Designing an Intelligent Cognitive Assistant as Persuasive Technology for Stress, Anxiety and Depression Relief

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Abstract. This poster proposal paper describes how intelligent cognitive assistant technology can be used as an effective persuasion tool for behavior change to reduce stress, anxiety and depression. After a brief review of related work, it is argued that our own design goes beyond the state of the art because it includes a personality-based user model, expert domain ontologies, personalized strategies, machine learning for strategy evaluation and smart bracelet integration.

Keywords: Intelligent Cognitive Assistant, Behavior Change, Mental Health.

1 Introduction

Stress, anxiety and depression (SAD) are becoming an increasing burden on our society, with figures in certain groups reaching 71% for stress, 12% for anxiety disorder and 48% for depression [9]. This provides an opportunity for scientific and technological interventions. Persuasive technology (PT) operates to change attitudes or behaviors without coercion or deception. An effective vessel for persuasion is intelligent cognitive assistant (ICA) technology. ICAs can communicate in natural language as well as understand context, adapt, learn, predict, perceive, act, and reason. Therefore, they can be designed for psychotherapeutic help. Such ICAs can offer a number of advantages in the mental health field: they can be free of charge and available around the clock; people tend to be more comfortable talking to an ICA than to a person [1]; ICAs are available in remote locations, etc. These benefits can reduce both the burden on health care systems and barriers to their access [2].

2 Related Work

After reviewing related papers on state-of-the-art (SOTA) psychotherapeutic ICAs (PICAs), three were selected for this work. The criteria for inclusion was the following: 1) the PICAs were researched in an ecological environment (user interaction took place in the "wild"); 2) the PICAs were empirically tested; 3) the PICAs were text-based. The use of ICAs as PT in mental health is a very young venture, making the pool of PICAs small.

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A PICA by Yorita, Egerton, Oakman, Chan and Kubota [10] is based on the Belief-Desire-Intention architecture, which contains three models: "a conversation model for acquiring state information about the individual, measuring their stress level, a Sense of Coherence (SOC) model for evaluating the individuals state of stress, and Peer Support model, which uses the SOC to select a suitable peer support type and action it" [Ibid., p. 3762]. The PICA tries to teach its users to improve their SOC and thus reduce stress levels, which the PICA succeeds in in the reported experiment.

Another effective PICA is called Woebot [1], which is based on a "decision tree with suggested responses that accepts natural language inputs" [Ibid., p. 3]. It selects a helping strategy in the form of educational content, personalized messages and scripted advice by collecting data on users' emotions and identifying their errors in thinking. In one experiment, Woebot was more successful in relieving SAD symptoms (about 20% improvement in mood) than the government-prescribed material (no improvement).

Tess is another PICA which "reduce[s] self-identified symptoms of depression and anxiety" [2]. It builds its foundation largely on an extensive emotion ontology, which then serves to identify the emotions of its users from the text. It uses scripted conversations to help the users, and collects journal data and user feedback to improve its interventions. In one experiment, Tess significantly reduced depression and anxiety symptoms (about 15% improvement in mood), while the government-approved eBook for self-help did not help.

Reviewed PICAs were successful in experiments, but do not fully exploit the possibilities PT offers (e.g. behavior change (BC) theories, user modeling, adaptation, personalization). The design of our PICA wants to leverage that.

3 Design

The main focus of our development is on what we call the PICA's 'theory of mind' (ToM). In cognitive science, ToM describes the ability to "understand the thoughts and feelings" [4, p. 528] as well as "attributing thoughts and goals to others" [Ibid.] in order to function in social life. The PICA's ToM is more domain-specific, but it serves the same purpose – to understand its user to the extent that it provides effective personalized help to alleviate SAD.

The PICA is designed to be button-based, which reduces the complexity in the users' linguistic input, making the system more predictable and controllable. Certain NLP skills and free text options appear at certain nodes in the scripted conversations.

The most important parts of the PICA include user modeling, adaptation and personalization. These largely have a basis in behavioral and cognitive sciences advances on human decision-making, BC and related phenomena [8], and they are largely what make the PICA persuasive as such. To effectively dispatch its strategies, our PICA holds and continually updates a model of its user. The PICA dialogically delivers a questionnaire [6] on the Big Five personality traits (B5), which represents the user's personality. BC strategy selection is largely based on B5. Another fundamental aspect of the user model are the SAD scores. These are determined by the Depression Anxiety Stress Scales 21 questionnaire [5]. The questionnaire is regularly posed to the user for

up-to-date SAD scores. A smart bracelet is also a part of the PICA for biophysiological measurements, which are used for automatic monitoring of SAD by creating an accurate model of a user's SAD scores. As the scores are updated continuously and in real time, there is no need for the PICA to pose the SAD questionnaire.

The user model is used by the domain knowledge module, which is built from ontologies on BC and SAD. The PICA uses the two modules for a range of activities that guarantee tailored persuasion: B5 is ostensibly used to personalize the persuasive messages the PICA dispatches; nudging is used at the times that are most beneficial to the user, and occurs when the user model reflects certain SAD scores from the smart bracelet readings; the ontologies on emotions are used in conjunction with the mental states in the user model to guide the conversation; the SAD knowledge determines the SAD severity and type for selecting the right strategy; and others. Strategies are dependent on the user in two ways: 1) domain-knowledge model uses the user model to determine the strategy, 2) strategies are selected according to their success – machine learning in the form of reinforcement learning (RL) [7] allows PICA to learn about historical interactions with the user to identify the right strategy.

4 Conclusions and Future Work

This work outlines a PICA that we believe goes beyond the existing SOTA. It is surpassed by what is termed as ToM, which consists of: a specifically constructed user model with global and local user data, which relies on behavioral and cognitive sciences advances, especially the use of B5; a RL algorithm to model historical interactions between the PICA and the user, thus capturing which strategies work and which do not; so far inexistent ontologies, especially on BC and SAD. SOTA is further surpassed by integrating two technologies, which is something not done before – ICA technology and wearables, to achieve our goals in BC for mental health.

The final implementation of the design is our next step. Later, user studies will inform about further steps to be taken. Moreover, the study by Fitzgerald et al [1] will be replicated by replacing Woebot with our PICA. We believe that our ideas can inform and advance relevant areas of research, especially in the field of personalized health.

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