Robo-friend: Can a Social Robot Empathize with Your Feelings Effectively?

Eshtiak Ahmed*[1,3], Ashraful Islam[2,3], Atiqul Islam Chowdhury[4], Mohammad Masudur Rahman[5], Shahnaj Chowdhury[1], and Md Imran Hosen[1]

[1] Tampere University, Tampere, Finland
{eshtiak.ahmed, shahnaj.chowdhury, imran.hosen}@tuni.fi
[2] University of Louisiana at Lafayette, Louisiana, USA
ashraful.islam1@louisiana.edu
[3] Daffodil International University, Dhaka, Bangladesh
{eshtiak, ashraful}.cse@diu.edu.bd
[4] United International University, Dhaka, Bangladesh
achowdhury201036@mscse.uiu.ac.bd
[5] Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
masudurism@gmail.com

Abstract. Social robots are becoming more popular everyday because of their resemblance with human behavior and interaction styles. They should be treated more like companions rather than just a fancy source of entertainment. Recent studies have shown great promise for robots to act as teachers, companions, caregivers and so on. In this study, primarily, a feasibility analysis is done to find out the way how a social robot can be used as a companion where it can sense the emotions of the users, empathize with their feelings and provide feedback with a view to changing their mood. A context study was conducted to make design implications where user experience goals such as inspiration, sense of control, relaxation, accomplishment and confidence were considered in the implementation. Furthermore, a prototype was design based on a social robot, Pepper which then was interacted with potential users, either in groups or individually. The results supports the fact that, a well-implemented social robot can effectively empathize with human users' emotions.

Keywords: Human-robot interaction, user experience, experience goals, experience driven design

1 Introduction

Robots are becoming more and more common everyday. They are being adopted into almost all the aspects of human life ranging from day to day life to even critical medical technology. Robots have enough potential to be useful if used in proper context. There are so many situations in human life where robots can still be introduced especially in social situations.

* Corresponding Author (Email: eshtiak.ahmed@tuni.fi)

Social or conversational companions are one of the important needs for humans to have sound mental health. They always try to express their feelings to others whenever they are sad, angry or feeling negative emotions, giving them a sense of empathy from the opposite and provide them with the sense of belonging. However, the society nowadays is becoming more and more monogamous [1] and people are starting to rely on technology as more of a companion that products. In all these circumstances, a robot could work as a viable companion to human beings [2]. They can be employed as companions that empathize with the user and provide feedback based on the emotions of the user. As an example, if the user appears to be sad, the robot can provide some feedback to make the user feel better.

There has been some previous work [3–5] which emphasizes robots being teachers or companions. But there are a lot of contexts where more work can be done. In this project, the primary target is to evaluate a social robot's functionality in having and performing social behavioral skills. We also aim to evaluate if a social robot can act as a friend who can react and empathize with people's feelings and provide consolation or feedback at the same time.

This study initially focuses on the feasibility of a robot being able to work as a companion. User studies are conducted to know and analyze the perception of the users in the scenario where robots can empathize with them and provide meaningful feedback depending on their mental conditions. Finally, a prototype evaluation has been done to support the facts.

2 Related Work

In recent times, there has been a good number of studies involving robots in the daily lives of people. Especially, there have been many studies on robots acting as teachers of a second language. In [3], several aspects of using a social robot as a language learning companion was assessed which included the potential application as well as limitations. In this study mainly focused on improving the vocabulary and grammar as well as speaking and reading skills. This paper reported 33 different studies which focused on robots' effect on children's learning motivation and the ways a robot should behave to maximize learning outcomes. In [4], some features of design were proposed keeping a social robot in mind which would be child-friendly, for assisting in learning a 2nd language. Both studies discuss the issues of motivation factors as well as social behaviors of learners.

Robot Assisted Language Learning (RALL) has been focused on in some of the studies which include the types of robots that can be employed [3]. Robots have also been employed as behavior teachers for children with autism spectrum disorder having delayed gestural development [6].

There have also been some studies which have tried to find out the role and influence of empathy in human robot interaction. Robots seem much more friendly and approachable if they empathize with people [7]. In this study, a robot was used during a chess match which was showing different types of emotions to a specific player and was neutral for the other. 31 participants were recruited

for this study and all of them found the robot to be empathically friendly. These studies show that robots can evoke emotions into human minds and can be used as companions and provide feedback based on the users' situations. These kinds of applications in robots can be developed using AI and intelligent algorithms [8].

3 Design Approach

Whenever a new product is designed, it needs to follow certain characteristics in order to be appealing to the end user. User experience models usually provide a better understanding of how people perceive and value objects as well as providing common operationalization and easy measurement of key elements. In this project the Components of User Experience (CUE) model [9] has been used to evaluate user experience values. This model takes into account many aspects of a system such as interaction characteristics, emotions of users, both instrumental and non-instrumental qualities, all in all the overall perception of the system's quality. It takes interaction characteristics into account to evaluate user experience components. There are specific components of user experience by which the behavior of any application or system is defined. A recent study [10] has shown the use of this specific model where they employed this model to understand the players' appraisal of their newly designed game.

The experience driven design approach has been followed here while designing the prototype. This starts with a "why" question which helps define the reason why the user will be using the product. Then comes a question which tries to identify the needs and emotions involved with the product and what the users actually can do with the product. Then there is the "how" question which tries to answer how the users interact with the product. Why goals are also called the be-goals which defines the experience of the product to the user. Defining experience goals rather than functionalities can help connect with the user more which could result in better response from the user [11]. The idea of creating an experience driven design is to define which experiences we want the users to have while using a particular design. While this is opposite of features driven designs, it's more effective in the long run as it's the experience that makes or breaks a system for a user.

4 Context Study and Conceptualization

To understand the users and the expectations better, context studies are very important. For this project, the context study was conducted in order to understand how potential users perceive the idea of having a social robot as a companion which can also empathize with their mental conditions. We plan to conduct studies with users and report in this section on later phases.

To get a better understanding of what a potential user would want, 16 university students, age ranging from 21 to 28, were interviewed. 7 of them had previous experience of interacting with a robot while the other 9 did not have

any or had seen people interacting with robots at best. Most of them reported positive experiences with robots while 2 of them reported some awkward and frustrating experiences.

The interview questions were designed to ask users about how they would like a social robot as a companion. Responses were analyzed on a topic basis, such as "what a robot should be able to do as a companion", "how a robot should behave in a certain situation" etc. This provided an idea about the design implications of the prototype. This also helped to understand what a user can expect from a companion robot in the context of providing feedback for different mental states. The participants were also asked about what type of response they expect from the robot in mental conditions like sad, angry, stressed, bored and depressed.

When asked about what a companion robot should look like, most of them answered that it should look like a human and mimic human behavior. 2 participants were neutral about their appearance but did prefer some physical appearance. In the user study, we asked participants what a robot should do when they are sad, angry, stressed, bored or depressed. Following are the suggestions that were collected from the results of the questionnaire.

- **Sad:** Touching or patting, singing a song, dance, offer to play fun games, show nice pictures, being funny in appearance, have a conversation.
- **Angry:** Music, show negative effects of anger, say motivational quotes about anger management, listen to the yelling and confession of the user.
- **Stressed:** Relaxing music, dance, tell jokes, make food
- **Bored:** Tell a joke, dance, play music, read a book
- **Depressed:** Motivational words, tell stories, show achievements of user

5 Design Explained

5.1 Experience Goals

In the initial phase, there were some pre-defined experience goals to create initial design implications which included relaxation, inspiration, empathy, confidence, assurance, sense of satisfaction, control, accomplishment and challenges. Later, while designing the experience journey map, in figure 1, the experience goals became more streamlined and closer to context. The experience journey map is the hypothetical portray of a potential user's journey of using a system. Here, the journey is divided into 3 phases, before using the robot as a companion, during the interaction and after using it. 3 activities of potential users were quantified to understand their experience during the 3 phases. These activities are "doing", "thinking" and "feeling". These 3 activities combined with the phases were then concluded into specific experience goals for each phase.

From the experience journey map, initially defined the experience goals as satisfaction, inspiration, sense of control, relaxation, accomplishment and confidence were defined. In the later phases of prototype development, the experience goals became even more defined and clear. The final experience goals were happiness, inspiration, relaxation, calmness and accomplishment.

Fig. 1. Experiences Journey Map

Users' perception on both instrumental qualities such controllability and effectiveness can be portrayed as some of the experience goals like sense of control and confidence. Users' emotional reactions are also taken into account. The experience goals as discussed in the following section along with their connection with the components of the CUE model.

- **Inspiration:** A user may get inspiration by the positivity of the conversation and stories shared by robot. The conversations with the robot can be designed in such a way that it will exhibit positivity. This can be related to components like visual aesthetics and psychological reactions.
- **Happiness:** Happiness can be created in the mind of the users by listening to their favourite songs, jokes, seeing nice pictures or even by interacting successfully with the robot. This experience goal can be related to controllability and psychological reactions. Users are supposed to get a positive experience.
- **Relaxation:** A sense of relaxation can be invoked through music, dance and motivational stories. Also, the robot should talk in a voice that could be relaxing for the user. This can be related to effectiveness and haptic quality.
- **Accomplishment:** After the interaction a user generally greets the robot and leaves the premises. During this time if he/she had feelings like, satisfied, happy, calm and inspired. Being able to overcome negative mental situations

by using the robot can create a feeling of accomplishment in the mind of the user. This can be connected with controllability.
– **Calmness:** Calmness can be achieved by the user through relaxing music, seeing nice pictures or even by listening to a joke.

5.2 Prototype Design

When deciding which robot to use to create a prototype for, uses' perception of companions was taken into account. Majority of the users so far from the context study mentioned that they would like a human-like figure for a companion robot. Also the robot will need to have the ability to have a proper conversation with them. Keeping all that in mind, we decided to design a prototype on the Pepper [12] robot which is a semi-humanoid robot manufactured by SoftBank Robotics.

To design the prototype, 4 mental conditions of the human mind were chosen. When a user approaches the robot, it provides 4 options to choose from to proceed. The options are "sad", "angry" "stressed" and "bored". Based on the choice of the user, the robot will offer to tell jokes, play music, show nice pictures etc. A storyboard is designed to explain a scenario on how robots will deal when a user is feeling sad, in figure 2.

The use context of this application can be either at home or at a workplace. In this study, it has been considered more suitable for use in an organizational context where different people can come and express their feelings with a view to improve their mood. The robot could be kept in a separate room and people can enter and use the application.

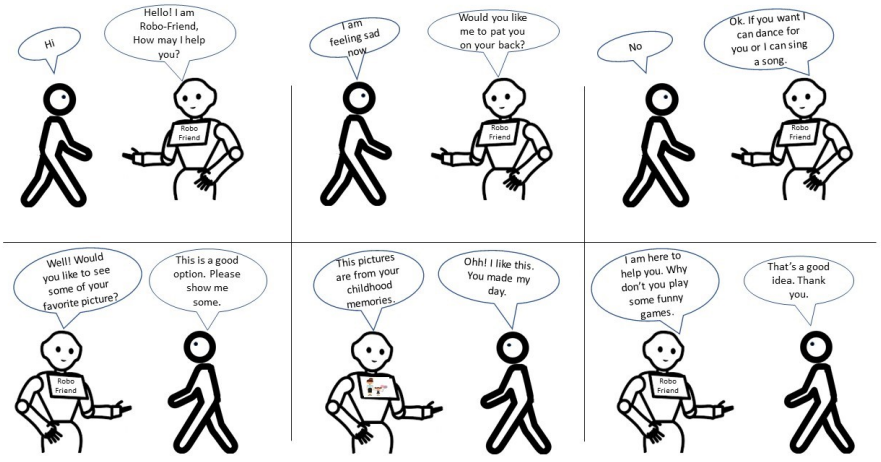

Fig. 2. Storyboard: When the User is Sad

6 Prototype Evaluation

The prototype was evaluated in two phases, first one was at prototype demonstration at the university with groups of participants and the second one was conducted with individual participants.

6.1 Evaluation Methods

In the first phase of evaluation with groups, the designed prototype was presented to the potential users before doing the prototype evaluation to make them understand the functionalities and how to use and interact with it and also the purpose of the evaluation was explained. After the presentation and demonstration, participants were asked to interact with the robot based on their own preferred choice of functionalities. During the participants' interaction with robots, behavioral observations were conducted which was followed by semi structured interviews. In the second phase, a mixed method [13] and meCUE [14] model for evaluation.

To get both the qualitative and quantitative data, mixed method research approach [13] was employed which consist of observation and semi-structured interview option to complement each other. Observation was done with a structured observation sheet to identify the participants appearance, approaching style to robot, selection of prototype functionalities, way of interaction, the emotional reaction with 10 other observation criteria and 3 open-ended observation questions. Semi-structured interview was conducted with a set of 11 questions to collect the data where questions were grouped into background data, experience and emotion evoked during the interaction with robot and the last group participants own thoughts, expectation and suggestion.

Along with the mixed method research approach, meCUE [14] model was also used to identify the dimensions of usefulness, usability, visual aesthetics, positive/negative emotion which is related to our defined experiences goals.

6.2 Participants

In demonstration day evaluation, the participants were the students of the university coming in groups. A total of 5 groups (2-4 members) of adult male and female participants took part in it. In second phase evaluation, participants were recruited randomly from the corridor of university who were passing by. Among 13 individuals, 3 participant is female and other 10 were male and the age range was 19-34. All the participants were student and from different nationalities, such as France, Vietnam and Bangladesh.

6.3 Results

From the results of the observation of both phases it became clear that the participants were curious to interact with the robot and also they were energetic

Table 1. Features and their usage

Features	Participants
Sad	13
Bored	8
Stressed	6
Angry	6

while interacting. The participants tried different functionality and features of the prototype. Most of the participants enjoyed the joke and song feature of the prototype and they specifically mentioned that the prototype and robot interaction was cool and enjoyable. They also rated the features of song, joke, pictures and motivational quotes. The table 1 shows the features and how many participants used each feature during the evaluation. In figure 3, the ratings given for each of the features from 6 of the users is shown. There were only 6 users who explored all the features, thus this presentation.

From the interview it was noticed that the participants' experience with the robot was good, enjoyable and they found the robot as friendly and informative. But it has some balancing and movement problem as per 2 participants. The feeling during the interaction was varied in different participants. And they also found the robot friendly, entertaining and it didn't do any scary or rude behavior to them. Figure 4 shows the participants' impression on the prototype and its behavior.

The participants preferred to interact with the robot through touch and speech modality. All the participants showed their interest to use the robot as companion for empathy except one and the encouragement behind using it is the humor level, intelligence, easy to share feeling to it then any human and its friendliness attitudes. Figure, shows the feedback ratings from the user.

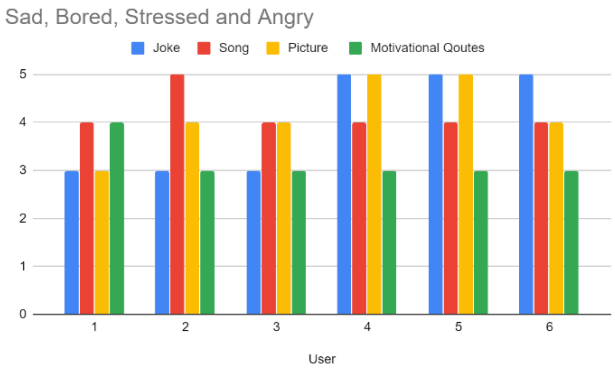

Fig. 3. Rating of different features from the range of 1-5

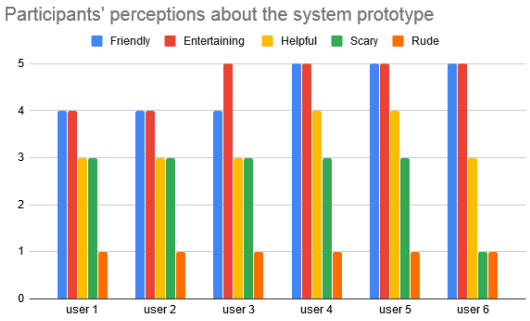

Fig. 4. Results from the interview about the feedback of robot behavior

However, they think there are some challenges also in this context like identifying the emotion properly, voice detection, more human like behavior and level of artificial intelligence. Comment from one of the participants (P2, age:19, male) 'I would like to have eyes interaction and the robot can realize the distinct people talking to it , so it doesn't repeat something it told to me, example the joke' represents the level of intelligence user expects from this type of service.

From the results of meCUE questionnaire it revealed that, the participants found the system as useful for the context and the system was also appealing to them due to the overall aesthetics. It was able to evoke positive emotions to the participants while they were using it. The figure 5 shows the meCUE model results for Usefulness, Usability and Aesthetics.

Fig. 5. meCUE model results for module I (Usefulness, Usability and Aesthetics)

7 Discussion

This study was focused on understand the potential usability of a robot working as a human companion. The initial user studies point towards a growing interest in robot based application and some specific requirements. In the beginning, a lot of experience goals were defined to go through with the experience driven design process. However, as the time progressed, some of them seemed very high level and superficial. It was also very unclear how these experience goals can be evoked and measured at the same time. Further discussions and primary prototyping decisions helped narrow down the experience goals to some realistic ones before starting the prototyping phase.

When prototyping started, some more experience driven aspects came to light. It was realized that some of the experience goals were still superficial and difficult to evoke. As a result, slight changes were made to them, keeping the main idea intact. While trying to measure if the experience goals were actually evoked or not, some of them were evident to be evoked while others were difficult to decide.

The results from the prototype evaluation portrays the usefulness of the system, at least according to the limited number participants. Results show that participants found the robot as funny, entertaining and helpful. One of the participants felt shy while interacting with the robot. Overall the results were very encouraging for any further investigation.

8 Conclusion and Future Work

This study focused on understanding people's perception towards using a social robot as an emotional companion. From the results, it can be said that potential users have a very positive feeling about the idea and they also find it useful. This study has been completed with a limited number of users, also all the participants were university students. This makes a future work to be very much possible with more users from more diverse groups based on age and profession. Also, only 4 states of human emotions were considered here, in future more specific states can be explored. In this study, the movements and gestures from the robot end were not explored which could be something very interesting to investigate.

References

1. Conley, T.D., Ziegler, A., Moors, A.C., Matsick, J.L., Valentine, B.: A critical examination of popular assumptions about the benefits and outcomes of monogamous relationships. Personality and Social Psychology Review 17(2), 124–141 (2013)
2. Dautenhahn, K., Woods, S., Kaouri, C., Walters, M.L., Kheng Lee Koay, Werry, I.: What is a robot companion - friend, assistant or butler? In: 2005 IEEE/RSJ International Conference on Intelligent Robots and Systems. pp. 1192–1197 (2005)
3. van den Berghe, R., Verhagen, J., Oudgenoeg-Paz, O., van der Ven, S., Leseman, P.: Social robots for language learning: A review. Review of Educational Research 89(2), 259–295 (2019)

4. Vogt, P., de Haas, M., de Jong, C., Baxter, P., Krahmer, E.: Child-robot interactions for second language tutoring to preschool children. Frontiers in Human Neuroscience 11, 73 (2017)
5. Han, J.: Emerging technologies robot assisted language learning (2012)
6. So, W.C., Wong, M., Lam, W., Lam, C., Fok, D.: Using a social robot to teach gestural recognition and production in children with autism spectrum disorders. Disability and Rehabilitation Assistive Technology 13 (08 2018)
7. Leite, I., Pereira, A., Mascarenhas, S., Martinho, C., Prada, R., Paiva, A.: The influence of empathy in human–robot relations. International Journal of Human-Computer Studies 71 (01 2012)
8. Yang, J., Wang, R., Guan, X., Hassan, M.M., Almogren, A., Alsanad, A.: Ai-enabled emotion-aware robot: The fusion of smart clothing, edge clouds and robotics. Future Generation Computer Systems pp. 701–709 (2020)
9. Mahlke, S., Thuering, M.: Studying antecedent of emotional experiences in interactive contexts. pp. 915–918 (01 2007)
10. König, A., Wegener, J., Pelz, A., Grippenkoven, J.: Serious games: A playful approach to reduce usage barriers of innovative public transport systems (10 2017)
11. Hassenzahl, M.: User Experience and Experience Design (01 2011)
12. Robotics, S.: Pepper the humanoid and programmable robot, `https://www.softbankrobotics.com/emea/en/pepper`
13. Johnson, R., Onwuegbuzie, A., Turner, L.: Toward a definition of mixed methods research. journal of mixed methods research, 1, 112-133. Journal of Mixed Methods Research 1, 112 –133 (04 2007)
14. Minge, M., Thuering, M.: The mecue questionnaire (2.0): Meeting five basic requirements for lean and standardized ux assessment (07 2018)