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Affect-Sensitive System for Social Anxiety Support

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Abstract—The aim of this research is to design an adaptive interactive system with the capability to sense the current states of affective behaviour and provide adaptive interventions to support users navigating social anxiety. Systems that adapt to anxiety levels, symptom severity, or user preferences can potentially better support them and increase adherence. Sensing users' current affective states and tailoring interventions accordingly will be explored in order to empower users to manage their social anxiety and ultimately enhance their overall well-being, given that human emotions and emotion regulation are critical factors in social anxiety. In doing so, an interdisciplinary approach will be followed, integrating knowledge from design, psychology, affective computing, and human-computer interaction and drawing upon state-of-the-art technological advancements.

Index Terms—social anxiety, affective computing, design research, adaptation

I. INTRODUCTION

What makes a life happy, healthy, fulfilling, and meaningful? Social well-being [19] encompasses our capacity to cultivate and nurture meaningful and enriching connections through our interactions with others, and is among the most important predictors of happiness [40]. Rooted in our innate sociability, it is strongly linked to a sense of belonging and connectedness. The presence of discomfort in social settings, behaviours of wishing to be alone, and unwillingness to keep in touch with others often can be associated with social anxiety [15]. Social anxiety can significantly affect social interactions, overall well-being, and quality of life [15]. A key feature of Social Anxiety Disorder (SAD) is the persistent fear and anxiety of being scrutinized by others, which leads to the avoidance of social situations or enduring them with extreme discomfort despite a strong desire for social relationships [36]. The reported distress and impairment, along with the high rates of treatment avoidance and attrition observed in this population [2], are underscoring the need to support traditional therapies with innovative approaches [20].

Recent technological developments present a promising opportunity to assist people in coping with social anxiety, especially by investigating means to support diagnosis by automatic sensing [34], as well as treatment focused interventions [16], [27]. Considering that treatment avoidance and attrition are notable trends in SAD, with only half of the affected population seeking treatment often after years of experiencing symptoms [15], [36], such technological interventions could provide needed support. However, they are usually one-size-fits-all, and while some show efficacy, they suffer from decreased user engagement over time [5], [28],

[37]. Literature indicates the use of virtual agents (VAs) for delivering interventions as a promising avenue [30], especially in fostering engagement. At the same time, there is a lot of interest in the automated assessment of anxiety based on sensing human physiological and behavioural signals [34]. However, studies on systems that combine sensing anxiety levels with interventions are scarce [9].

Thus, the main research question reads as follows:

“Can an adaptive affect-sensitive virtual agent-based system be designed to support users with social anxiety?”

To answer this main research question, a set of two research sub-questions is formulated:

- 1 What does it mean to design a virtual agent-based system for social anxiety users' support?
- 2 What conceptual model and implementation of the interaction design supports the envisioned virtual agent-based system design?

In order to properly address the second research sub-question it is divided into two parts:

- 2.1 Can the fusion of multiple modalities enable effective and accurate sensing of social anxiety users' affective states?
- 2.2 Can virtual agent-based interventions be designed to support users with social anxiety by adapting to their affective states?

This document presents a structured research plan alongside the preliminary work conducted, aimed at addressing these research questions.

II. SCIENTIFIC BACKGROUND AND IDENTIFICATION OF KNOWLEDGE GAPS

A cross-disciplinary literature review has been performed to uncover the work and limitations across various fields, considering recommended further research, and identifying the research gaps.

A. Multimodal Sensing for Social Anxiety Assessment

Social anxiety states are reflected in cognitive, behavioural (e.g., vocalisation, speech, posture, and gestures), and physiological (e.g., cardiac activity, electrodermal activity, and blood pressure) symptoms and can manifest in a range of behaviours (e.g., blushing, and reducing eye contact) [34]. Over the past decade, interest has grown in investigating machine and deep learning techniques for detecting anxiety characteristics [26], identifying multimodal sensing as a promising direction in this

field [34]. Further, multimodal sensing is found to be more robust, meaning that it performs in a stable manner across various users and usage contexts [25]. However, challenges such as data representation and fusion that reaches a meaningful semantic interpretation of the given signals remain, due to the heterogeneity of the data and the complexity of human behaviour among others [1].

B. Technological Interventions as Treatment for Social Anxiety

There is also a considerable body of research on technology-assisted psychological interventions that aim to increase treatment efficacy and overcome shortcomings of existing treatments regarding access, acceptance, and implementation [16], [27]. These interventions are deployed either as web-based or mobile applications, wearable devices, or artificial agents (e.g., virtual reality, virtual agents, or social robots) [16], [37]. A meta-analysis of technological interventions for social anxiety disorder performed by Kampmann et al. [16] identified internet delivered cognitive behaviour therapy (iCBT), virtual reality exposure therapy (VRET), and cognitive bias modification (CBM) as three major technology-assisted psychological interventions for SAD. In comparison to conventional mental health interventions, these applications are beneficial due to their accessibility and affordability compared to traditional psychotherapy, and have demonstrated effectiveness [37]. However, a decline in user engagement over time has also been identified [5], [28], [37].

Woebot [10] is a conversational agent that provides text-based self-help content derived from Cognitive Behaviour Therapy (CBT) for symptoms of depression and anxiety. Several other studies have also investigated the potential of employing virtual reality and virtual agents in mental health interventions for addressing mental health problems such as anxiety and public speaking anxiety [18], [38], [41]. Trinh et al. [38] present the DynamicDuo system that uses an automated, life-sized, animated agent to help inexperienced speakers deliver their presentations in front of an audience, demonstrating improvements in public speaking anxiety. Similarly, multiple studies have indicated the benefits of using social robots in delivering psychological interventions to decrease users' anxiety. Rasouli et al. [31] co-design a robotic mental well-being coach specifically targeted at helping university students manage public speaking anxiety. Matheus et al. [22] design the robot Ommie that supports deep breathing practices for the purposes of anxiety reduction, showing a reduction in anxiety measures and engaging experience interacting with Ommie. This emphasizes the potential of artificial agents to complement the support provided by therapists in the context of interventions for social anxiety.

C. Research Gaps

1) *Design Gap*: Designing effective and appealing artificial agents for mental health interventions remains an ongoing challenge that requires the identification of features and functionalities that are viewed as engaging, desirable, and effective

[11]. The majority of the studies have assumed system requirements without adequately considering stakeholder needs [5].

2) *Combining Assessment and Treatment*: A systematic review by Fernandez-Alvarez et al. identified combining assessment and treatment as an emerging topic [9].

3) *System Adaptivity*: Targeting a full range of social anxiety affective states from different modalities with multimodal sensing, while ensuring adaptive interventions for user benefit still remains a challenge [29].

4) *User Engagement*: Research suggests that the decline in engagement may be a consequence of applications' limited social presence [10], indicating that using virtual agents (VAs) for interventions is a promising avenue [30], particularly in fostering engagement compared to other forms of technology. However, solutions to maintaining user engagement over longer periods of time still have to be found.

III. RESEARCH DESIGN AND METHODS

This section outlines the methods for addressing the research questions.

A. What does it mean to design a virtual agent-based system for social anxiety users' support?

Designing systems for users with social anxiety requires an understanding of human behaviours, particularly in the context of social interactions. This is linked to the identified design research gap. This research will follow a co-design approach to design a system that caters to the needs of the actors involved. In this case, the actors include not only users with social anxiety but also domain experts. Co-design workshops will be set up in the form of interactive sessions where actors can actively contribute to the various technology and design-related decisions and challenges of this project. This will provide a tool to identify additional requirements, enhance understanding of the problem, and serve as a way to increase acceptance. Similarly to Yang and Aurisicchio [42], the main elements of Self-Determination Theory (SDT) (e.g., competence, autonomy, and relatedness) will be used for the workshops in order to facilitate the design process by supporting actors' psychological needs.

Further, understanding users from both their perspective and the system's perspective involves designing useful, usable, and user-friendly interfaces [4]. Designing the VA-based system will consider various functionality-related factors, including visual appearance, embodied presentations, and intelligence [8]. User experience factors will include perceived adaptivity and user-friendliness. These factors are connected to the system adaptivity and engagement research gaps.

Value Sensitive Design (VSD) will be used to ensure that the system aligns with the core values and needs of its users. VSD emphasizes the incorporation of ethical considerations and human values throughout the design process, fostering a more user-centered approach [23]. By integrating values such as reliability, trustworthiness, and privacy, and by involving stakeholders early in the design process, this work aims to deliver a system capable of empowering its users to deal with social anxiety and reach high acceptability.

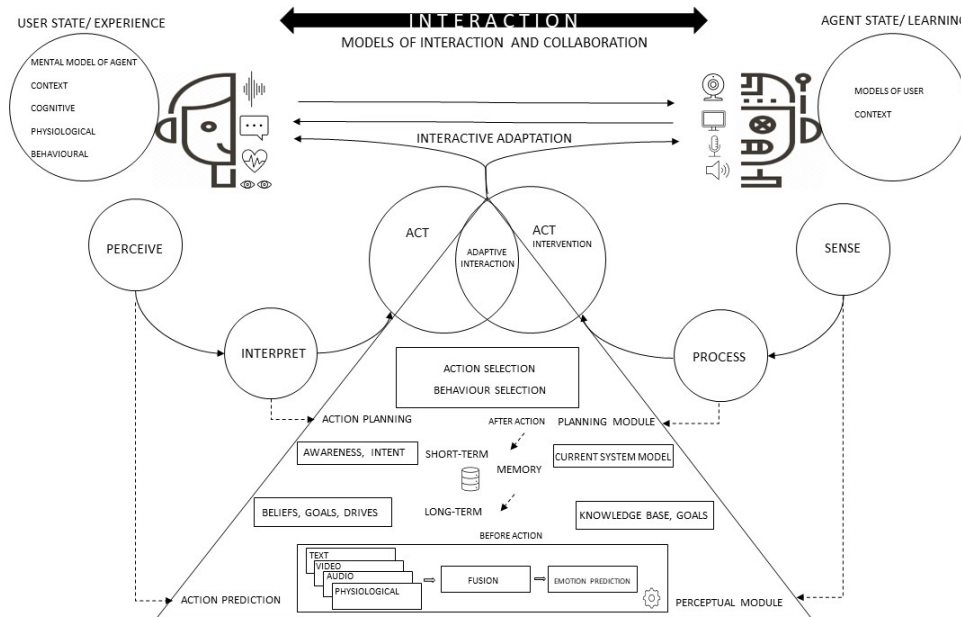


Fig. 1. Proposed Model of VA-based System

B. What conceptual model and implementation of the interaction design supports the envisioned virtual agent-based system design?

This second research question is related to the identified research gap in combining assessment and treatment.

The user, the agent, and the context of their interaction form a complex system [3]. Figure 1 illustrates the preliminary proposed model to represent this system.

Interaction defines the manner in which the user and the agent interact. In this case, it will be a collaboration to accomplish a goal to support users with social anxiety [12]. One of the characteristics of such an interaction is to be adaptive [17]. Achieving this is necessary, given that people have a natural predisposition to interact adaptively. Besides adaptation for the purpose of communication, adapting the difficulty level of the intervention will be considered. This can be seen as the intensity of the stimulus in an exposure setting and can be optimised based on advise of domain experts in response to the users' arousal. The ability of an agent to be adaptive requires sensing the current user's affective states and being capable of adapting its behaviour to them. This is recognized as another research gap. The proposed VA-based system will have the role of being interactive in dyadic human-agent activities, with its interface directly interacting with the users. In direct interaction, the information flow is bi-directional: information is communicated between the agent and the user in both directions, and they are interacting proactively, and autonomously.

Multiple communication channels will be considered, in-

cluding visual, auditory, and physiological channels, based on the literature review findings and restrictions identified by the first research question. The advantages of multimodal interaction are that they can better support users' preferences, enhance the expressive power of the user interface, reduce user errors, and lead to small efficiency improvements [7]. A successful multimodal interaction requires different levels to be in coordination, including: timing, sequence of behaviour, responsiveness (e.g., facial expression, posture, and distance), and emotions.

1) *Can the fusion of multiple modalities enable effective and accurate sensing of social anxiety users' affective states?:* One of the main components of the adaptive system is the sensing module for perceiving emotions/users' affective states (multimodal sensing) in order to provide multimodal interaction. State-of-the-art multimodal sensing algorithms and fusion methods will be examined using available datasets in order to investigate the most promising approaches for recognizing behaviours relevant to social anxiety.

One potential starting point could involve the attention-based Deep Learning (DL) approach Transformers [39]. Current works that use Transformer architecture for emotion recognition in a multimodal setting focus primarily on using audio, visual, and text inputs [21], with limited research on using other inputs such as physiological signals. Considering the recent popularity of Transformers in intermediate fusion-based approaches, an intermediate fusion that enables both intra-modal and inter-modal correlation appears as a promising fusion strategy.

Software Tools and Datasets. The plan is to take advantage

of existing frameworks and libraries. Currently, only limited datasets are available for social anxiety. It will be further explored to determine whether to use existing publicly available datasets, such as the Anxiety Phases Dataset [33], or to potentially collect additional data if necessary.

2) *Can virtual agent-based interventions be designed to support users with social anxiety by adapting to their affective states?*: This research question will be answered by integrating psychological theoretical foundations with insights obtained from co-design sessions, particularly relying on information provided by domain experts.

The VA-based system will consider different use cases that seem promising based on previous work such as exposure therapy and social skills training.

To enable the desired adaptivity, the VA-based system will adjust both the timing of interventions and the intensity of stimuli to match the users' current affective states.

In order to accomplish better engagement, the basic psychological needs of the users will be targeted with Self-Determination Theory (SDT) [24], [28]. SDT is a motivational theory, which proposes that all human beings have three basic psychological needs which are essential nutrients for effective functioning and well-being [6]. In this context of social anxiety, SDT can be used taking into account users' autonomy, innate determination toward psychological growth and development, and striving to be competent in facing ongoing social challenges. Using SDT addresses the user engagement research gap by exploring how to influence engagement with technology.

Since human emotions and emotion regulation are some of the most powerful factors in the context of social anxiety [14], and a lack of effective emotion regulation is a diagnostic factor for conditions such as social anxiety [35], the design of the interventions will consider emotion regulation [13]. In relation to social anxiety, the combination of SDT with emotion regulation [32] illustrates how users might try to mitigate negative emotions, such as fear, which can positively impact the overall user experience and effectiveness of interventions.

Recognizing the interconnectedness among these psychological constructs and their link to social anxiety will provide a robust theoretical foundation to build upon and integrate their key elements in the form of a VA-based system tailoring adaptive technological interventions aimed at addressing social anxiety.

C. Evaluation

The final phase will involve evaluating the system, considering accuracy, relevance, adaptability to users, and overall experience. This evaluation will be conducted both in lab settings and potentially in-the-wild. A combination of quantitative and qualitative methods will be used.

IV. EXPECTED CONTRIBUTIONS TO AFFECTIVE COMPUTING FIELD

The research strategy that will be followed is Research Through Design (RtD), which allows framing and reframing

the problem space, investigating what to design rather than determining the best way to design something potentially of little value, and creating the system as the process unfolds [43]. Considering the needs of potential users and domain experts [5] will aim to create more inclusive, engaging, adaptive, and user-friendly solution for users with social anxiety. Using these findings will contribute to the design of affective computing systems traditional techniques and possibly inspire new directions.

ETHICAL IMPACT STATEMENT

Ethical concerns are an important aspect of this research, and all possible measures will be taken to ensure that it will be conducted in an ethical and responsible manner, requesting and obtaining authorization from the university ethics committee. Special attention will be paid to personal data management, considering privacy, confidentiality, and GDPR compliance, while avoiding any harm to the users involved. Users will be properly informed, and informed consent forms will be signed and collected.

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