shown in Table III.

TABLE III  
RESTRUCTURED ALTERNATIVE THOUGHTS

Examples of Automatically-generated Alternative Thoughts	
Spoken Alternative Thought	Displayed Alternative Thought
Although there is a chance I might make a mistake and feel embarrassed, the audience might not think I'm stupid because making some mistakes when presenting is normal, and I do not know the audience, so their opinion does not matter	The audience might not think I'm stupid because making some mistakes when presenting is normal, and I do not know the audience, so their opinion does not matter

4) *Microplanning and Surface Realization*: The microplanning process serves to fully specify text specifications for each message by carrying out the following task: 1) lexicalization - the task of choosing words and syntactic structure; 2) aggregation - the task of determining how messages should be combined; and 3) referring expression generation [29]. In our system, we use a combination of pre-authored text, such as a phrase from a user input, and procedurally generated texts that are a derivation of a user response. For instance, if the user input is a percentage less than 35, as a response to disputing questions 1 (Table I), then the generated phrase indicates a small likelihood (e.g. "*there is only a small chance*"). We used simple conjunctions such as "*although*" to express contrast relations between messages that express validation and those that provide alternative scenarios. We also used other connective such as "*and*" to combine two or more phrases. At the surface realization stage, we used the SimpleNLG realization engine [33], to generate strings from the microplanning process.

#### IV. CBT VIRTUAL COACH EVALUATION

We conducted a between-subjects study comparing the effects of having two brief CBT sessions, with a virtual agent before an oral presentation, against having a social chat with the virtual agent for an equivalent length of time (time and attention control condition). In this study, our aim was to assess the effectiveness of the CBT virtual coach in reducing distorted thoughts and public speaking anxiety.

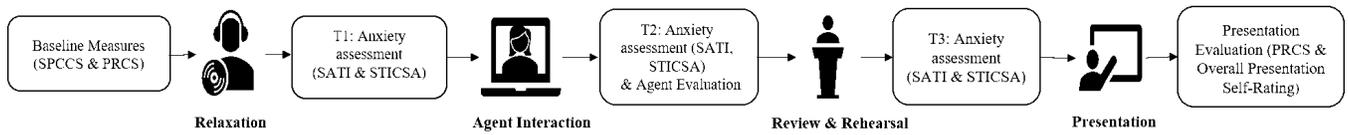


Fig. 2. Study procedure including measures taken before and after each activity.

1) **Participants:** Participants were recruited from an online flier posted at our institution, were required to be 18 years of age or older, speak and read English, have some college education and have some public speaking experience.

2) **Measures:** In addition to social demographics and Self-Perceived Communication Competence measures, we assessed presenters' attitudes using the following measures:

- **Public speaking competence** - assessed at the beginning of each session and after each presentation using the Self-Perceived Communication Competence Scale (SPCCS) [34].
- **Speaker confidence** - assessed at the beginning of each session and after each presentation using the Personal Report of Confidence as a Speaker (PRCS) questionnaire [35].
- **Cognitive and somatic speech anxiety** - assessed before and after each agent interaction and before each presentation using a State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA) questionnaire [36].
- **Maladaptive cognitions or thoughts associated with speech anxiety** - assessed before and after each agent interaction and before each presentation using Speech Anxiety Thought Inventory (SATI) questionnaire [37].
- **Agent interaction rating** - assessed after agent interaction using a 12-item, 7-point scale questionnaire as shown in Table IV.
- **Overall presentation self-rating** - assessed after each presentation using a 7-item, 7-point scale questionnaire as shown in Table V.

#### A. Study Procedure: Intervention Group

The study comprised two 90-minute sessions at least three days apart. The first session was to study the effects of a brief CBT on public speaking anxiety and in the second session was to study the effects of repeated exposure to the CBT virtual coach. In each 90-minute session, we asked participants to rehearse (in the absence of experimenter) and deliver a 10-minute presentation on a pre-defined topic. The first session presentation topic was on nutrition and the second presentation was on physical activity. Both presentations were presented in English using Microsoft PowerPoint with pre-prepared slides.

**Session One:** When participants reported for the first session, they were consented and randomized to either the CBT agent condition or the social chat agent condition. All participants were then administered baseline assessments (sociodemographic, SPCCS) and then asked to relax for 5 minutes watching a calming video. After the relaxation activity, we explained the presentation task, setting, and requirements to

participants, before asking them to fill out the first administration of anxiety measures (STICSA, SATI) indicated by T1 in Fig. 2. Participants then interacted with the agent (approximately 10 minutes) and filled out the anxiety measures again (T2 in Fig. 2) along with an agent rating questionnaire (Table IV). We then introduced participants to the task of preparing and delivering the prepared presentation using pre-made slide decks and notes. We instructed participants to address all key points in the notes, but not word-for-word. We gave each participant a maximum of 20 minutes to prepare and rehearse, by themselves, before filling out anxiety measures (T3 in Fig. 2). Participants were asked to read aloud, by themselves, their alternative thoughts that were generated by the CBT agent. They were then asked to deliver the video-taped presentation to an audience of three confederates, selected from a pool of 14 student volunteers that were trained to remain neutral in all presentations. After the presentation, the presenter was administered the speaker confidence assessment (PRCS) [34] and overall presentation rating questionnaire (Table IV). Finally, we conducted a semi-structured interview, prompting for comparisons of experiences before and after interacting with the agent. After a debrief, participants were compensated for their participation. Fig. 2 visualizes the study procedure and highlights measures taken at each time point.

**Session Two:** The second session was similar to the first session (Fig. 2) except that the initial interaction with the agent was only 5 minutes long. The agent reviewed the anxious thoughts that the participant identified in the first session and reminded them of the alternative rational thoughts that they had generated.

#### B. Study Procedure: Control Group

The Control Group experienced two sessions identical in structure and duration to the Intervention Group (see Fig. 2), with the only differences being in the content of the agent interactions. Rather than talking about public speaking anxiety, the agent engaged the participant in social chat about places to visit in Boston and Australia and other social activities.

#### C. Results: Participants

A total of 28 undergraduate and graduate students participated: 22 females, 6 males, ages 18-30 (mean 23). Of these, 9 were highly competent public speakers and 18 had moderate competence, according to SPCCS. An equal number of participants were randomized to each condition, with no significant differences between groups on baseline measures. Twenty-four participants returned for the second session: 13 in the CBT condition and 11 in the control condition.

TABLE IV  
VIRTUAL AGENT RATINGS

2 <sup>nd</sup> Session Participant's Virtual Agent Ratings (Median (Range) and P-value of Wilcoxon Rank Sum Test)				
Items	Range Description	CBT Condition	Social-Chat Condition	p-value
How <b>satisfied</b> are you with Angela?	1, Not at All; 7, Very Satisfied	5(2-6)	6(3-7)	0.1
How much would you like to <b>talk</b> with Angela in <b>future</b> presentations?	1, Not at All; 7, Very Much	5(1-6)	6(3-7)	0.21
How much do you <b>like</b> Angela?	1, Not at All; 7, Very Much	5(2-6)	6(2-7)	0.25
How <b>easy</b> was it to use the computer character?	1, Very Easy; 7, Very Difficult	3(2-7)	3(1-7)	0.79
How much do you feel you <b>trust</b> Angela?	1, Not at All; 7, Very Much	6(1-7)	4(3-7)	0.30
How much do you feel the Angela <b>helped</b> you?	1, Not at All; 7, Very Much	5(1-7)	4(3-6)	0.44
How helpful was Angela in <b>reducing</b> your public speaking anxiety?	1, Not at All; 7, Very Much	5(1-6)	4(3-5)	0.30
How much do you feel Angela <b>helped you recognize your unhelpful or anxious thoughts</b> about public speaking?	1, Not at All; 7, Very Much	5(1-7)	4(1-5)	0.11
How much do you feel Angela <b>helped you deal with anxious thoughts about how the audience</b> will view you?	1, Not at All; 7, Very Much	5(1-6)	4(1-5)	0.08
How much do you feel Angela helped you deal with anxious thoughts about your presentation skills?	1, Not at All; 7, Very Much	5(1-7)	3(1-5)	0.07
How effective was Angela in <b>helping you come up with new and helpful thoughts</b> about public speaking?	1, Not at All; 7, Very Much	5(2-7)	3(1-5)	<b>0.01*</b>
How <b>helpful is the new thought</b> in reducing public speaking anxiety?	1, Not at All; 7, Very Much	5(1-6)	4(1-6)	0.18

#### D. Quantitative Results: Session One

Analysis of the first session measures showed that, mean change in thoughts associated with speech anxiety (measured by SATI) from T1 to T3, differed significantly by study condition according to a Welch's t-test,  $t(25) = -2.38$ ,  $p = .03$ . Participants that interacted with the CBT virtual agent ( $M = -20.15$ ) had significantly greater reduction in maladaptive thoughts or cognitions associated with speech anxiety from T1 (before talking to the agent, Fig. 2) to T3 (after rehearsal and just before their presentation) than participants who interacted with the social chat agent ( $M = -4.57$ ). However, there was no significant differences in change in maladaptive thoughts associated with speech anxiety from T1 to T2 (immediately after talking to the agent) and from T2 to T3.

Participants in the CBT condition rated the virtual coach highly on satisfaction measures but there were no significant differences between study condition in agent satisfaction ratings. Similarly, all other comparisons were non-significant.

#### E. Quantitative Results: Session Two

We found significant differences between condition in change in cognitive and somatic anxiety (STICSA), from T1 to T2 (Fig. 2)  $t(22) = -2.08$ ,  $p = .05$ . but no significant differences in change in cognitive and somatic anxiety from T2 to T3.

Overall, participants who interacted with the CBT agent rated it highly on most measures (Table IV). Participants who interacted with the social chat agent had lower ratings for the role of the agent in dealing with anxious thoughts (items 8-12). Results of a Wilcoxon rank sum test showed a significant difference between the CBT agent and the social chat agent in helping presenters come up with new and helpful thoughts ( $W = 87.5$ ,  $p\text{-value} = 0.01$ ).

Similarly, participants who interacted with the CBT agent rated their presentation high on most measures. Table V summarizes second session presentation self-rating. A Wilcoxon

rank sum test showed that there was a significant difference in presenters' self-rating on nervousness between the different study conditions, ( $W = 126.5$ ,  $p = 0.03$ ), with participants in the CBT agent condition reporting less nervousness than the social chat agent condition. Results of a Wilcoxon rank sum test also showed a significant difference between self-rating of how entertaining the presentation was ( $W = 97.0$ ,  $p = 0.02$ ). Participants in the CBT condition rated their presentation as more entertaining than those in the social chat condition. All other comparisons of between study condition were non-significant.

#### F. Qualitative Findings

We analyzed first and second session exit interview transcripts using thematic analysis, starting with open coding, followed by clustering of codes into common themes and concepts. We identified the following themes that reflect participants' attitudes towards the CBT and social chat agents and public speaking.

1) **Connection with presenters and understanding their fears:** Participants that interacted with the CBT agent "*felt connected to it*" [P18] and that the agent understood their presentation experience: "*It actually understood what I'm going through. So that's what I like about her.*" [P1]. They also felt the CBT agent "*...pointed out their weak points*" [P26] and some found this very helpful: "*It was a bit helpful because someone points out mistakes is always good, so you get to know where you're lagging behind.*" [P16]. Additionally, some participants, felt that the CBT agent "*she was very reassuring*" [P22] and this may have increased their confidence: "*She did help me reassure myself and say that, okay, I can do this and it's not a big deal and probably gave me more confidence*" [P27]. Participants that interacted with the social-chat agent also reported a connection with the agent "*...was like a normal friend, the camaraderie she showed was like how*

TABLE V  
PRESENTATION SELF-RATING RESULTS

2 <sup>nd</sup> Session Self-Perceived Ratings of Presentation Quality (Median (Range) and P-value of Wilcoxon Rank Sum Test)				
Items	Range Description	CBT Condition	Social-Chat Condition	p-value
How engaging was your presentation?	1, Not at All; 7, Very Engaging	4(2-6)	3(1-5)	0.25
How nervous were you during your presentation?	1, Not at All; 7, Very Nervous	3(2-6)	5(1-7)	<b>0.03*</b>
How understandable was your presentation?	1, Not at All; 7, Very Well	5(3-7)	5(2-7)	0.37
How exciting was your presentation?	1, Not at All; 7, Very Exciting	4(2-7)	3(2-5)	0.06
How entertaining was your presentation?	1, Not at All; 7, Very Entertaining	4(2-7)	3(1-5)	<b>0.02*</b>
How competent were you during your presentation?	1, Not at All; 7, Very Much	5(3-7)	4(1-6)	0.08
How would you rate the overall quality of your presentation?	1, Very Poor; 7, Very Good	5(3-6)	4(2-6)	0.11

you speak to your friend.” [P17], and that this “...It helped to calm me down” [P25]. However, the agent did not help them address maladaptive thoughts associated with anxiety, and most reported experiencing these thoughts before and during their presentations: “I was more anxious when I was presenting ...when I was doing my presentation I had six eyes...they were looking at me and so I was just thinking that what these people might be thinking of me while I am presenting and how I talk and if I tremble...” [P3].

2) **Including presentation task in conversations with the agent:** In both conditions, most participants reported that they would like to interact with the agent for future presentations. However, in the social chat agent condition, some participants reported that they would talk to agent about something related to their presentation or delivery: “She could give some suggestions, like, how to reduce anxiety or stress, just before the presentation.” [P24]. Interestingly, some in the social-chat condition had the expectation that the agent was “giving me hints about what the presentation would be. giving me verbal cues or something to get in memory before I had to present” [P7] and felt that “It would have been helpful” [P7] if that was the agent's role. Participants in the CBT condition reported that they felt that the conversation about anxiety inducing thought was helpful “It does give me some talk that I can remember at times when I feel little bit anxious” [P8] and that they would like have a similar conversation in future presentations: “I will come to Angela for tips or before going for a presentation. Those things like interacting with Angela helps give a little more confidence and doing more self-reflection.... I would love to include Angela in all my protestations” [P19]. During their interaction with the CBT agent, participants were asked by the agent to read aloud displayed alternative thoughts on the screen. They were also asked to read aloud these thoughts, by the research assistant, just before presenting. Most participant in this condition reported that they found this helpful “read it aloud and I feel it really helped you once you hear it, that's when it comes into action” [P18].

Some participants in the CBT condition suggested that a future version of the CBT agent should further customize the cognitive restructuring feedback to include different presentation settings and audience parameters: “I think if Angela knows what kind of presentation I am giving and if she could give customized suggestions.... So, depending on the audience, like if there are like 100 people, you can make Angela give a better,

broader suggestion than there are like just a couple of people ...it could be different ...maybe every person customized” [P27].

## V. CONCLUSION

We described the design and evaluation of a CBT virtual coach for public speaking anxiety. Our virtual coach addresses irrational thoughts associated with speech anxiety using automated cognitive restructuring, implemented using natural language generation techniques. We evaluated our CBT virtual coach against a social chat agent and found that the CBT coach led to significantly greater reductions in irrational thoughts associated with speech anxiety, as well as significantly less self-reported nervousness.

A significant reduction in maladaptive thoughts in participants who interacted with the CBT agent from T1 (before talking to agent, fig. 2) to T3 (after presentation rehearsal) was observed in the first session but not from T1 to T2 (immediately after talking to the agent) or from T2 to T3. This could be due to the fact that they were able to test or put in practice thoughts they had restructured between T1 and T2.

Previous public speaking studies [12], [16] that used virtual agents for CBT, have mainly focused on presenters with high speech anxiety and low speaker competence. Although this population might benefit the most from the therapy, our study findings suggest that presenters with moderate to high speaker confidence could also benefit from a brief CBT session, when preparing for their presentation.

Cognitive behavioral therapy often requires patients to participate in many lengthy sessions with a therapist [16]. Our results showed the CBT agent was associated with significant reduction in maladaptive thoughts associated with speech anxiety and nervousness in the second presentation, even with reduced length of exposure to the therapy. But, we also acknowledge that more sessions with a therapist (virtual or human) could be more helpful, especially for people with high speech anxiety.

Our virtual coach could be extended to address other aspects of oral presentations, such effective presentation delivery. As suggested by some of our participants, our CBT virtual coach could also be more customized to provide counseling for specific presentations and settings. Automated cognitive restructuring could also be used in many other areas of automated CBT, such as treatment for depression, PTSD, and substance abuse.

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