PTSDialogue: Designing a Conversational Agent to Support Individuals with Post-Traumatic Stress Disorder

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ABSTRACT

Post-traumatic stress disorder (PTSD) is a serious public health issue. Approximately 8 million adults in the United States suffer from PTSD in any given year, and 7–8% of the U.S. population will have PTSD at some point in their lives. Recent studies have explored eHealth technologies to support persons living with PTSD. However, current approaches are often unable to sustain adherence, leading to sub-optimal clinical outcomes. Conversational agents (CAs) can help to improve longitudinal adherence by interactively engaging users and maintaining social presence. In this work, we present prototypes of *PTSDialogue* — a finite-state CA to deliver evidence-based strategies and support self-management for individuals living with PTSD. We also discuss the design requirements and process of adapting existing eHealth content to interactive dialogues. Furthermore, we detail design decisions to address safety and ethical concerns to develop a CA for a vulnerable population.

KEYWORDS

conversational agents, chatbot, PTSD, user engagement

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1 INTRODUCTION

Post-traumatic stress disorder (PTSD) is a chronic and persistent mental health disorder. Traumatic events such as combat experiences, serious accidents, and physical or sexual assaults can cause PTSD. Approximately 8 million adults in the United States suffer from PTSD in any given year and 7–8% of the U.S. population will have PTSD at some point in their lives [29]. PTSD results in serious public health concerns and societal burdens. For example, the Department of Veterans Affairs (VA) spent 3 billion dollars on PTSD care in 2012 [16]. Furthermore, according to the Congressional Budget Office, VA expenditure increased considerably after 2000, averaging more than 6% each year [30]. However, there remains a severe treatment gap — only 33% of persons living with PTSD receive adequate treatment [38]. This treatment gap is mostly due to logistical reasons, including cost and lack of trained professionals.

Recent approaches have focused on using eHealth technology for offering evidence-based PTSD intervention in order to resolve concerns. For example, the VA has created a mobile phone app called PTSD Coach [21]. It aims to support PTSD self-management by providing tools for assessment and monitoring symptoms, learning about PTSD, and getting support. PTSD Coach successfully reduces symptom severity after a short period of use [22]. However, sustaining user engagement and adherence remains a challenge for PTSD Coach. Although the PTSD Coach has been downloaded over 500,000 times in 115 countries worldwide, only 15.2% of users participated with the PTSD Coach after three months, and only 5.5% remained active after a year [31]. Low engagement in treatments can have a detrimental effect on health outcomes because PTSD can be a chronic disorder that requires ongoing care.

Recent studies have explored using conversational agents (CAs) to ensure user engagement and adherence by focusing on trust, and social presence in various application domains including support for autism spectrum disorders [40], schizophrenia [7], depression [12, 15, 39], and anxiety disorder [12, 15, 19]. However, even though a myriad of CAs are invented for supporting mental health, the efficiency of CAs is still not well-understood, especially in sustaining user engagement and adherence. Furthermore, there are some CAs developed for assessment and intervention delivery in PTSD. For example, DeVault et al. [12] developed a CA for PTSD assessment. Tielman et al. [41] built a CA for intervention delivery in PTSD. However, there have not been any CAs designed and developed for understanding the effectiveness of CA supporting self-management and maintaining longitudinal user engagement in PTSD.

In this paper, we present prototypes of *PTSDialogue* — a CA aimed to support self-management for individuals living with PTSD effectively. PTSDialogue specifically focuses on interactivity (e.g.,

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turn-taking, short dialogues) and social presence to improve user engagement and sustain adherence. PTSDialogue is designed to provide a range of support features for individuals living with PTSD including psycho-education, assessment tools, and personalized illness management strategies.

The remainder of this paper is organized as follows. Section 2 presents prior studies on user engagement and adherence of eHealth technologies and CAs in healthcare. Section 3 describes different prototypes of the CA for supporting self-management for individuals living with PTSD. We also discuss different design requirements and decisions in developing the prototypes. Section 4 concludes the paper.

2 RELATED WORK

As CAs that support persons living with PTSD are the focus of this study, this section considers user engagement and adherence of eHealth technologies and CAs in healthcare. First, we observe the ways in which eHealth technologies have gained prominence and expose current theoretical shortcomings. Next, we introduce socially engaged CAs intended to converse with a human to provide support for specific tasks, mainly focusing on mental health disorders. Lastly, we focus on CAs for supporting mental healthcare.

2.1 User Engagement and Adherence in eHealth Technologies

eHealth technologies, such as mobile apps, have received significant attention in recent years. An emerging trend in eHealth technology centers on mental health intervention [1], including depression [14], bipolar disorder [2], schizophrenia [46], and PTSD [22]. Given the global burden of mental health challenges [36], and the absence of existing infrastructure to provide support [45], these technologies solve a crucial problem in mental health care delivery by offering wide dissemination of evidence-based interventions.

However, most eHealth technologies for providing evidence-based interventions suffer from poor engagement and adherence issues. For example, in a clinical trial for depression using mobile technologies, the participation rate dropped below 44% after only four weeks [3]. Web-based interventions for anxiety and depression have similarly indicated low adherence, with attrition rates as high as 50% [11]. The mobile app for schizophrenia patients revealed that the degree of involvement decreases dramatically over time [43]. According to data from the PTSD Coach app, only 5.5% of patients stayed engaged after a year [31].

This engagement problem is not unique to eHealth technologies for mental health; for example, a recent survey showed that 63% of users engage with apps less than ten times [32]. However, the effects of eHealth technology are arguably more severe. Successful interventions for improved health outcomes often necessitate high participant engagement, and adherence [13]. Since mental health problems are chronic illnesses, long-term interventions are required. The failure of existing technology to support longitudinal engagement can result in non-optimal results and weaken their effectiveness. As a result, new theoretical frameworks and methodologies to solve engagement and adherence problems are needed [25].

2.2 A Socially Engaged Conversational Agent

A CA is a dialogue system designed to converse with a human to provide support with particular tasks [48]. It has either embodied or non-embodied forms. This CA technology can represent a response using one or more of the following methods of communication: text, voice, images, haptics, gestures, and other modes of communication on both the input and output channels [9]. Most CAs have two types of dialogue: spoken and written. A CA that uses spoken language receives and sends verbal input and output. Apple's Siri and Amazon's Alexa are examples of verbal CAs. A CA that uses a written language, such as a chatbot service, receives and sends text-based input and output.

CAs have been investigated in a variety of application domains, including internet shopping and customer service. Most of the literature in these application domains focuses on the social interaction between users and CAs as interactions that build trust and maintain a social presence. For example, Purington et al. [34] discovered that user interactions with Amazon Alexa devices are characterized by sociability. According to Chattaraman et al. [10], using CAs in online stores improved perceived social support and trust among older consumers.

CA features have been analyzed to determine their effect on different degrees of perceived trust and social presence. Nowak and Biocca [28] investigated the impact of CAs on social presence and its property features, anthropomorphism. The experiment was conducted in three different levels of anthropomorphism: high, low, and no anthropomorphism. Users socially referred to CAs, and users interacting with low anthropomorphism reported more social presence than users interacting with either high or no anthropomorphism [28]. Araujo [4] investigated how human-like cues such as language style and name, as well as the framing used to present a CA to the customer, can affect customer perceptions of social presence. Ho et al. [17] demonstrate the consequences of psychological, relational, and emotional disclosure between individuals and CAs as CAs mimic human-to-human interaction. These results appear to be consistent with the seminal framework of "Computers as Social Actors" [35]. As a result, the interactions and engagement of users with CAs are fundamentally social in nature.

2.3 Conversational Agents for Mental Healthcare

CAs' social aspects can be beneficial to mental health care. Since the first CA, ELIZA, which was designed to offer automatic psychotherapy [47], CAs of varying capacities have been used to treat a variety of mental disorders such as autism spectrum disorders [40], schizophrenia [7], depression [12, 15, 39], and anxiety disorder [12, 15, 19]. CAs perform various functions, including education, intervention delivery, and assessment, in addition to targeting various mental illnesses.

Tanaka et al. [40] built embodied CAs for autistic spectrum disorder patients. The study aimed to provide social skills training, which is a well-established tool for acquiring appropriate social interaction skills. CAs used audiovisual engagement to help participants improve narrative skills. The proposed CAs improved overall social skills significantly. Fitzpatrick et al. [15] have created Woebot, a conversation agent, to provide psychotherapy support and

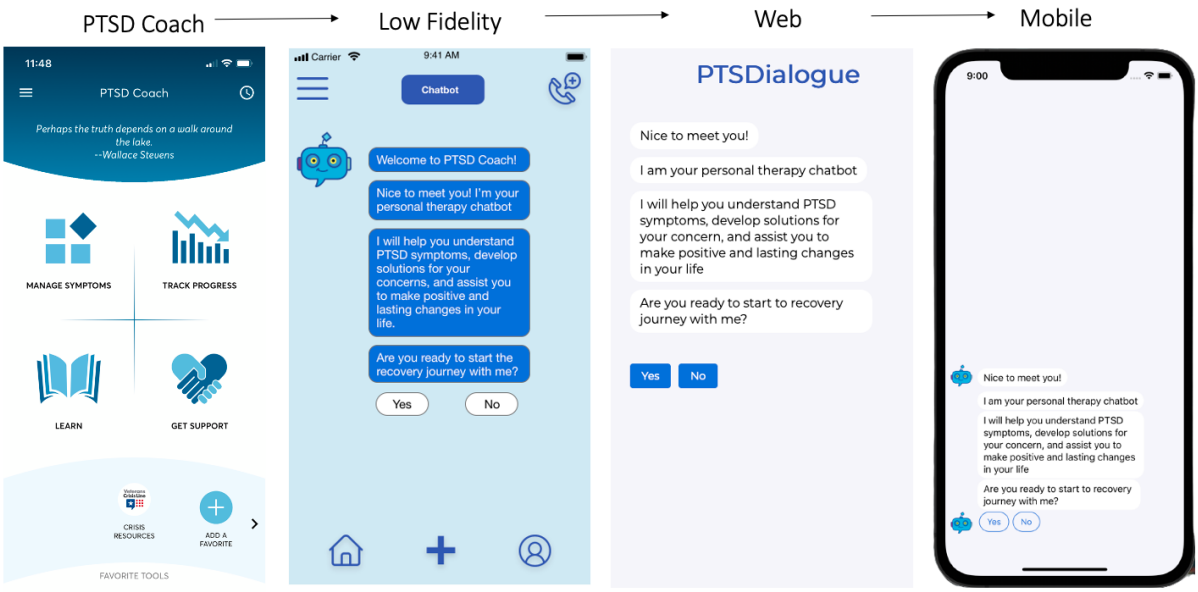

Figure 1: We created multiple prototypes for PTSDialogue. We first adapted the content from PTSD Coach — a mobile app developed by the VA (*first panel*) to create a low-fidelity prototype (*second panel*). We then developed a web prototype (*third panel*) and a mobile prototype (*fourth panel*).

education to people suffering from depression and anxiety disorders. This text-based CA provided cognitive behavioral therapy and was compared to an educational eBook given to the control group. Fitzpatrick et al. [15] discovered that the effectiveness of a CA is that it not only educates participants about depression and anxiety disorders, but it also greatly decreases symptoms of depression. Swartout et al. [39] developed SimCoach, which imitates social interactions such as establishing rapport with patients. SimCoach is used to educate veterans and their families about PTSD and depression. This virtual CA disseminates information and imparts knowledge based on users' desires, preferences, and concerns. Only 5% of participants responded that SimCoach is unethical or untrustworthy.

Focusing on providing intervention of mental illness, Bickmore et al. [7] developed embodied CAs to improve antipsychotic medication adherence in patients with schizophrenia. In this research, the conversation agent was intended to provide behavior medicine both verbally and nonverbally. The findings indicated that socially engaged CAs are a feasible and promising intervention approach for treatments such as medication adherence. Morie et al. [26] developed an autonomous intelligent agent in an online virtual environment to help individuals living with PTSD by providing virtual healing opportunities such as seating areas around fireplaces. The results showed that veterans successfully reintegrate into civilian society after six months of using this CA. Tielman et al. [41] suggested a virtual coach to inspire and support individuals living with PTSD during therapy. It was beneficial to alleviate users' painful memories in therapy.

CAs have also been used to diagnose mental illnesses. Kang and Gratch [19] investigated the interaction between socially anxious patients and a CA. The CA's intervention influenced socially anxious people, leading them to share more details about themselves; however, less socially anxious people did not show this difference. Thus, CAs could be helpful not only for educating patients and delivering interventions but also for eliciting self-disclosure. DeVault et al. [12] introduced SimSensei Kiosk, a virtual human interviewer for generating interactive situations favorable to automated distress assessment. Participants reported a desire to share their symptoms by using the SimSensei Kiosk. Similarly, Lucas et al. [24] used virtual human interviewers, which increased the rate of individuals living with PTSD expressing symptoms.

However, as recent studies [23, 33] have highlighted, evidence on the efficacy of CAs is limited. Most studies were limited to pre-post measurements of minimal sample sizes, and only a few studies progressed beyond the development and piloting phases. There is a significant knowledge gap when it comes to recognizing the effect of CAs on user engagement and adherence. Furthermore, A few studies reported high user engagement over a short period [15, 37], but there has not been any systematic evaluation in this respect. While there have been some promising developments in the usage of CAs assessment [12, 24], intervention delivery [26, 41], and education [39], none of these systems have concentrated on longitudinal user engagement and adherence.

3 PTSDIALOGUE

In this work, we have designed a prototype for PTSDialogue. It is a finite-state CA that interactively delivers intervention strategies and tools for PTSD self-management. A finite-state CA consists of conversations as a sequence of a finite number of states. We have adapted existing content from the PTSD Coach to create dialogues

and interactions for the CA. We have also developed two personas, which can support different styles of interaction and social presence.

3.1 Adapting Self-management Content and Evidence-based Intervention Steps from PTSD Coach

Interaction design for a CA is different from a traditional web- or mobile-based eHealth application. In particular, successful interactions with a CA requires active information flow in both directions rather than passive transmission of information content to the user. This involves turn-taking, dialogue management, handling user input for branching, and delivering appropriate dialogue content.

To create dialogues in PTSDialogue, we have adapted and leveraged existing content from PTSD Coach. Specifically, we have adapted content from six modules in PTSD Coach: *Take assessment, Manage symptoms, Get support, Learn about PTSD, Track progress, and Daily symptom checker*. The *Take assessment* module provides a checklist to assess symptom severity. The content in the *Manage symptoms* module provides a number of strategies to manage PTSD symptoms. The *Get support* module provides information for a number of resources (e.g., phone numbers to helplines). The *Learn about PTSD* module aims to inform users about causes, symptoms, and management strategies for PTSD. The *Daily symptom checker* module allows users to perform daily self-assessments. Lastly, the *Track progress* module shows users' results of past assessments.

For each of these modules, we have created a set of decision trees. In these decision trees, edges reflect potential branching, and each node contains information and message for a participant. We use the pre-defined decision tree for turn-taking and information delivery for an interactive session with a user. The use of existing content from PTSD Coach in the decision trees enables interactivity and two-way information flow while being grounded in evidence-based interventions.

In the decision trees, we have adapted content at each node such that user inputs can be limited to pre-defined options (e.g., the node "Would you like to know more about PTSD?" leads to two options: "Yes" or "No"). In the current prototype, users can provide these inputs by clicking on a given button (see Figure 1). In other words, users are not allowed to enter free-form text inputs. These pre-defined options correspond to different branches in the decision trees (i.e., finite states). By limiting user inputs to these pre-defined options, we also minimize exposure to potentially sensitive content (e.g., suicidal ideation).

3.2 Personas to Support Different Interaction Styles and Social Presence

Forming an intimate and trusting relationship with users is critical to sustain long-term engagement [18]. Perceived social presence is an essential factor in building strong trust with users [4, 17, 28, 42]. Prior studies have demonstrated that the adoption of personas and consistent interaction styles can help to create a more engaging and positive relationship between users and CAs [4, 5, 18]. Specifically, a CA with an empathetic persona can help users to effectively manage mental health [6]. Similarly, a friendly persona can help to form a more positive relationship between users and a CA compared to the neutral persona [18]. In this work, we aim to compare the impact of different personas to support long-term engagement and adherence.

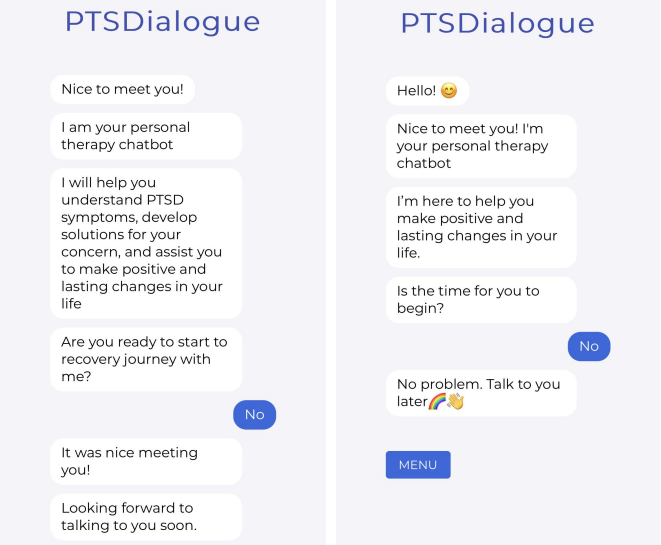

Figure 2: Screenshot of interactions with both personas: the professional, straightforward, and precise persona with a formal and neutral interaction style (*left*) and the cheerful, friendly and open persona with an informal interaction style (*right*).

To develop personas for the prototypes, we focused on two different types of conversational styles. Figure 2 shows the resultant personas. The first persona aims to be professional, straightforward, and precise with a formal and neutral interaction style. The second persona focuses on being cheerful, friendly, and open. It uses an informal interaction style with emojis. While creating the prototypes, we have ensured that all messages follow the interaction style of a given persona.

3.3 Ethical and Safety Concerns

Designing a CA for a vulnerable population needs to address a number of ethical and safety concerns. First, unsupervised CAs that support unconstrained natural language content might be dangerous for some mental health contexts [8]. It is essential to ensure that responses and messages from a CA are appropriate for a given user. This can be difficult to ensure if responses from CAs are generated in an automated way. Second, enabling free-form inputs to users can lead to additional safety concerns. For example, user inputs might contain sensitive information (e.g., suicidal ideation). A CA providing free-form inputs will need to include a robust risk management plan to address such cases. However, current CAs often fail to include adequate safety protocol [20].

To avoid these issues, we have focused on developing a finite-state CA. This allows us to ensure that responses and messages from the CA are appropriate and grounded in previously established practices. Furthermore, user inputs are limited to pre-defined options instead of free-form text or speech. This allows us to avoid potentially sensitive disclosures from a user.

3.4 Prototype Development

Figure 1 shows steps in prototype development for PTSDialogue. We first created a low-fidelity prototype using Adobe XD. This low-fidelity prototype allowed us to explore how existing content from PTSD Coach might be adapted for the CA. Also, the prototype showed how the pre-defined decision trees would work for different interactive sessions. Furthermore, it allowed us to explore and define a set of design guidelines for the prototype (e.g., turn frequency, dialogue content length). The resultant prototype consisted of more than 100 screens in Adobe XD.

Based on the low-fidelity prototype, we then created a web-based prototype using the BotUI framework [44]. We considered a number of different frameworks (e.g., Google Dialogflow). However, we selected the BotUI framework as it allowed us to create a stand-alone prototype without requiring dependency on third-party services. In other words, by using BotUI, we are able to retain complete control over deployment and data collection, which is important for user privacy. Furthermore, the BotUI framework allowed us to render conversational UI elements in a web environment. For the framework, we created a JSON document that reflects the finite-state decision trees created in the previous stage, including turn-taking points and dialogue content.

We then developed PTSDialogue as a stand-alone module that could be integrated into a mobile app. This module will streamline the deployment of the system for testing and experimentation throughout the project. We have explored the React Native framework [27] to support the cross-platform implementation of the CA. This will make the system available on both iOS and Android platforms.

4 CONCLUSION

In this paper, we have presented different prototypes of PTSDialogue — a finite-state CA to deliver evidence-based interventions and support self-management for individuals living with PTSD. The prototypes specifically focus on interactivity and social presence to sustain longitudinal engagement and adherence. We have also created two different personas to support different interaction styles in PTSDialogue. Finally, we plan to conduct future studies to systematically assess the efficacy of PTSDialogue.

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