What Skin Is Your Robot In? Co-Design of a Personalizable Robot for People Living with Depression

Sawyer Collins
Indiana University, Bloomington
Bloomington, Indiana, USA
sercolli@iu.edu

Daniel Hicks
Indiana University, Bloomington
Bloomington, Indiana, USA
hicksdan@iu.edu

Zachary Henkel
Mississippi State University
Starkville, Mississippi, USA
zmh68@msstate.edu

Kenna Baugus Henkel
Mississippi State University
Starkville, Mississippi, USA
kbb269@msstate.edu

Jennifer A. Piatt
Indiana University, Bloomington
Bloomington, Indiana, USA
jenpiatt@indiana.edu

Cindy L. Bethel
Mississippi State University
Starkville, Mississippi, USA
cbethel@cse.msstate.edu

Selma Šabanović
Indiana University, Bloomington
Bloomington, Indiana, USA
selmas@indiana.edu

ABSTRACT

The use of socially assistive robots is able to alleviate some depression symptoms, according to existing research. However, due to comorbidities that often accompany depression and the unique experiences of each individual, it is necessary to get a better understanding of how SARs should be personalized. Through 10 hour-long workshops with 10 individuals living with depression, we explored the customization of a zoomorphic SAR for adults with depression. By using the SAR Therabot™ as a base platform, participants designed their own unique covering for the robot, and discussed desired robot behaviors and privacy concerns around data collection. Though the physical designs of the robots varied greatly, participants expressed common themes regarding their preference for a soft touchable exterior, comfort with sharing data with their therapists, and interest in the robot producing more realistic sounds and movements, among other design features.

CCS CONCEPTS

• **Human-centered computing** → *HCI design and evaluation methods.*

KEYWORDS

Social robots, socially assistive robot, Robot design, Depression, Mental health technology

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1 INTRODUCTION

Over 350 million people are living with depression around the world today [1]. Depression is often accompanied by comorbidities such as substance abuse [2], insomnia [3], and other physical conditions like heart disease [4], all of which can detrimentally affect quality of life. Throughout the COVID-19 pandemic and its continued effects, there has been a steady rise in the incidence of depression [5]. Socially assistive robots may benefit people with depression by providing companionable interaction [6], while helping track the individual's social behavior and local environment to inform users' self-reflection from ongoing therapies.

Socially assistive robots (SARs) vary in design and ability. Depression affects people of varying ages and has a wide variety of comorbidities, which makes it difficult to develop a one-size-fits-all solution and makes personalization necessary. In this paper, we present the findings from 10 one-on-one workshops performed with participants living with depression, in which we sought to identify specific aspects of SARs that participants consider desirable for their use. Using the dog-like SAR Therabot™ (fig. 1) [10] as a foundational technology, we explored how this robot could be adapted for the needs of people with depression more generally, and for diverse individuals' needs more specifically. During the workshops, participants discussed the robot's appearance, its environmental sensing abilities, and aspects of privacy and data sharing that they considered important for in-home use. Building upon our prior findings that participants were interested in communicating with their SAR via a mobile app when away from home [11], we also asked participants to describe features they would find useful in a companion mobile app.

Figure 1: Therabot Robot

2 BACKGROUND

2.1 Depression

Major Depressive Disorder (MDD) is a leading cause of mental illness and disability affecting nearly five percent of adults globally and 8.4 percent of adults in the United States [12]. MDD can impair a person's ability to function in daily life, as commonly experienced symptoms include: a lack of reactivity, complete loss of pleasure in activities, and delayed psychomotor response [13]. During the COVID-19 pandemic, the global prevalence of anxiety and depression increased by 25 percent from pre-pandemic estimates [14]. In the U.S. this particularly impacted young adults ages 18-25 and adolescents 12-17 [12]. In 2020, 18.9 million people aged 12+ in the U.S. experienced a severely impairing depressive episode, and of those with severe impairment 71 percent received treatment [12]. Several treatment options exist, including animal-assisted therapy.

2.2 Socially Assistive Robots for Mental Health

Socially assistive robots have been used throughout the world to provide comfort and care to elderly individuals. Our previous work showed a reduction in depression symptoms in older adults using SARs in their homes [19]. Less explored is the use of SARs for depression in the broader population, which is of interest due to the widespread nature of depression among people of all ages.

Research suggests social robots such as Vector could potentially decrease loneliness when acting as companions [20]; however the effects of SARs have been less explored for loneliness in tandem with depression. Anxiety is another area in which SARs have been shown to have positive effects, with some users reporting a decrease in anxiety symptoms [21]. While anxiety and loneliness are often comorbid with depression [22], SARs for the aid of those living with depression have been less explored. Particularly of interest is the concept of using SARs in place of live animal-assisted therapy. SARs with zoomorphic designs can be of interest for those living in care facilities because they are not live animals, but a zoomorphic design can allow the formation of connections with those who enjoy animals [23].

3 METHODS

Through Indiana University's online classifieds system, we recruited 10 individuals who self-reported as having been diagnosed with depression. Each individual participated in an hour-long online workshop. Participants answered the PhQ-9 depression questionnaire [24], as well as demographic questions.

3.1 Workshop Format

Each workshop lasted one hour and all were performed virtually through video chat. Participants were first introduced to two pet-like SARs, the cat-like Joy for All and the seal-like robot Paro and were given information about how these robots have been used with other populations. Next, they viewed the SAR Therabot™ through both a picture and a video, and were shown what the robot looked like without it's exterior covering to get an idea of the basic physical foundation they would be designing around.

At the beginning of the workshop, participants were asked to sketch out an alternative covering for Therabot™ and were shown an uncovered version of the robot to help guide their designs (figure 2). They were then asked to also sketch a covering for someone who does not prefer dogs or cats.

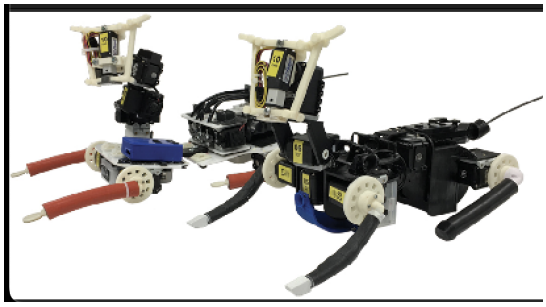

Figure 2: Therabot Picture Shown to Participants for Sketching

Once participants had their desired covering, they were asked generally about what sensors they feel would be most useful for their robot to have. Rather than naming specific sensors, they were asked to describe what the robot was sensing, to allow for participants to explore the idea of useful sensors rather than trying to remember specific technical names.

We then asked what behaviors the robot should be able to exhibit, such as sounds and movements. We also asked specific questions regarding therapeutic exercises and heartbeat. Participants were also asked to imagine an app that could pair with the robot, particularly for when they are away from home and without the robot. Thinking about the app and data that is collected from the robot, participants were asked if they were comfortable with sharing the data with their therapist. We also asked if there were any concerns about those living with depression using these types of devices, to get a better understanding on any hesitancy participants may have in adopting the robot companion they just designed.

The workshop was divided into five main parts with sub-questions for each (table 1).

Table 1: Participant Demographic Data.

Age	Gender	Ethnicity	Education	PhQ-9
22	Male	White	College Degree	4
26	Male	Asian	Post-Graduate Education	12
25	Male	White	College Degree	6
31	Female	White	Post-Graduate Education	16
23	Female	White	College Degree	18
56	Female	White	Post-Graduate Education	22
25	Female	Asian/Other	College Degree	22
24	Female	White	College Degree	11
49	Male	White	College Degree	7
30	Female	White	Post-Graduate Education	7

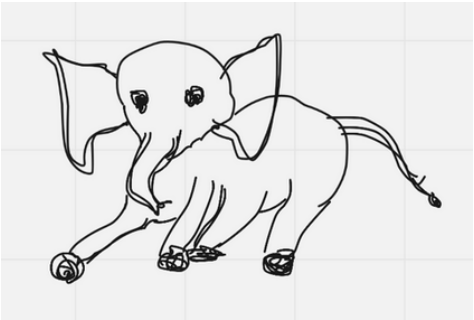

Figure 3: Participant Sketch

4 RESULTS

This study was approved by Indiana University's institutional review board (IRB).

After the 10 participants had completed the hour-long workshop, the collected video data was transcribed and anonymized. The data was coded through inductive coding. Coding was done by the first author, and an inter-rater reliability test was done by the second author who was presented with 30 of the 213 final excerpts to code independently with a code list (*irr* = .78). Once this was completed, the second author also reviewed each coded excerpt, and any changes or concerns were discussed by the first two authors.

Participants included six women and four men, all of whom had at least a college degree, aged 22 to 49. They were experiencing depression symptoms as measured by the PHQ-9 that ranged from 4 to 22, ranging from normal (0-4) to severe (20+) [24], with an average of 12. All participants indicated having been diagnosed with depression previously, but were not asked to provide proof of their condition to respect their medical privacy.

For individual demographic details see Table 1.

4.1 Robot Physical Design

After being introduced to the concept of pet-like SARs and shown example zoomorphic robots, participants were asked to draw two designs for fabric coverings that they would want to use to cover Therabot™. The most common initial coverings were a cat (n = 4) and dog (n = 4), but participants were also requested to draw a design aimed for someone who did not like cats or dogs. This led to many interesting animal-like designs, including an elephant, (fig. 2) platypus, hamster, as well as a few more fantastical designs such as a dragon. Participants were also asked about specific design features, such as the color or feel of the robot. Most participants wanted the robot to reflect the more natural coloring of the animals that they imagined (n = 9), rather than emphasizing the artificial nature of the robot.

P6 – "For me, I would do natural colors. If it was more of a tabby cat feel, I would probably stick with like the tabby cat coloring more at the butterscotch kind of coloring."

Participants also wanted the robot to be soft to the touch (n = 6).

4.2 Robot Sensors

Keeping their new robot designs in mind, participants were then presented with some examples of sensors, such as light and sound sensors. They were asked what sensors they felt would be most useful for their designs. Participants overall preferred not to have a camera on their robot (n = 6), but rather requested different ways of sensing whether the individual was present.

P1 – "I definitely think that there's definitely certain things people wouldn't want, like cameras. I feel like "Wow why is there a camera in here? Are they trying to spy on me?"

P2 – "Maybe some sort of movement-based sensor, if I'm trying to move that robot in some direction in terms of having a gyroscope or something and it can follow some sort of movement and things like that."

However, the most common sensor requested by participants for their designs was a touch sensor (n = 9).

P7 – "So I would want them to have the touch sensor and respond to me petting them because in my mind, this is like a service animal without the actual animal component."

4.3 Robot Behaviors and Usage

Once participants had their robot designed, they were asked about specific aspects of the robots' behavior, such as what sounds and movements the robot should make, and its potential uses by participants.

When asked about the robots' voice, participants indicated that they did not want the robot to have a human voice (n = 7), but were more interested in the robot making more natural noises that fit its design (n = 9).

P8 – "I guess I'd want them to make real animal sounds, like barking or purring"

Overall, the idea of the robot having an artificial heartbeat was well received, with seven of the participants indicating interest.

P3 – "So just being able to maybe even listen to the Therabot™'s chest area or stomach and kind of hear even a heartbeat or like it's breathing in and out might be beneficial for doing breathing exercises, for you to be able to kind of copy and that sort of thing."

4.4 Data Collection and Sharing

We were also interested in what individuals may do with the data that is collected by the robot via the sensors. Overall, nine participants indicated being comfortable with sharing the information collected by the robot with their therapist.

P2 – "I think I wouldn't mind to share it with family or therapists. I think for me having a record of how my mood was during those times and there might be situations where I might not even realize that I'm in a bad mood or having a breakdown or something so if the robot can kind of accurately sense that in terms of, if that person is crying during that time or having a breakdown or this person is angry and the robot can sense that and put that in the record."

4.5 Robot Connect App

Participants were also asked to think about a mobile app that could connect to their robot. Two of the 10 participants did not complete the app portion of the workshop due to time constraints. Of those that completed the app portion of the workshop, four mentioned wanting to be able to set goals in the app.

P1 – "Yeah I still think that's a good idea, you could have sensors in the app that say like, "you're 10 percent below average light source for this week you should be more active, step it up a bit" in an encouraging way. You could see your score and the average score."

Participants also thought that the app could be used to interact with a virtual version of the robot, a virtual companion (n = 4).

P4 – "Having the avatar be like a Tamagotchi sort of thing. Where like you log that you drink water or eat food or exercise or whatever, and then your avatar gets it and like so you're taking care of the avatar creature."

4.6 Concerns over SARs

Participants expressed varying concerns regarding safety of the user, informational privacy, and the potential to be overwhelmed by this system. The most common concern, however, was that the user might develop to much attachment to the robot (n = 4).

P5 – "Instead of like helping them to feel better and get better over long term, maybe there could be like a bad form of like attachment that could form for some people. Like way overly dependent on it or something"

5 DISCUSSION

The goal of this study was to get a better understanding of how socially assistive robots would need to be customized for those living with depression.

The most common physical design was a cat (n = 4) and a dog (n = 4). A few participants mentioned when drawing their cat or dog sketches that they were modeling them after animals they already own or had owned, suggesting that they found these designs comforting due to their familiarity. Interestingly, other studies have found that despite being a zoomorphic design, older adults wanted pet robots like Joy For All to be able to communicate verbally [27]. In contrast, our participants preferred natural animal noises that would match their zoomorphic appearance (n = 9).

Our participants were interested in the potential of the robot being able to lead them through therapeutic exercises as a way of integrating the tools they learn in therapy with the robot. This, paired with their interest in the robot having a heartbeat (n =7), shows potential for integrating coping mechanisms for reducing anxiety [25], a common comorbidity with depression, into SAR design.

Participants were also keen to be able to monitor their data collection and who that data was being sent to. Therapists have previously indicated that sensor data collected by the robot may be helpful in their work with their clients, such as sleep data [7], and our participants in this study indicate being willing to share that information with their therapists (n = 9).

Mobile games and digital pets have been used to teach children certain behaviors [28], and to motivate individuals to engage with therapeutic life tools [29]. Our participants indicated wanting something similar, but customized to their robot and their specific therapeutic practices. Moreover, the app could provide a way of allowing the individual to track their own depression symptoms, such as the monitoring of light or sound. Prior studies with children with diabetes have shown that keeping track of one's behaviors through a robot can be more successful than keeping a paper journal [30].

One limitation of this study is its digital format, which does not allow participants to get hands on experience with the robot. While this format allowed us to adapt to the availability of the participants, as well as their potential remote locations, it is recognized that in person interaction with the robot as well as sensors may change participant's opinions. In-person workshops are planned to provide participants with the opportunity to interact with robots and experience sensors to better inform their understanding of these technologies.

6 CONCLUSION

Overall, participants designed their customized zoomorphic robot based on their preferences and needs.Their designs imagined a desire for naturalistic sounds and physical look to animals that they were familiar with. Participants also expressed interest in an app that could help reinforce therapeutic tools, reflected in the robots behaviors as well as provide a way to share the sensor data with their care team. Our future work will expand upon these workshops by holding longer or multiple workshops with participants diagnosed with depression to get more detailed information on the requirements for a personalized robot.

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