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Human-centered Robot Interaction: Emotional Engagement Factors in Anthropomorphic Social Robots for Finnish Older Adults

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Social robots are expected to have an important role in Finnish older adults' everyday life nevertheless, some of the future challenges are represented by social human robot interaction and integration of user needs.

This research-oriented thesis aims to cover gaps in research concerning the integration of user experience in human robot interaction. Additionally, this study explores emotional engagement factors in human robot interactions of Finnish older adults and an anthropomorphic social robot. Furthermore, proposes a design framework and guidelines for anthropomorphic robot companions for Finnish older adults.

An online user study was conducted in which eight older adults participated as well as, a separate controlled experiment was performed with a different sample of eight older adults with age range from 67 to 75 years old.

In the controlled experiment, adopting Wizard of OZ technique, older adults conversed with Furhat an anthropomorphic social robot and two conditions were tested. Group A conversed with the male version of the robot and Group B conversed with the female version of the robot. After the interaction participants undertook a post survey.

The main findings of this study revealed that emotional engagement in anthropomorphic social robots refers to users´ affect and emotions in terms of happiness, interest, curiosity and trust. Trust contributes significantly to emotional engagement. Additionally, the gender of the robot has no effect on participants in terms of trust or emotions elicited by the robot in the participant.

User study and controlled experiment presented discrepancies in terms of trust towards the robot and emotions elicited by the robot in the users. This finding represents evidence that user experience methodologies need to be integrated in human robot interaction.

Finally, the proposed design framework and design guidelines consider user mental model and calibrate the design of the robot through emotional engagement factors promoting natural social human interactions according to users 'needs.

Keywords
Human Robot Interaction, Social Robotics, Robot Companion, User Experience, Emotional Engagement, Older Adults

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Terms and Abbreviations

HRI	Human Robot Interaction
UX	User Experience

Key Concepts

Human Robot Interaction: the science dedicated to understanding human behaviour and attitudes towards robots in regard to technological features, with the aim to enable and facilitate efficient and acceptable interactions between humans and robots, in a manner that emotional and social users 'needs are met, and human values are respected. (Dautenhahn 2013).

Social Robots: "social robots are designed to interact with people in a natural interpersonal manner and achieve positive outcomes". (Breazeal, Takanishi & Kobayashi 2008).

Robot Companion: conversational social robot that accompanies its owner over a life long period, provides companionship rather than just assistance. (Buindo & Wendemuth 2017, p. 3.).

Anthropomorphism: the word derives from Greek. Anthropos relates to man, and morphe relates to form/structure. It is the predisposition to attribute human characteristics to "inanimate objects, animals and others to help us rationalise their actions." (Duffy 2013).

User Experience: "the totality of the effect or effects felt by a user as a result of interaction with, and the usage context of, a system, device, or product, including the influence of usability, usefulness, and emotional impact during interaction and savouring memory after interaction". (Hartson & Pyla 2012, p. 5.).

Emotional Engagement: "The feeling users construct through their emotions and cognitive development in terms of values, trust, freedom and ownership". (Dirin & al. 2017).

Older Adults: a respectful term suggested by the International Longevity Center and used as standard term in several journals. The term is used to avoid ageism and any form of prejudice when referring to elderly or seniors. (Avers, Brown, Chui, Wong & Lusardi 2011).

1 Introduction

In Finland, as in many other European countries, social robots are expected to increase and have an important role in older adults´ everyday life. Studies show that older adults prefer to age in place continuing with their independent living at home. To support this trend is important to address the challenges social robots present. According to research, social human robot interaction and integration of user needs represent some of the future challenges in social robots for older adults and social robots in general (Robotics in Care Services: A Finnish Roadmap 2017).

The introduction of social robots in human environments results challenging due to the complexity of the interactions between humans and social robots in comparison to other technologies. Human Robot Interaction (HRI) is the field that studies interactions between humans and robots and continues to grow and develop. Studies focusing on human centered approach in HRI are relatively new and rare creating a gap in research (Lindblom & Andreasson 2016). Hence, HRI studies are needed to understand how people interact and respond to social robots bearing in mind that, the nature of social interactions is emotion based. Furthermore, the integration of a user experience in HRI has been overlooked regardless is necessary to better understand users´ needs, produce positive experiences in terms of interaction and to increase the opportunities of user acceptance in regards of social robots (Breazeal, Ostrowski, Singh & Park 2019; Alenljung, Andersson, Lindblom & Ziemke 2017).

Furthermore, recent studies demonstrated that social robot companions are perceived as helpful companions, support older adults promoting human-human interaction and social wellbeing (Breazeal, Ostrowski, Singh & Park 2019).

This experimental study aims to cover the gaps in research aforementioned, adopting a human cantered approach and integrating user experience in HRI. Additionally, this study explores emotional engagement factors involved in social human robot interactions. The outcome of this study aims to provide a design framework and guidelines for anthropomorphic social robot companions for Finnish older adults.

1.1 Objectives and Research Questions

According to Lindblom and Andreasson (2016), human-centered HRI has received less attention than the other approaches creating a gap in research. Additionally, according to Alenljung and colleagues (2017) user experience (UX) is rarely addressed in HRI research notwithstanding, positive user experience supports the adoption of social robots in the society.

Furthermore, among the challenges identified in the ROSE Project (Robots and wellbeing in Finland) social human robot interaction and integration of user needs represent some of the future challenges in social robots for older adults and social robots in general. (Robotics in Care Services: A Finnish Roadmap 2017).

The purpose of this study is to address the current gaps in research implementing a human centered approach with the integration of user experience in HRI.

Additionally, the author of this thesis researches the factors involved in emotional engagement between Finnish older adults and social anthropomorphic robots, the emotions experienced during the first interaction with an anthropomorphic social robot and whether the gender of the robot influences the emotions experienced. Additionally, the facet of trust is explored.

This study explores the research problem:

RQ: What are the emotional engagement factors in anthropomorphic social robots?

To gather data, the research problem is dived into three sub-questions that constitute the research questions:

- **RQ1: What emotions older adults experience when they engage in a conversation with an anthropomorphic social robot?**

- **RQ2: How these emotions change when the gender of the anthropomorphic social robot changes?**

- **RQ3: How trust affects engagement in a conversation with an anthropomorphic social robot?**

The questions are answered through theory and qualitative research.

1.2 Significance of the study

In consideration of the thesis objectives, this study would be significant as contribution to academic knowledge addressing the current gaps in research.

Additionally, this study can provide the first steps towards understanding emotional engagement factors in social human interaction of Finnish Older Adults with anthropomorphic social robots.

The outcome of this study is to provide a design framework and guidelines, specifically for anthropomorphic social robot companions designed for Finnish older adults. As stated by Buindo and Wendemuth (2017), the design of social robot companions should be capable to support users´ individual needs which vary over the time. Hence, the design framework and guidelines aspire to calibrate the design of the social robot and the human experience through emotional engagement factors.

This knowledge constitutes the first steps to design social robot companions specifically for Finnish older adults and potentially informative future avenues of research about emotional engagement factors in social robotics given the novelty of the study.

1.3 Scope

This research-oriented study does not discuss or explore the system (robot) and its technological impact. The study concentrates on the human center robot interaction of Finnish older adults with an anthropomorphic social robot.

1.4 Thesis Structure

The structure of the thesis is presented as follows:

Chapter 2 presents the theoretical framework of this thesis. Existing research and theories related to HRI, social robots, human perception of social robots, social robots for older adults, related work and robot companion are examined. Additionally, theory about user experience is presented and expanding the topic on the relevance user experience in human robot interaction, user studies methods. The chapter is finalized, presenting theory about basic emotions, emotional engagement, trust and trust in relation to speech and gender.

Chapter 3 examines the empirical section of the study including the research the methodologies to investigate the research problem, collect and measurements data.

Chapter 4 discusses the experiment design and implementation. It includes the system (robot) and ethical considerations.

Chapter 5 reports the findings of this study.

Chapter 6 constitutes the discussion of this thesis. In this chapter, the significance of the findings is interpreted and described as well as, new insights that emerged as a result of this study.

Chapter 7 concentrates on the conclusion of the study and recommendations for future research.

2 Related Research

Throughout this chapter the author of this thesis reviews existing research and theories supporting this study.
The chapter begins with an introduction to human robot interaction (HRI), to provide a brief understanding about the field, research approaches, factors influencing interactions between humans and robots as well as, methods of evaluation used for human studies in human robot interaction. Furthermore, the factors influencing interactions between humans and robots support and justify the interaction design of the experiment. Next, theory about social robotics is presented including how social robots can be built according design perspective, existing design frameworks for social robots, issues imposed by social interaction and design implications are discussed. Subsequently, a section about human perception of social robots is discussed as well as, social robots for older adults and related work. This section is followed by general theory related to user experience and expands on the relevance user experience in human robot interaction, user studies methods as they support and justify the data collection methods used in this study. The chapter is concluded with theory about basic emotions, emotional engagement, trust and trust in relation to speech and gender. Theory necessary to answer the interrogative questions of the study and to measure the results of the experiment.

2.1 Human Robot Interaction

Human Robot Interaction (HRI) is a new field of studies which is inspired by theory and models used in Human Computer Interaction (HCI). This new field of research can be defined as: the science dedicated to understanding human behaviour and attitudes towards robots in regard to technological features, with the objective to enable and facilitate efficient and acceptable interactions, between humans and robots, in a manner that emotional and social users´ needs are met and human values are respected. (Dautenhahn 2013)

HRI research is categorized into three different approaches related to social interaction with robots: robot-centered HRI, robot cognition-centered HRI, and human-centered HRI.

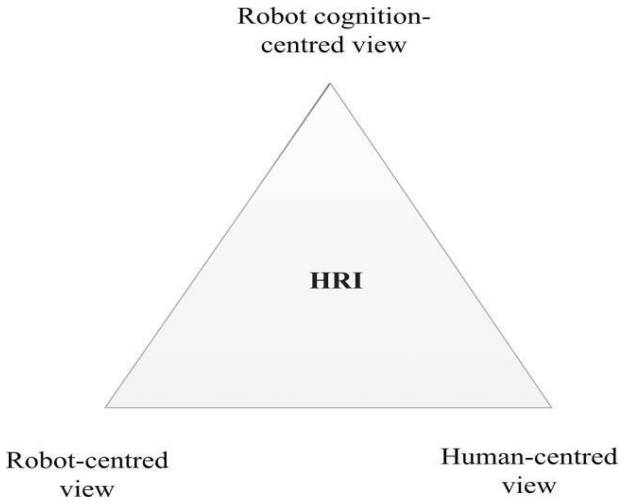


Figure 1. Conceptual space of approaches for social interaction in HRI research (Dautenhahn 2007)

The approaches for social interaction illustrated in figure 1, can be briefly stated as (1) Robot -Centered HRI: the robot is seen as an autonomous entity with own needs, emotions, motivations and the human should identify and respond to the robots´ needs ; (2) Robot-Cognition - Centered HRI: views the robot as an intelligent system, the robot makes decisions on its own and solves problems; and (3) Human- Centered HRI, assumes the human perspective. This approach takes into consideration issues related to design of robot behaviour as well as, involves acceptability and believability, humans' expectations, attitudes towards, and perceptions of robots. (Dautenhahn, 2007; Alenljung & al. 2017). Human-centered HRI has received less attention than the other approaches. (Lindblom & Andreasson 2016).

The foundation of HRI is "the problem of understanding and designing the interaction between humans and robots".(Goodrich & Schultz 2007).

Interaction concerns the communication between human and robot as well as, the "process of a human and a robot working together to accomplish a goal".(Goodrich & Schultz 2007). Hence, designers need to understand and analyse the type of interaction required between a human and the robot. Namely, a designer needs to break down the design problem considering the factors influencing the interaction and system requirements additionally, the interaction between human and robot may take different forms and can be conditioned by several factors as represented in the table below (Goodrich & Schultz 2007).

Factor Influencing Interaction	Factor Classification
Physical Proximity	*Proximate interaction - Remote Interaction*
Group Structure	*Individual - Group - Team*
Task Nature	*Task Oriented - Social Oriented*
Task Structure	**Task Oriented:** *competitive – mixed motive – creative* **Social Oriented:** *collaborative, Planning, Social.*
Duration (interaction)	*Short – Medium - Long Term*
Motivation (interaction)	*Spontaneous - Forced (assisted task)*
Information Exchange	*Limited media exchange - Wide Variety of Media Exchanged*
Autonomy Level	*Controlled - Autonomous*
Embodiment	*Abstract - Natural*

Table 1. Factors and Categories influencing Human Robot Interaction (Paiva 2015)

Table 1. provides a summary of the factors influencing human robot interaction (HRI) based on previous studies conducted by Paiva (2015) and Goodrich and Schultz (2007). This table represents the model used to design the interaction carried out in the experiment of this study (see Chapter 4).

Physical proximity refers to closeness and it can be separated into two categories as follows: (1) remote interaction, human and robot are separated spatially and/ or temporally as well as, not co-located. An example of remote interaction is Mars Rovers which is separated from earth in relation to space and time. (2) proximate interaction, human and a robot are in the same space. An example of proximate interaction is service robots. Service robots usually are located in the same space (room) with the human (Paiva 2015; Goodrich & Schultz 2007).

Group structure concerns the types of interactions that can be categorized as (1) individual interaction, human and robot interacting alone; (2) group interaction, the robot interacts with a group of humans and; (3) team interaction, the robot interacts with a team of humans and robot and humans will have a common goal. The common goal or objective represents the team aspect of the interaction (Paiva 2015).

Task nature indicates the nature of the interaction that can be (1) social oriented, this interaction include social elements and refers to human and robot interacting through dialogue, social behaviours, common understanding, emotions, cognitive processes etc. (2) task oriented , the interaction is performance oriented, the objective of the interaction is a

task that needs to be performed together between robot and human with the human proving the instructions to the robot (Paiva 2015).

Task Structure varies depending on the design requirements nevertheless task structure can be briefly listed as competitive task, collaborative task, creative task, planning task, mixed motive task and judgemental task (Paiva 2015).

Interactions duration refers to (1) short interaction when the interaction is very short to and no repeated over the time; (2) medium when the interaction is not neither long term and does not repeat over the time and; (3) long term interaction, indicates an interaction that occurs over a long period of time and continues over the time (Paiva 2015).

Information exchange addresses the process of giving and receiving information between human and robot. It can be represented by limited media exchange to wide variety of media exchange. Nevertheless, the method in which the information is exchanged represents the metric of interaction efficiency (Paiva 2015). The factors that influence interaction efficiency are time required to communicate instructions to the robot, time required for intent, cognitive or mental workload of an interaction, the degree of situation awareness produced by the interaction and shared understanding between a human and robot (Goodrich and Schultz, 2007). The medium and modality of the communication in the interaction can vary from visual displays, augmented reality, gestures including facial movements, speech and natural language, non-speech audio (alerts) physical interaction and haptics usually adopted for teleoperation or remote operations and social and assistive modalities (Paiva 2015; Goodrich & Schultz 2007).

Motivation refers to the reason behind the interaction between human and robot. Two motivation types are identified (1) forced, when human and the robot are required to interact as outcome of a task or situation in which they both are involved and; (2) spontaneous. when human and robot interact voluntarily by the social environment in which both are located (Paiva 2015).

Autonomy level refers to the human and robot degree of freedom during the interaction and to which extent of freedom the robot is allowed (Goodrich & Schultz 2007). To classify the level of autonomy Sheridan´s scale is used.

1. Computer offers no assistance; human does it all.
2. Computer offers a complete set of action alternatives.
3. Computer narrows the selection down to a few choices.
4. Computer suggests a single action.
5. Computer executes that action if human approves.
6. Computer allows the human limited time to veto before automatic execution.
7. Computer executes automatically then necessarily informs the human.
8. Computer informs human after automatic execution only if human asks.
9. Computer informs human after automatic execution only if it decides too.
10. Computer decides everything and acts autonomously, ignoring the human.

Figure 2. Sheridan Scale (Goodrich & Schultz 2007)

Briefly stated, Sheridan scale classifies the level of the autonomy of the robot using a scale from one to ten. One refers to a not autonomous robot and ten refers to the opposite, a robot completely autonomous.

A factor that strongly influences interactions is the embodiment of the robot, discussed in detail in subchapter 2.2.

After analysing the factors influencing interactions between human and robot, Bethel and Murphy (2010), in their literature review “study methods in human robot interaction”, present five primary methods of evaluation used for human studies in human robot. These methods can be briefly listed as (1) self-assessments, (2) interviews, (3) behavioural measures, (4) psychophysiology measures, and (5) task performance metrics.

The most common methods found remain self-assessment and behavioural measures. Each method has advantages and disadvantages nevertheless, the adoption of more than one method of evaluation or complementary approaches remains beneficial as “there is a need for strong experimental designs and methods of evaluation” (Bethel & Murphy 2010). Most of the evaluation methods and metrics are oriented towards engineering perspective and do not fully address the social interaction perspective or user experience (see chapter 2.3).

The studies for HRI usually are designed as experiments. Experimental design needs to be carefully plan, design (see chapter 4) therefore, the following factors should be considered: type of study, amount of groups used in the study, amount of participants required, type of evaluation methods, environment (lab, field etc.), type of robot, type of equipment

needed, study protocol, how to recruit participants and what type of assistance is needed in the study (Bethel & Murphy 2010).

Furthermore, to design suitable human robot interactions, it is essential to understand the role and context in which the robot will be used. Depending on the application area the robots might need to have social skills, these robots are referred to as social robots (Dautenhahn 2007).

2.2 Social Robots

Social robots are an emerging technology with social, emotive, and cognitive aspects notwithstanding, the terminology to define social robots is not consistent across the literature as the definition of social robot is related to the type interaction scenario.

For the purpose of this study, focused on human centered robot interaction, a social robot is defined as a robot that has social skills, designed to interact with people in a natural manner and to achieve positive outcomes (Breazeal, Takanishi & Kobayashi, 2008; Fong & al. 2003 in Alenljung & al. 2017).

Social Robots display social intelligence (Alenljung & al. 2017) in contrast with industrial robots that are tools used by humans to complete tasks (Cucco, Fisher, Dennis, Dixon, Webster, & al. 2017) constrained to operational performance mainly operating industrial settings (Alenljung & al. 2017).

Regarding design perspective social robots can be built according to two categories as follows:

Biologically inspired social robots relates to robots designed according to cognitive, behavioural, motivational theories. They are built to mirror social intelligence of living creatures and recreate what in the field of social robotics is defined as “life like” (Fong & al. 2003).

Functionally designed social robots concerns robots designed according to functional design principles to generate only certain effects and experiences with the user and built to display external social intelligence but they do not require to have an emotional internal model as biologically inspired robots (Fong & al. 2003).

The evaluation criteria and technique of the design will relate to the design perspective chosen thus, it will be different for every social robot representing a challenge in terms of comparison of social robots and common design frameworks**.**

In literature, several design frameworks examine interactions from technical perspective, emphasizing task, reward, nature and autonomy level of the robot or examining team / collaboration interactions. These frameworks provide basics for understanding how to structure human robot interactions, but they purely focus on the robot and its capabilities (Markowitz 2015)**.**

Breazeal (2004, in Markowitz, 2015,153) proposes a classification of social robots considering social model and complexity of interaction attributed to the robot as follows:
(1) socially evocative: robots that rely on anthropomorphization of technology an example are robot toys; (2) social interface: a robot designed to mimic social norms and normal speech to facilitate interaction with humans however, the robot is not driven by social norms; (3) social receptive: robots designed to learn social skills based on imitation, these robots learn during the interactions with humans; and (4) sociable, robots that proactively engage with humans, have social drivers, their goals and look for social contact.

Forlizzi and Battarbee, (2004, in Markowitz 2015), discussed another framework that undertakes a design-centered perspective providing broad guidelines to design social robots aimed to facilitate co-experience and social interaction.

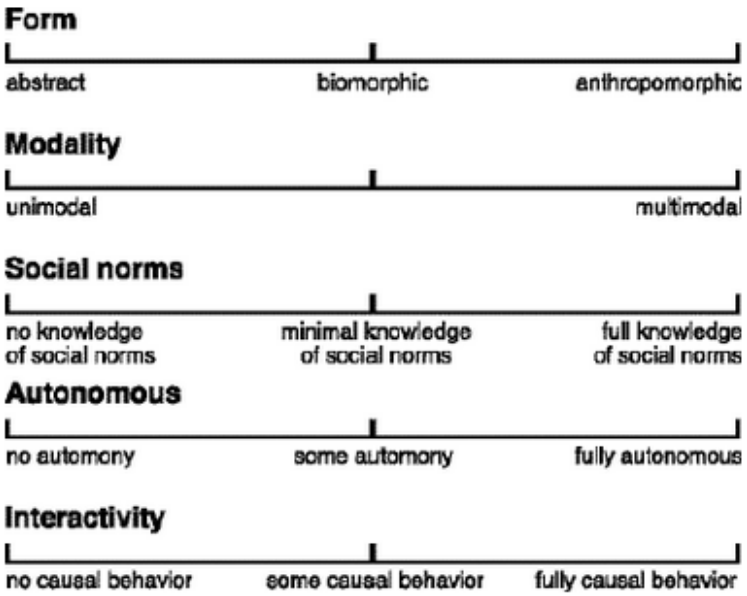


Figure 3. Design- Centered Framework for classifying social robots (Forlizzi & Battarbee 2004)

Form indicates materials and behavioural qualities of the robot and classifies the robot in abstract, biomorphic that mimics a lifelike object or, anthropomorphic that mimics a human like robot (Forlizzi & Battarbee 2004).

Modality refers to the communication channels involved ranging from unimodal and unimodal communication channels (Forlizzi & Battarbee 2004).

Social norms are intended as how the members of a group behave (culture, believes etc.). The robot can display no knowledge of social, minimal knowledge of social norms or complete knowledge of social norms (Forlizzi & Battarbee 2004).

Autonomy is defined as the capability of the robot to act with direct or without direct input from humans (Forlizzi & Battarbee 2004).

Interactivity indicates the response of the of robot to the interaction with the human. The robot can react and express its behaviour ranging from no casual manner to fully casual behaviour (Bartneck & Forlizzi 2004).

The framework presented in figure 3 exhibits similarities with the framework presented table 2 (subchapter 2.1) as it considers form (embodiment) of the robot, autonomy level and modality referred as information exchange in table 2. Nevertheless, this framework incorporates social norms (chapter 2.6) and interactivity producing a comprehensive framework to design robots adopting a human centric approach notwithstanding, this framework as Breazeal´s categorization of social robots, focusses only on the robot and its capabilities.

The features required for robots to be social are affective modalities, emotion-based interaction, behaviour coordination with human through verbal and non-verbal cues (Breazeal 2004) and ability to communicate affective state to others through internal model of emotion (Siciliano & Khatib 2008), pose design challenges (Fong & al. 2003).

The design challenges can be categorized as: (1) human oriented perception: the ability of the robot to interpret human behaviour, gestures, social cues and human feedback; (2) natural human – robot interaction: a regulated social interaction in which humans and robots communicate as equals for this the robot should have a credible behaviour, establish appropriate social expectations, follow social norms and conventions; (3) readable social cues: the robot is able to send to the human feedback about its internal state as in human – human interactions. In this way the human is able to interact intuitively and naturally with

the robot; and (4) in time performance: the robot performs in real time with dynamic stimulus of the user, interaction and environment demands (Fong & al. 2003).

Subsequently, substantial design considerations are represented by the morphology and embodiment of the social robot. Embodiment refers to the physical form in which the robot is represented. Every physical form or embodiment of the robot is aimed to afford a specific interaction pattern. A machine-like robot with its machine form affords the interaction pattern of carrying and moving objects instead a human like embodiment affords the interaction pattern of socializing. The physical form of the robot can vary from abstract to human-like (Fong & al. 2003).

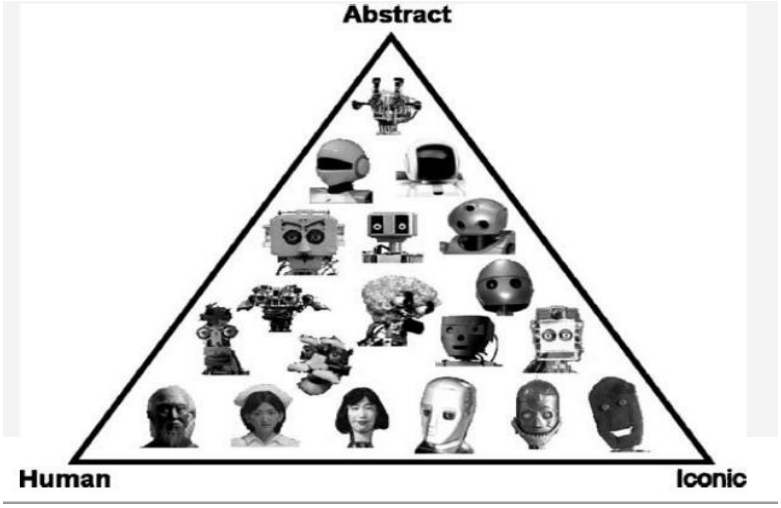


Figure 4**.** Anthropomorphism Design. The diagram illustrates robotics heads to transfer the idea of the various types of embodiment of a robot (Duffy 2003)

The extremities of the diagram illustrated above represent the main categorisations for robots adopting anthropomorphism. “Human” indicates an as-close-as-possible as a human like design aesthetics. “Iconic” relates to a design that uses a minimum set of features found in comics that result expressive. “Abstract” refers to minimal human-like relating to a mechanistic functional design of the robot (Duffy 2003).

The embodiment of the social robot “is grounded in relation between the system and its environment “(Fong & al. 2003) while the morphology is the component that supports the creation of social expectations, biases for interaction and might constrain interaction with the robot if chosen wrong.

The phenomenon referred as the uncanny valley, first mentioned by Masashiro Mori in 1970, declares that when a robot design, specially its face, looks closer to human, the hu-

man emotional response becomes positive and empathic translated in likability of the robot. Nevertheless, when the robot resembles closely to a human, the human response is rejection and the robot is seen as creepy and unsettling. This phenomenon applies, as well, to robotic motion in particular to movements and gestures of social robots. The Human will perceive the robot as pleasant as long as the movement and gestures are natural and fluid (Mathur & Reichling 2016).

Additionally, features such as emotion, body language, facial expressions speech and dialogue and personality of the robot represent further design considerations. These elements are briefly mentioned and not discussed as they are outside of the scope of this study.

2.2.1 Human Perception of Social Robots

In the future scenario of social robots becoming part of people's life and being introduced into daily activities, identifying interaction factors forming social experiences from human perspective is fundamental (Haring, Matsumoto & Watanabe 2013).

This type of research is still in its exploratory phase (Broadbent 2017). Studies that investigate the human disposition to interact with social robots (Fong & al. 2003) or studies analysing humans' reactions at behavioural level towards social robots are relatively rare (Lakatos, Gácsi, Konok & al. 2014) as well as, investigations on how and in which ways humans respond to interactions with robots. Therefore, additional research is necessary as engineers and designers need to understand more about human beings to design social robots (Broadbent 2017).

Research in human computer interaction suggests that humans prefer to interact with machines in the same way they interact with other humans (Breazeal, Takanishi & Kobayashi 2008) this is known as media equation phenomenon. The interactions of humans with social robots are just like real life interactions with other human beings, natural and social. This tendency has also been associated with the human "need to belong". Humans tend to form relationships with other social beings and this tendency is replicated in social robots (De Graaf 2016).

Studies have shown that humans feel closer to robots that display some human likeness than other type of robots. These findings reveal that physical embodiment of the robot has a strong effect in human robot relationships (Broadbent, 2017). Anthropomorphic embodiment facilitates the likelihood, human emotional attachment to artificial beings and brings to light the issue, studied in robotic ethics, of humans bonding with non-human objects

(De Graaf 2016). Furthermore, humans tend to assign qualities such as intelligence and sociability to social robots capable to interact with natural language and intentionality to social robots that present autonomy. These associations tend to rise humans´ expectations about social robots.

The knowledge humans hold in mind about social robots is referred as mental model. Mental models serve to understand the intentions, emotions and motivations of others. In the case of social robots are ideas and assumptions humans have in mind about social robots. Mental models effect people´s beliefs and preferences furthermore, impact the behaviour of humans when interacting with social robots and the way they communicate with them. Nevertheless, mental models develop and change with experience (De Graaf 2016) and factors such as prior experiences with robots influence the perception humans have about social robots (Haring, Matsumoto & Watanabe 2013) as well as, cultural settings and contexts (De Graaf 2016).

Khan and Germak (2018), investigated people's attitudes towards intelligent service robots, their findings revealed that people's attitudes towards robots were influenced by science fiction. Respondents preferred robots looking like a rounded shape machine with a serious personality (like R2-D2 of Star Wars) and verbal communication with voice similar to human voice.

Related studies have shown the possibility that human personality traits may influence preferences about robots´, appearance and behaviour. According to the study, introvert individuals tend to prefer machine like robots and extroverts' individuals tend to prefer humanoid robots (Haring, Matsumoto & Watanabe 2013).

Furthermore, humans prefer natural movements in social robots. Head nods and gaze of the robot impact positively social interactions with humans (Avrunin & Simmons 2014, in Broadbent, 2017). Humans apply social rules to interactions with social robots such as gender and ethnicity to categorize and form impressions about them.

A study revealed the application of the social norm of in-group bias. German participants felt closer to a social robot with German name and made it in Germany. The participants rated the robot as being warmer and having better designed when compared to a social robot with Turkish name and presented as developed in Turkey. (Eyssel & Kuchenbrandt 2012). Gender stereotypes that on average bias social perception of humans seem to be applied to robots as well. A robot with short hair and flat lips was perceived as less feminine than a similar robot with long hair and larger lips. The first robot was rate as suitable

for technical tasks given it less feminine appearance and the second robot was rated as more suitable for child caring tasks because its feminine nurturing appearance (Eyssel & Hegel 2012).

In terms of reciprocity, human perceptions of a care robot were positive when the robot asked for help and returned the help than when the robot behave differently (Lammer & al. 2014 in Broadbent, 2017). with regards to human affection towards robots, Social robots´ positive behaviour seems to increase it. In a study a robot played cards with humans. Its´ encouraging comments were rated higher than neutral comments when measuring friendship of social robots (Pereira & al. 2011 in Broadbent, 2017).

2.2.2 Social Robots for Older Adults and related work

Social robots developed for older adults can be categorized in two different types (1) assistive social robots designed to support basic activities such as eating, bathing, getting dressed and monitoring of those older adults that might need continuous attention maintaining them safe and (2) social robots' companions which main function is to enhance health and psychological wellbeing of older adults providing companionship. These robots can be as well programmed with assistive tasks. The form and embodiment of both categories varies based on usage context. (Broadens & Heerink 2009).

Figure 5. Assistive social robots; (a) Aibo, (b) Pearl, (c) Robocare with screen, (d) Robocare without screen, (e) Care-o-bot I, (f) Care-o-bot II, (g) Care-o-bot III, (h) Homie, (i) iCat, (j) Paroand, (k) Huggable (Broekens and Heerink 2009)

The majority of social robots designed for older adults have been developed to help them in daily activities in which they experience difficulties (cleaning, picking up objects, getting into and out of bed) and health problems. The table below, presents the related work on social robots for older adults (for design form of some of the robots refer to Figure 5).

Robot	Category	Study and Objective	Authors
Paro	Robotic Companion	Attitudes, emotions, and engagement with PARO and possible ways in which PARO could provide social and emotional support to healthy older adults.	Mcglynn, Kemple, Mitzner and King and Rogers.2017.
Huggable	Robotic Companion	Design and early results in recognizing affective touch-based interactions with older adults	Stiehl, W., Lieberman,J., Breazeal, C., Basel, Lalla, L., and Wolf, M. 2005.
Pearl	Nurse Robot	Test the robotic assistant designed to assist elderly people in navigating their daily activities in elderly care	Pollack, M., Brown, L., Colbry, D., Orosz, C., Peintner et al; 2004.
Icat	Generic companion	Social presence and acceptance of robot companion by older adults	Heerink, M., Kröse, .A., Evers, V., and Wielinga, B.J. 2008.
Hobbit	Assistive Robot	Explore day to day experiences of older adults with an assistive service robot in their homes.	Frennert, S., Eftring, H., and Östlund, B. 2017.
ElliQ	Social Companion	Keep older adults active and engaged	Intuition Robotics , 2019.

Table 2. Related Work on Social Robots for Older Adults proposed by the thesis author for this study

Paro is a robotic seal, initially designed as therapeutic robot to replace animal therapy in older adults with dementia. The research presented in this study was a first step understanding the effects of the robot in older adults. The variables tested in the study were attitudes, perceptions of ease of use and usefulness, active engagement, and emotions in 30 older adults with independent living life style. Attitudes were positive, but engagement type and frequency of interaction varied between participants (Mcglynn, Kemple, King and Rogers 2017).

Huggable is a robotic companion, shaped as teddy, able to share information with medical staff. The robot can collect tactile, auditive and video information and transmit it to the medical staff in time such tight squeeze or high pulse (Stiehl, Lieberman, Breazeal, Basel & al. 2005).

Pearl is a nurse robot with touch screen incorporated and a machine-like form. The robot was developed with primary functions such as reminders and guiding older adults through their environments. Pearl was tested in an elderly care facility nevertheless, the test concerned the system and software (Pollack, Brown, Colbry & al. 2004).

Icat is a generic companion toy like. In this study perceived enjoyment and intention to use were tested in a group of 30 participants. Both variables scored high in terms of social presence of Icat (Heenrik, Kröse, Evers & Wielinga 2008).

Hobbit is a robot that presents a form similar to Pearl. Hobbit was tested with 49 participants in controlled laboratory experiments in three European countries (Greece, Austria and Sweden). The robot can detect falls, emergencies, bring objects, offer reminders and entertainment. The user study demonstrated positive responses in terms of perceived usability, acceptance, and affordability (Frennert, Eftring & Östlund 2017).

ElliQ is the most advanced social companion with abstract form resembling an embodied social assistant. The design refers to an object that users can easily understand and trust generating a feeling of engagement and companionship. Some of ElliQ´s features are video call, message, reminders, daily routines, reading the news, answering to questions, playing music and videos, sharing photos, etc. ElliQ keeps older adults socially engaged and fight loneliness. (Intuition Robotics 2019).

2.2.3 Robots Companions

Robot companion is defined as a “conversational social robot that accompanies its owner over a life long period, provides companionship rather than just assistance” (Buindo & Wendemuth 2017, p. 3.).

The capabilities of robot companions apart from advanced social skills should take into account individuality, adaptability and trustworthiness. Additionally, robot companions should adapt to users´ individual needs that change over time as well as, should conform with user´s emotional state (Buindo & Wendemuth 2017).

Recent studies show that social robots can enhance the wellbeing of older adults. Social robots’ skills and capabilities such as real time eye contact, facial expressions, physical embodiment, natural interactions, and nonverbal cues help to increase people’s engagement and trust of social robots. Furthermore, these skills and capabilities create a sense of comfort and decrease feelings of being judged in older adults. Unlike digital assistants,

robot companions can recreate face to face interaction facilitating and supporting older adults' social and relational needs (Breazeal, Ostrowski, Singh & Park 2019).

A 6-week home study, of personal health coach for weight management, demonstrated that higher rates in engagement, trust and credibility, team work and emotional bond were achieved with a social companion robot over a computer version of the coach (Kidd & Breazeal 2008 in Breazeal, Ostrowski, Singh & al. 2019).

In a study, conducted in Portugal, related to increase the quality of life of older adults, was found that older adults prefer a robot with tasks such as meteorological information, reading the news, reading books, answering the door, playing cards and domino, keeping company in daily life, such as walking outside to the park and to the cinema. Older adults prefer robots as conversational partners with its owns ideas even if they are different than users´ ideas (Paiva, Alves-Oliveira, Correira, Petisca, & Maia 2016).

In another study carried out in Japan, older adults shopped with a robot as shopping assistant. It was found that most of the participants preferred conversational functions in the robot, humanlike features and companionship function (Imamura, Masahiro, Takayuki, Ishiguro, & Norihiro 2011)

A separate recent study, about in-home health companion, concluded that isolated older adults preferred to interact with a social robot over a computer-based human avatar (Sidner & al. 2018 in Breazeal, Ostrowski, Singh & al. 2019).

These studies indicate that social robot companions are considered as helpful companions capable to promote human-human interaction and support social engagement in older adults improving the quality of their lives (Breazeal, Ostrowski, Singh & Park 2019).

2.3 User Experience

The term user experience (UX) is associated with a wide variety of meanings (Forlizzi & Battarbee 2004), alternating from usability to hedonic or affective aspects of technology and seems to be difficult to unify it with a common meaning.

For the purpose of this study, UX is defined as an outcome of the interaction between user and technology that is dependable on user´s the emotional state as well as, the particular situation and context of use (Hartson & Pyla, 2012; Hassenzahl & Tractinsky, 2006).

Psychological and emotional needs of the user impact on how an interactive product is experienced and it is referred as hedonic quality of user experience. The user can find the product beautiful, trustworthy, satisfying, fun, enjoyable etc. These hedonic aspects emerge when the user interacts with the system and are usually portrayed as the emotional impact (Hartson & Pyla, 2012).

To positively impact the experience of the interaction it is necessary to design with the intended users and the usage context in mind to contribute to the quality of the users' designing for a high-quality interaction Hassenzahl and Tractinsky (2006) argue that a main objective of the UX field should be to contribute to the quality of human life.

The process used in UX to design user experiences is referred as iterative user experience design or UXD process. It consists of four key elements of UX activities than can be briefly described as (1) analyse refers to understand the users' and their needs; (2) design relates to conceptualize design ideas and the look and feel of the interaction between the user and the product or system; (3) implementation indicates the activity of prototyping products and interaction situations. Prototypes may vary from low fidelity to high fidelity prototypes and; (4) evaluation is concerned about the different methods and techniques used to investigate and analyse the design including to what extent the design meets the users' needs, requirements, and expectations. These activities are referred as whole UXD wheel and correspond to an iterative UX lifecycle that is accompanied by defined UX goals that complete the intended experience (Hartson & Pyla 2012).

2.3.1 Significance of user experience in HRI

A literature review identifying trends in HRI research related to the relevance of UX presented the following trends:

UX is related to positive experiences it is of fundamental importance to examine how certain aspects or specific features of the robot have positive impact on the users' experience (Alenljung & al. 2017).

UX is rarely addressed in HRI research most of the studies are concentrated on technical aspects of the robot. The interaction between human and the robot is rarely considered nevertheless, user centric studies are necessary to design social robots that produce positive experiences in terms of interaction and increase the opportunities of user acceptance (Alenljung & al. 2017).

UX evaluation is essential the evaluations conducted only after the interaction might bias user´s responses and might lead the user to reflect on the interaction experience only after the actual interaction (Alenljung & al. 2017).

Essential part of the ongoing interaction between humans and robots involve some emotional and interactive aspects related to the UX with a social robot such as engagement, safety, acceptance, cooperation, and likeability. These aspects have been widely investigated in HRI but still are poorly connected with UX studies (Khan & Germak, 2018).

UX in HRI is concerned about what type of impact the interaction quality has on the user experience, the type of emotions that arise and form in the user in a particular situation and context. In addition, UX is focused on positive emotions, such as joy and engagement as well as, the effects produced by positive emotions that are supposed to meet the user's needs and goal (Lindblom & Alenljung 2015; Hassenzahl & Tractinsky 2006).

UX in HRI contributes to develop positive experiences taking in consideration users, their needs, goals, expectations, emotional needs and emotional state when experiencing the interaction with the robot.

Considering that social robots pose significant challenges related to the design of interactions with humans as they are the antithesis of desktop workstations (Scheeff & al. 2000) and their nature is embodied (Breazeal, 2003) according to Alenljung and colleagues (2017), it is essential to identify and characterize what kind of feeling the social robot should arouse in the users. This aspect allows to consciously design and evaluate the robot and if the robot elicits the intended experience in the user.

Additionally, social robots designed to long term use, such as robot companions, will need to support a "wide range of users: different genders, different cultural and social backgrounds, different ages, etc." (Fong & al. 2003). Users' subjective feelings need to be analyzed, taking into account a broader perspective (Khan & Germak, 2018) as the user experience evoke feelings of different nature and intensity and has many facets and it is complex. (Anderson & al. 2010; Hartson & Pyla, 2012).

The design process should consider as well, the scenario in which a robot could operate, usage context (Khan & Germak, 2018) and include the whole cycle of central activities such as analysis, design, implementation, and evaluation "(Anderson & al. 2010; Hartson & Pyla, 2012). To meet these needs, Katz-Hass, defined six UCD questions to place the

user at the center of the design process, and to considered in the design process of social robotics or robotics technologies in general and to be used as guideline as follows:

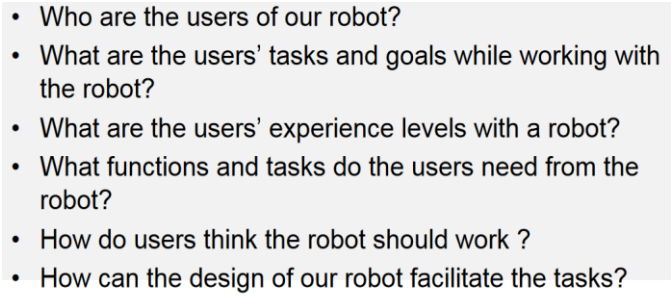


Figure 6**.** Users in HRI Design (Paiva 2015,b)

2.3.2 User Study Methods

User research does not necessarily assume an iterative process. The information from users is gathered by a variety of qualitative and quantitative methods (Interaction Design Foundation 2019).

The methods and techniques for evaluating UX in HRI have roots in HCI. The commonly used evaluation methodologies in HRI include, scenario-based evaluations, questionnaires, interviews and focus groups, self-reporting, Wizard of OZ (WOZ), expert evaluations, physiological measurements, subjective measurements, behavioural measurements (Vermeeren & al. 2010; Weiss & al. 2010).

For the purpose of this study, behavioral analysis and subjective measurements as evaluation methods are discussed.

Behavioral analysis is an observational method with "no specific methods reported in the literature" (Champney & Stanney, 2007) with roots in psychology and ethology. In UX assessment methods such as facial expression assessment has been largely used as behavioral analysis to recognize users´ nonverbal behaviour.

Facial expression assessments identify what an individual is feeling through the evaluation of basic emotions (e.g., happiness, surprise, fear, anger) observed in the individual face and aims to understand users' emotions that are aroused while interacting with a product or a system (Champney & Stanney, 2007; Vermeeren & al. 2010). Nevertheless, this type of observational measurement is limited to basic emotions and facial expressions that often modulated by cultural display rules (Champney & Stanney, 2007).

A more accessible methodology to measure emotions seems to be subjective measurements. Subjective measurement is a self-reporting methodology in which users assess their emotions through self-report. Studies shown that some subjective feeling measurements are able to assess mixed emotions. Nevertheless, also this methodology presents limitations as it relies on the ability of users to express their emotions which means that some individuals might not be able to verbalize their emotions properly (Champney & Stanney 2007).

Given the limitations of both methodologies presented, Vermeeren and colleagues (2010) suggest composite methods for UX evaluation that include hybrid techniques and user's own comments.

2.4 Theory of Basic Emotions

Emotions are complex, and their multifaceted nature prevents a comprehensive review of the topic. There is no empirical prove that a widely acceptable definition of emotion exists. In broad, emotion can be defined as: "a conscious mental reaction (such as anger or fear) subjectively experienced as a strong feeling usually directed toward a specific object and typically accompanied by physiological and behavioural changes in the body." (Merriam Webster Online Dictionary 2019).

Nevertheless, it is possible to state that emotions are basic to human beings and they are part of human communication.

Charles Darwin (in Ekman, 1975) identified that emotions are a product of evolution**,** they evolved through adaptation to our surroundings. In fact, emotions evolved to serve as communicative function for humans. Paul Ekman (1975), in his work about universal recognition of emotion from facial expression, suggested a list of six basic emotions "The Big Six". These emotions possible to recognize from the individual face were listed as: happiness, sadness, anger, fear, disgust, and surprise.

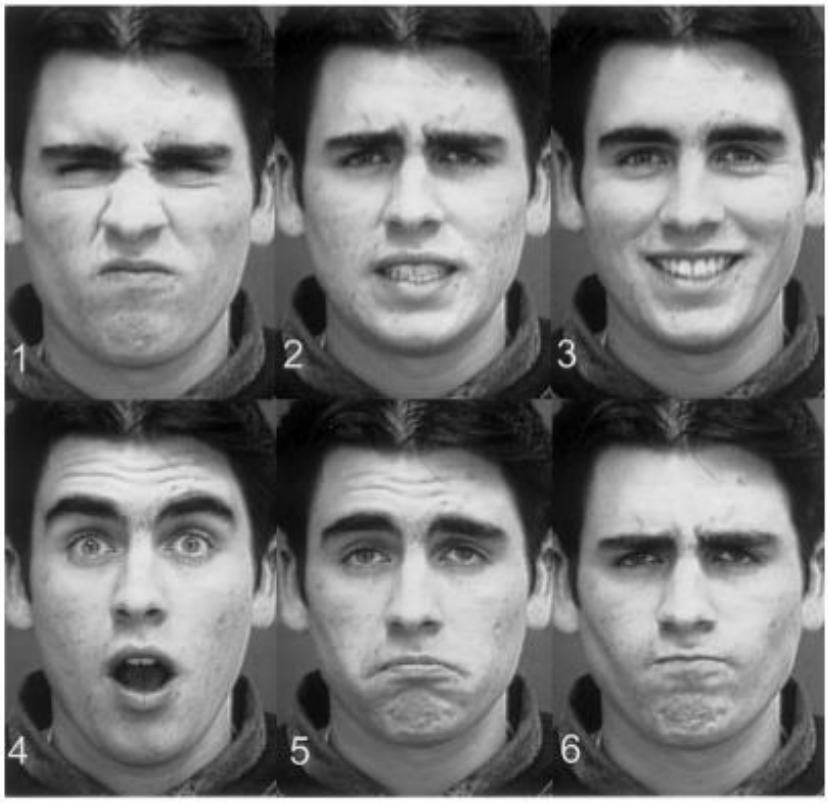


Figure 7. Facial Expressions of the six basic emotions; (1) disgust, (2) fear, (3) joy, (4) surprise, (5) sadness, (6) anger (Smith & Cohn 2001)

Ekman´s studies confirmed Darwin´s theory underlining that basic emotions are recognized and expressed in the same manner universally including facial expressions of discrete emotions (Ekman, 1975).

According to Parkinson (in Ekman & Cordaro, 2011), discrete emotions are socially constructed, they are ways that human react universally to shared stimuli and experiences as human beings.

In the analysis of neuro-cultural theory of emotions, Ekman, argues that culture influences emotion and constrains how emotions are felt and expressed. Furthermore, social contexts as well, influence facial expressions (Turner & Stets 2005; Ekman 1971).

2.5 Emotional Engagement

Emotional engagement has been studied by academics derived from engagement and commonly used in UX.

Emotional engagement is associated to positive affective outcomes and can be defined as the “feeling users construct through their emotions and cognitive development in terms of values, trust, freedom and ownership” (Dirin & al. 2017).

According to social psychology, feelings and actions are the basis to human experience and human attitudes. Attitudes are formed during cognitive processes and mainly from our own experiences thus, feelings and emotions are factors of engagement (Hogg & Vaughan 2010).

In the domain of Human Robot Interaction there are no studies related to emotional engagement nevertheless, modelling emotions in robots has been used to create affective modalities and to foster emotion-based interaction with humans (Breazeal 2004). Notwithstanding, engagement has been largely studied in human robot interaction.

Studies have found that trust is a factor of engagement (Cucco & al. 2017). Additionally, the value users attribute to the goal of being together with a robot and continue an interaction (Poggi 2007). Castellano and colleagues (2009), in their study determined that user engagement is the user´s willingness to interact and maintain the interaction with the robot. They evaluated the number of users´ looks at the robot and users´ tendency to smile regardless the robot´s behaviour. The study argues that engagement could include the expression of a positive feeling.

According to Peters (2016), expressive non-verbal behaviour has been previously linked to user engagement with a robot, namely eye gaze and smiles. Ultimately, Ghazali and colleagues (2018) in their research, highlighted that positive impressions are associated to engagement.

2.6 Trust

Extensive research and studies have been dedicated to human-automation trust which provides valuable insights in terms of trustworthiness.

In automation, the degree of trust is related to the decision to delegate to the robot and its performance (Lewandowsky, Tan & Mundy 2000). On the contrary, previous research suggests that trust in the case of social robots, especially in assistive or companion robots, is similar to human-human relationships (Ghazali & al. 2018) and that trust in robots as interaction partners becomes essential for developing human-robot relationships. (Ghazali & al. 2018; Chen & Terrence, 2009).

Schafer (2013), highlights that lack of trust in human-robot relationships leads to disuse of the technology and directly affects the willingness of user´s to accept a robot.

To date, in literature there is no common definition of trust. Nevertheless, common characteristics appear in the definition of trust such as: reliability, beliefs, predictability, safety, acceptance and expectations (Schaefer 2013; Tkalčič & al. 2016).

Trust can be defined as a “multidimensional psychological attitude involving cognitive, affective features and affective processes such as beliefs and expectations about “the trustee’s trustworthiness derived from experience and interactions with the trustee in situations involving uncertainty and risk” (Abbass, Scholz & Reid, 2018, p 137.)

Current academic literature predominantly focuses on different models to represent trust in HRI. Transparency and Feedback have been the principal measures to evaluate trust. Emotion theory has also been utilized to evaluate the robot ability to display or recognize universal emotions (Zecca & al. 2009). These measures and evaluations are referred to the system lacking human centric approach.

According to Hancock and colleagues (2011) trust in human-robot is multifaceted and dynamically therefore, influenced by environment(s), human(s) and robot(s). These factors constitute the Three Factor Model, a model that takes into consideration the human related aspects.

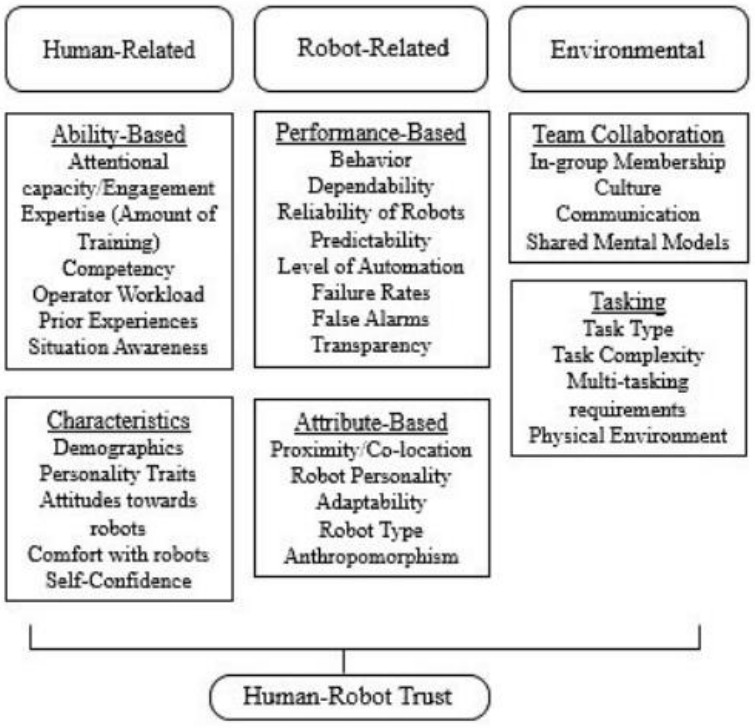


Figure 8. Three Factor Model of Human-Robot Trust (Hancook 2011 in Kessler, 2017)

The model illustrated in figure 8, has been used by researchers to create scenarios that test trust in robots through the manipulation of the constructs present in the model.

Schafer (2013), proposes affect based trust defined as the attitudinal state in which the human assigns motivations based on feelings to the behaviour of the robot.

Human emotive factors can be represented by comfort with the robot, confidence with robots, satisfaction related to the capabilities of the robot and attitudes towards robots. Furthermore, affect based trust is subject to changes after the initial stages of interaction between human and robot. (Schaefer 2013)

Ishak and Roberts (2015) suggest that is beneficial for researchers to implement a more holistic approach when trying to build trust between human and robot given the variety of factors influencing it.

2.6.1 Trust relation to voice and gender

Several studies have found that voice is vital in the perception of trust (Large & al. 2014). Nevertheless, only few studies have investigated how the robot's gender influences trust similarity between a robot's and a user (Verberne 2015).

A study observed that both gender and voice pitch influence listeners' perception. Additionally, in terms of perceived ability and trustworthiness, female and low-pitched voices ranked highest (Santana & al. 2015).

Another, study, identified that female listeners were unaffected by gender differences while male listeners were more prone to trust female voices (Dykema & al. 2012). Additionally, a research exploring trust through the use of natural dialogs in real world scenarios, concluded that trust is moderated by speaker´s vocal pitch and gender (Halimahtun, Khalid, Shiung & Nooralishahi 2016).

Similarity in terms of gender might increase the user's trust both men and women trust robots of the opposite gender more than robots of the same gender (Siegel & al. 2009), synthetic voices (male vs. female voices) and gender-specific names can be used to manipulate user perceptions of robot gender (Crowell, Scheutz, Villano & Schermerhornz 2009).

3 Research Methods

This chapter corresponds to the empirical section of this study. The empirical section describes and justifies the selected research methods and approach chosen by the author of this thesis to answer to the research questions:

RQ: What are the emotional engagement factors in anthropomorphic social robots?

- RQ1: What emotions older adults experience when they engage in a conversation with an anthropomorphic social robot?
- RQ2: How these emotions change when the gender of the anthropomorphic social robot changes?
- RQ3: How trust affects engagement in a conversation with an anthropomorphic social robot?

3.1 Qualitative Research

According to Tracey (2013), qualitative methods are useful for achieving diverse research goals. It is an umbrella term used to gain insights, collect, analyse and interpret data. Qualitative researchers´ task is to report the observations collected by constructing explanations for the readers.

Qualitative data collection methods vary using unstructured or semi-structured techniques. Some common methods include focus groups (group discussions), individual interviews, and participation or observations. The sample size is typically small, and respondents are selected to fulfil a given quota. Qualitative research is useful for understanding issues that arise from particular contexts (Tracey 2013).

For the purpose of this study, qualitative research, appears to be the most suitable methodology.

3.2 Wizard of Oz

Wizard of OZ (WoZ) is a qualitative research technique utilized in user experience as well as in human robot interaction.

In human robot interaction Woz involves a human interacting with a robot that is secretly operated by an operator, a wizard, usually without the awareness of the human interacting with the robot (Riek, 2012).

This technique is used to gain insights and first validation of how to program robots and design their behaviour. Furthermore, allows researchers to gather large amount of data about human preferences, use patterners, interactions, behaviours as well as, enables researchers to modify on the fly the robot responses depending on the setup (Höysniemi & al. 2004 in Lazar, Feng, & Hochheiser 2017).

According to previous studies and literature review, this research methodology has been found and used in 72.2% of the papers (n = 39 papers reviewed), using natural language processing as a component controlled by a Wizard. For example, the robot is controlled by an operator to appropriately respond to things the user said to it (Riek 2012).

Additionally, the following methodology is suggested for scenario construction as it reflects users´ behavior hypothesis and designer's beliefs about users´ actions within the scenario.

Component	Hypothesis
Robot Behavior	What the robot will ?
	How the robot will behave?
User Behavior	Who is the user ?
	What the user will say?
	How the user might behave?
Wizard Behavior	In case of error, what the wizard will do?

Table3. Behavior Hypothesis WOZ proposed for this study adapted from Riek 2012

In 79.6% of the papers reviews (n = 43 papers reviewed) authors specified their hypotheses for user behavior during the interaction. For example, the study of Pleo Robot, carried out by Kim and colleagues in 2009, tests three behavioral hypotheses for users interacting with the robot in terms of their affective vocalizations (Riek 2012).

3.3 Data Collection

In this qualitative study, data is collected through user study, observational methods and post survey including subjects self-reporting in open questions.

The user study represents the integration of UX methodologies in HRI. The user study is utilized to understand who the users are allowing the author of this thesis to gain general insights about Finnish older adults. Furthermore, the data collected supports the conversational topics selected for the script used in the experiment.

Observation is used to gather data related to users´ emotions during the conversation with the robot and insights of emotional engagement.

The post survey collects data related to post interaction and factors such as emotions, trust, engagement and influence of robot gender in emotions felt by the participants, trust towards the robot and chances in perception related to social robots.

3.4 Measurement

In this study a composite methodology is applied as measurement. This methodology allows to determine the emotional states the subjects experience during the interaction with the robot furthermore, enables to evaluate emotional engagement, engagement overall and if the felt emotions and subjects´ perception about the robot change after the interaction.

The observational scheme proposed in this study refers to the “Interactive Behaviour Codification System (Amara, Pardo, Diaz and Angulo,2013) and it is adapted to this study according theory and empirical design.

Data Collection Method	Interaction Stage	General Categories	Sub – Category	Specific Categories
Observational Methodology	During	Emotions		Happiness, sadness, anger, fear, disgust, and surprise.
		Non-verbal communication	Body Language	Leaning away, closeness, face touching, crossing arms, rise eyebrows, none
		Gaze		Directed gaze, maintained gaze or none
		Facial expressions		Smile, laugh, frown, inexpressive

Table 4. Proposed Observational Scheme adapted from Amara, Pardo, Diaz and Angulo (2013)

During the interaction the following questions are asked to participants:

(1) what are some small things that make your day better?

(2) What is the best way a person can spend time?
(3) What do you hope never changes?
These questions are used to determine emotional engagement through trust.

The question: Would you talk to me again? Is used to determine satisfaction as factor of trust and engagement (see chapter 2.6) as well as positive user experience as outcome of the interaction.

To examine individual experiences after the interaction, a post survey (appendix 5) with five-point Likert scale, nominal scale and open-ended questions, was used.

4 Design and Implementation

This chapter describes the design of the study and how it was implemented. Experimental design (see subchapter 2.1) is a common methodology used in human robot interaction. This design methodology allows to have an experiment carried out in a controlled environment and define how many conditions can be tested.

4.1 Experiment

The experiment was designed to be conducted in a controlled environment, the media lab at Haaga-Helia University of Applied Sciences.

The experiment consisted of two parts. Part one consisted of a semi structured dialogue (scripted) between the robot and the participant. The Robot was operated by a human following Wizard of OZ technique (see subchapter 3.2). Participants were unaware that the robot was completely operated by a human. During the first part of the experiment, participants were asked to enter into a room, the media lab, meet the robot and have a conversation. The scenario of the social interaction was to simulate a first-time meeting and have a casual conversation with the robot. The interaction was designed as presented in the table below.

Factor Influencing Interaction	Factor Classification
Physical Proximity	*Proximate interaction*
Group Structure	*Individual*
Task Nature	*Social Oriented*
Task Structure	**Social Oriented:** *Social Interaction*
Duration (interaction)	*Short*
Motivation (interaction)	*Spontaneous*
Information Exchange	*Wide Variety of Media Exchanged*
Autonomy Level	*Controlled*
Embodiment	*Natural*

Table 5. Experiment interaction model based on Paiva (2015)

The experiment was designed based on proximate interaction, this indicates that the participant and the robot were in the same room face to face. The interaction was an individual

interaction therefore, each participant interacted alone with the robot as the purpose of this experiment was to evaluate individual experiences. The nature of the interaction was social, the task was to reproduce a social interaction similar to a first-time meeting a robot. Thus, the motivation of the interaction was designed as spontaneous and a wide variety of information was exchanged between the participant and the robot nevertheless, it was designed as short interaction with a time setup of 15 min. max. 20 min. The mean of information exchange was speech and natural language.

The robot displayed basic facial movements such as gaze and head rotation. The shared understanding between participant and robot was the use of Finnish language. The conversation topics were selected from the user study (see appendix 3). The autonomy of the robot was controlled following Wizard of Oz Technique (WOZ) and the embodiment used in this interaction was natural (see subchapter 4.4).

The second part of the experiment consisted of a post interaction survey where participants self-report their experiences (see subchapter 4.6).

4.2 Script

The script used in this experiment is found in appendix 3.

The purpose of the script is to have a guide for the robot´s operator to conduct the experiment as well as, represents the behaviour hypothesis (subchapter 3.2) used in this experiment. Furthermore, the flexible structure of the script allows a natural interaction and possibility to quickly modify the topics of conversation.

The script is divided into five sections as follows:
(1) introduction and greetings, 3 minutes;
(2) opener question and questions about robots to participant, 4 minutes;
(3) getting to know each other in which participant and robot talk about different topics, 6 minutes;
(4) small question depending on the type of interaction a space for small questions is given to the participant, 3 minutes;
(5) ending of the interaction and greetings, 3 minutes.

The conversation topics used in the script were selected from the user study results (appendix 4).

4.3 Conditions

To gain more insights and provide an answer to research question number two:

- RQ2: How these emotions change when the gender and voice of the anthropomorphic social robot changes?

Two conditions were implemented. Participants were divided into two groups as follows:

Group A, interaction with robot female version, female voice;
Group B, interaction with robot male version, male voice.

4.4 Subjects

The subjects of interest for this experiment are Finnish Older Adults within age range 67 – 75 years with independent lifestyles, Finns and Finnish speakers. Participants were recruited via online invitations and no prior experience with robots was required. The participation to the study was voluntary. Four participants (n=8) were male and four were female. Three participants (n=8) were Swedish speaking Finns.

4.5 System

The system refers to the robot used in this study. It is briefly described as the scope of this study is not to test the system or technological impact (see subchapter 1.3).

Furhat was developed by Furhat Robotics in Sweden and awarded by UNESCO Netexplo as Forum 2019**.** Emerging technologies and their contribution to society are awarded in this event (UNESCO Netexplo 2019). Furhat is described as a social intelligent robot with a human-like interface “designed to forge emotional bonds” (Furhat Robotics 2019).

The interface can be customized to create unique characters with their own personalities resembling a real human. For example, the robot can look like a man or a woman. Furhat can display complex expressions and gestures. These expressions are pre-built and can be further customized. Furhat´s voice, is directional audio via two Hi-Fi 2.5" speakers furthermore, the system supports high quality text-to-speech voices in over 30 languages. It is possible to record your own voice and have Furhat lip sync automatically. Eyes and ears are a high-fidelity camera and beamforming stereo microphones providing the robot situational awareness. Furhat dimensions are 410mm x 270mm x 220mm. (Furhat Robotics 2019).

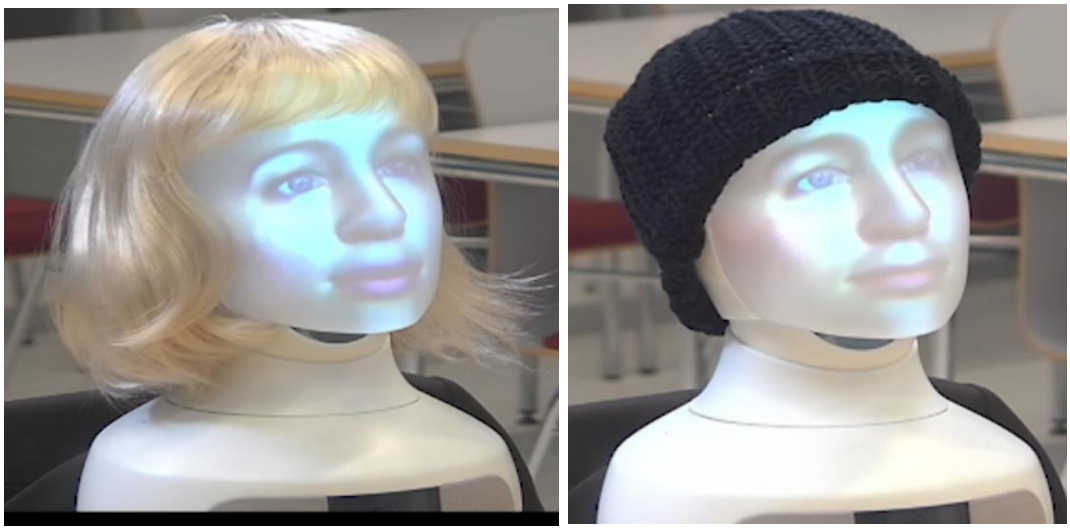


Figure 9. Furhat female and male version used in the experiment

4.6 Experiment Set-up

For purposes of readability, the author of this thesis refers to experimental set-up as “experiment set-up”. In this study, the setup is not the experiment and it is not tested.

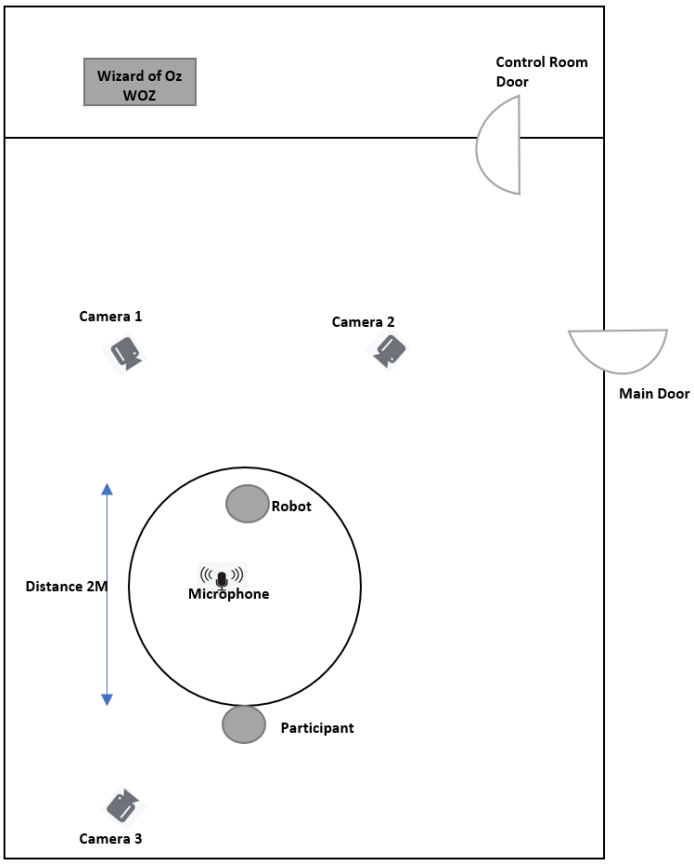


Figure 10. Experiment Set-up

Figure 10 refers to the space of the experiment setup at the media lab at Haaga-Helia University of Applied sciences.

The space was organized to simulate a face to face interaction (see subchapter 4.1). The rounded table was purposely organized with 2 meters of distance between the participant and the robot to recreate a social proxemic distance for a proximate interaction considering cultural aspects of proxemics in Finland.

4.7 Procedure

The procedure of this experiment followed the protocol suggested by Breazeal (2005) in HRI experiments. Additionally, followed the general guidelines of the Association for Computing Machinery (ACM) Code of Ethics.

Subjects were pre-instructed, offered assistance if required, the interaction allowed participants few minutes to familiarize with the robot nevertheless, for the purpose of this study the robot was not introduced in advance. The subjects were pre-instructed via email about video cameras and provided their written consent to record the interaction which was used for research purposes only.

After the interaction was completed the post interaction survey was administered to the subjects.

Stages	Procedure
Pre- interaction	• Participants were instructed via Email • Participants signed Consent Form
During interaction	• Participant interacts through conversation, natural dialogue, in Finnish with the robot.
Post-interaction	• Participant answered post-interaction questionnaire and self report in open ended questions • After the post-interaction questionnaire the participant was informed the robot was controlled by an operator.

Table 6. Experiment procedure adapted from Breazeal (2005) and ACM (2019)

4.8 Ethical Considerations

The experiment was intended to be transparent and ethically correct. The ability participants to give informed consent was not questionable furthermore, their participation to the experiment was voluntary

Participants were well informed and instructed before the experiment. The participants signed a consent form to give consent to be recorded only for research purposes. Therefore, no images of the experiment are presented in this study. A copy of the consent form was provided to each participant.

At the end of the experiment, participants were informed the robot was operated by a human in order to avoid false expectations about the technology and ensure the transparency of the experiment.

After the experiment was completed, participants received a final email explaining the full purpose of the research and clarifications about Wizard of OZ technique.

5 Results

This chapter reports the findings of this study based on the methodologies applied to gather information (see subchapter 3.3)

5.1 User Study

Following the integration of UX in HRI, a user study (appendix 4) was conducted to understand “who are the users, their preferences, perceptions and emotions towards the social robots in general and Furhat, before designing the experiment and script.

The respondents to this study were a different sample and they did not participate to the experiment.

The main findings of the user study were:

- Most of the respondents were females;
- The general opinion about social robots in general is positive;
- Users are willing to accept social robots with a 25% very willing to accept social robots;
- Users´ preference about the embodiment of a social robot is divided between neutral and human like;
- Gender is not important in a social robot although 1 participant preferred it to be the same gender (female);
- They perceived comfort in a scenario of talking to Furhat;
- The main emotion felt about Furhat was curiosity;
- The preferred topics of conversation were:
    - 29% would ask the robot to talk to them about what is new in the world, what is going on and what are they missing,
    - 23% would prefer small talks such as weather
    - 18% that would preferred to talk about books, music and art
    - 12% would talk about everything but not feelings.
- They would not trust the robot;
- Gender would not influence the perception of trust.

5.2 Observation Results

The data was analysed using the observational scheme (table 3, subchapter 3.4) and was extracted from the video recordings as well as, common and different features of participants reactions were examined.

Overall participants reacted positively to the interaction with Furhat. During the interaction participants showed positive emotions such as happiness and curiosity as well as, strong engagement. One participant showed a difference reacting negatively.

In order to show the reaction patterns the author of this thesis detailed the participants´ cases**.**

Subject	Gender	Age	Emotion	Body Language	Gaze	Facial Expression
A	Female	67	Happiness , surprise	Crossing arms, closeness	Direct and maintained gaze.	Smile
B	Female	68	Happiness	Crossing arms, closeness, face touching.	Direct and maintained gaze.	Smile, laugh
C	Female	70	Happiness , surprise	none	Direct and maintained gaze.	Smile
D	Male	74	Happiness , surprise	Crossing arms, closeness,	Direct and maintained gaze.	Smile, laugh
E	Male	74	Anger	Crossing arms, face touching,	none	Frown
F	Female	75	Happiness	None	Direct and maintained gaze.	Smile
G	Male	67	Happiness, surprise	None	Direct and maintained gaze.	Smile
F	Male	68	Happiness	None	Direct and maintained gaze.	Smile

Table 7. Participants detailed reaction patterns

It was observed that seven participants expressed happiness during the interaction with Furhat, they smiled and maintained eye contact.

Overall, participants talked to the robot about weather, books, music, hobbies as well as, answered to the questions: what are some small things that make your day better? What is the best way a person can spend time? what do you hope never changes?

Four participants expressed surprise when they first saw the robot. Among the participants who expressed surprise, one participant complimented the female version of the robot *“It is very nice to meet you. You have very nice hair!”* another participant complimented the male version by saying *“you have beautiful eyes”.*

During the interaction, one participant stated *“in my opinion you robots are very interesting” w*hile another participant said to the robot *“You are easier to talk with because you look more like a person. That’s nice!”* when comparing the robot with Nao.

Three participants asked to robot about its opinions on politics. Three participants asked the robot its age and where was it was from as well as, what he could do.

Four participants took the initiative in the conversation and did not wait the robot ask them for questions. Four participants shared detailed information about their hobbies, travels and family. One participant said to the robot *“summer is coming. If you would have legs, I could bring you with me to walk with me to the beach. We can go to sun bedding. Wouldn´t be nice?”*

Two participants asked the robot if it could speak English moreover, the Finnish Swedish participants asked the robot if it could speak Swedish. One tried to speak Swedish with it.

One participant taught the robot about mushrooms, another suggested books, another taught the robot about political parties and finally, a participant taught the robot to sing.

The participant who represented the exception interacted with the male version of the robot. When saw the robot at first, removed the robot´s hat but the hat was placed back. During the experiment the participant demonstrated annoyance. He did not maintain eye contact, looked around, touched the face, crossed his arms nevertheless, the participant maintained the interaction, answered to the questions and completed the experiment.

At the end of the interaction the robot asked to the participants “would you talk to me again?” overall participants said yes.

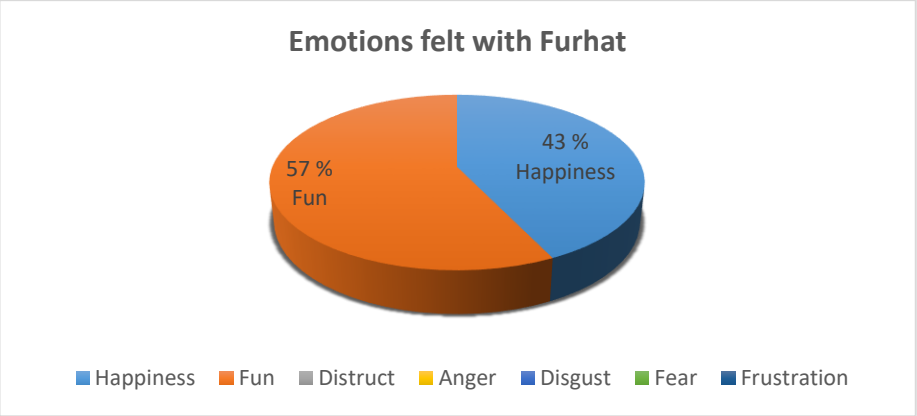
A participant replied “Yes, *it was a rewarding conversation and you learnt new things. It was a really nice experience.”* Another replied “We have exchanged lot of topics, we got to know well each other maybe we see again coz it would be nice to talk again” another said “Not immediately but when the development goes further to compare although it was a very natural conversation, more natural than what I expected” another said “ *I am guided by the fact I am talking to a machine but, the things I told to you are true but I presented different than in a conversation with a human however, we have reached what I would have reach with a human. Let´s meet again”*

5.3 Post -Survey Results

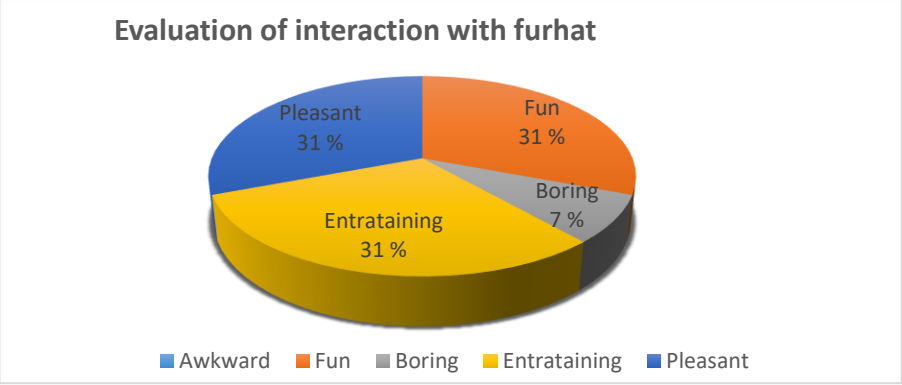
After the experiment, participants filled in a post survey (appendix 7). The main findings as follows:

- Overall, the participants have an independent lifestyle at home with their families;
- Participants have knowledge and can use up to date technologies;
- Participants mainly use smartphones, computers and tablets;
- Half of the participants did not have previous experience with robots;
- Participants who had experience with robots reported to have positive previous experiences with robots.

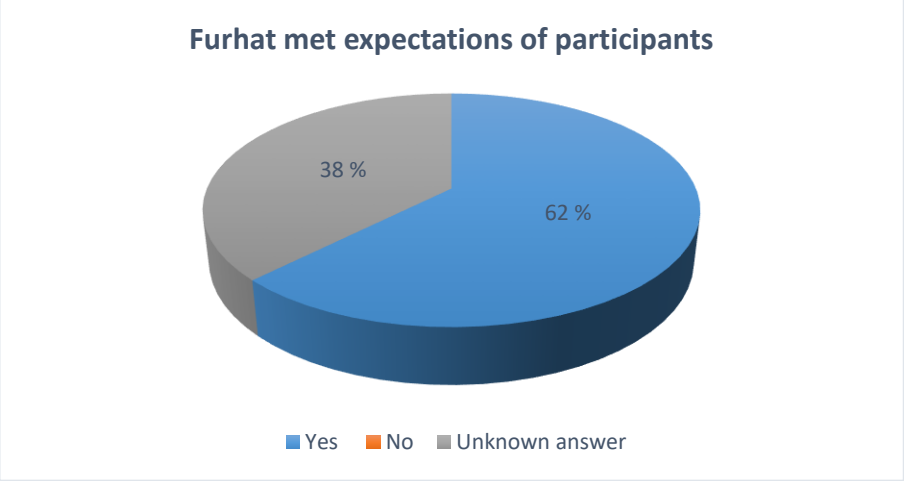
The emotions felt during the interaction can be summarized as fun followed by happiness



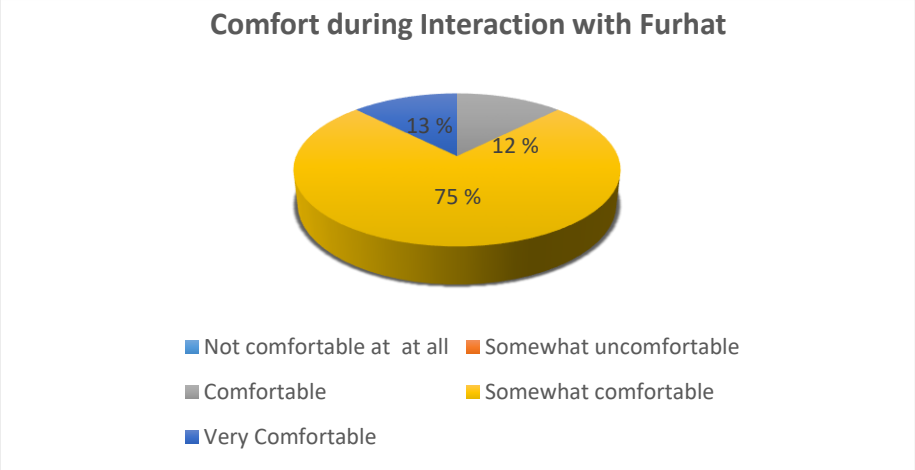
The interaction with furhat was rated as fun, entrataining and pleasant



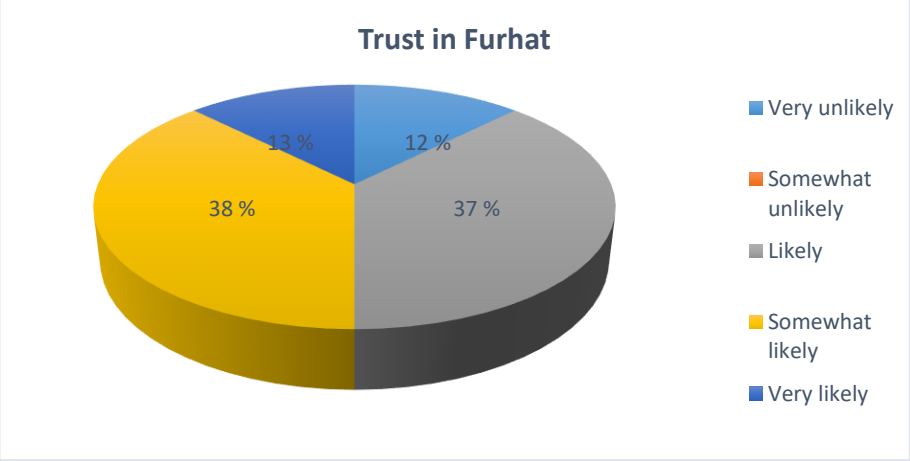
Furhat met most of the participant expectations



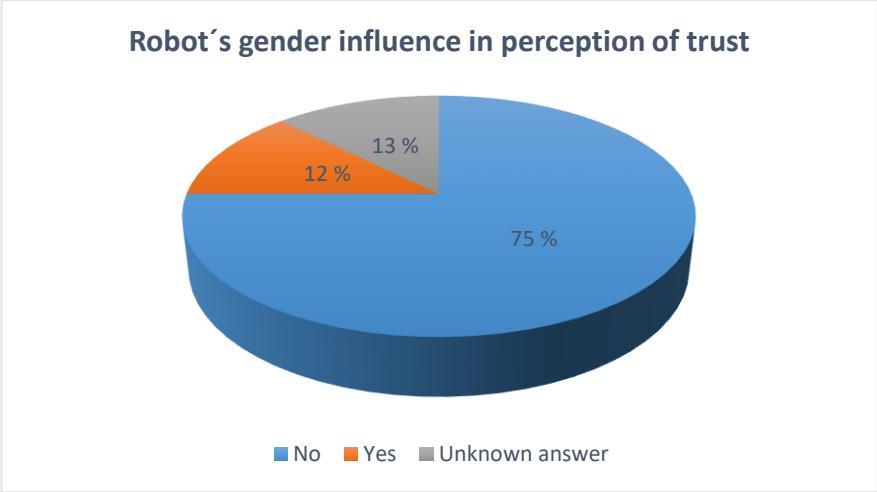
The interaction with Furhat was experienced as somewhat comfortable by most of the participants



Participants are very likely and somewhat likely to trust Furhat.



Overall, the gender of the robot does not influence the perception of trust



5.3.1 Open Code

The open answers of the survey are reported as follows:

Code (Factor)	Description	Subject words
Prior Experience	The type of experience the subject has with robots and what kind of robots	"Nao Robot" "I have only see them in Tv" "Hotel Service Robot seen in Tv" "Siri"
Expectations	Idea the subject has in mind about the look and behaviour of the robot.	"I had no expectations, but this robot is reasonable" "I did not expect I could have a conversation with this robot" "The robot exceeded my expectations, it was more clever than those I know" "I didn't actually have any expectations except interest"
Changes in perception	How the perception of the subject changed after the interaction with Furhat.	"My perception changed because the interaction felt nice even though I did not have previous experience with Robots" "My perception changed because the speech of the robot was very clear and natural. That was a positive surprise" "My perception changed because the robot was so "human" " "My perception changed because the robot did not provide stereotypical answers as I would have expected"
Satisfaction	The robot fulfilled subjects expectations or wishes related to the interaction.	"I´m satisfied because it was sympathetic, the questions and the answers were good" "I am satisfied because the robot knew surprisingly much and recognized for instance an artist I mentioned" "I am satisfied because the robot looked pleasant " "I am satisfied because we nicely talked about literature. To my question about the meaning of life it provided a wise answer" "I am satisfied because of the natural dialogue but it was a bit slow and lagging"
Comfort	The subjects feels at ease during the interaction, with the topics of the interaction and with the robot	"I was comfortable, the robot was friendly" "The speech of the robot was very clear and natural, it was comfortable" "The closing of the eyes made it more human and comfortable" "The answers lagged, it wasn´t that comfortable but it was not uncomfortable" "I talked a bit like to a child because the answers were slow"
Trust	The perception the subject has about the robot being safe, reliable, good, honest and that will not cause harm	"It was certainly trustworthy" "I believe the data it uses is from trustworthy sources" "When one programs the robot well, it works as it should/as desired" "The amount of information was huge. I don't think that a nordic company would put other than confirmed facts or would aim to manipulate" "I trusted it but trust can depend on the context we would have met"
Emotions	Emotions experienced and felt during the interaction	"It was fun, the robot had sense of humor and was friendly" "Fun but is related to that I learned " "Fun related to the experience of something new" "Fun and happiness .The communication was natural" "Fun and happy experience!"
Gender	Idea of the subject about how gender could / can influence perception of trust in robots	"As a woman I trust more other women and I don't suspect that they have preconceptions about me" "Both genders are trustworthy " "I did not pay attention to the gender" "Gender has no influence"

Table 8. Open Code

6 Discussion

The purpose of this chapter is to discuss the findings presented in the previous chapter as well as, answer to the research questions and examine limitations of the study. Additionally, discuss new insights that emerged as a result of this study.

6.1 Answers to the research questions

RQ: What are the emotional engagement factors in anthropomorphic social robots?

The findings of this study highlight that the factors of emotional engagement in anthropomorphic social robots refer to users´ affect and emotions during the interaction in terms of happiness, interest, curiosity and trust. These factors are reinforced by users´ positive experiences and positive emotions felt during the interaction with anthropomorphic robot.

Emotional engagement can be measured by willingness to maintain and continue the interaction with the robot, maintained and direct gaze, tendency of users to smile as stated in subchapter 2.5

Referring to the previous studies carried in human robot interaction, it can be stated that the construct of emotional engagement includes factors such as user´s willingness to interact, continue the interaction with a robot, not verbal behavior (looks, smiles) and positive feelings and emotions (Castellano et al; 2009; Peters 2016; Ghazali et al; 2018) that can change and being reinforced after the interaction.

The values of freedom and ownership (Dirin et al. 2017) were not found in this study as users´ interacted with robot for a short period of time regardless, it was found that trust contributes significantly to emotional engagement as stated previously by Dirin (2017) and Schefer (2013).

RQ1: What emotions older adults experience when they engage in a conversation with an anthropomorphic social robot?

The study reveals that fun is the main emotion experienced by most of the older adults nevertheless, in this study fun is related to happiness. Furthermore, happiness correlates to comfort during the interaction, satisfaction about the robot and conversation.

Conversation was rated as entertaining additionally, the positive emotion relates to the conversation topics, natural language, robot friendly personality and sympathetic answers. Additionally, pleasant embodiment of the robot contributed greatly to the overall positive experience.

Nonetheless, the delayed answers from the robot to the participants´ questions impacted the overall satisfaction another element that impacted satisfaction was the pitch of the female voice.

RQ2: How these emotions change when the gender of the anthropomorphic social robot changes?

The highlight of this study contradicts other studies carried out in other countries in which gender has a strong influence in the interactions between humans and robots or in which female are unaffected by gender differences while male is more prone to female voices (Dykema et al. 2012).

In this study there were no changes in emotions when gender of anthropomorphic social robot changed neither in gender influence on perception of trust.

RQ3: How trust affects engagement in a conversation with an anthropomorphic social robot?

The findings of this study confirm that trust is a factor of engagement (Cucco & al 2017) and has a great impact on emotional engagement.

Participants associated trust to trustworthy sources of information and reliability in Nordic producers therefore, trust is associated to safety and reliability as stated by Schaefer (2013) and Tkalčič and colleagues (2016).

Additionally, the dimension of affect based trust (Shaefer 2013) was found through human emotive factors such as comfort with the robot and satisfaction related to the capabilities of the robot as discussed in RQ2.

Furthermore, the positive attitudes participants had towards robots contributed further to strengthen the trust expressed by participants towards the robot.

6.2 New insights that emerged in the study

This study reveals that the older adults that participated to the experiment do not fall into the category of older adults that have been previously evaluated in other studies. This group of older adults have advanced technological knowledge, some have good knowledge artificial intelligence, some are interested to learn about robots, they have very active lifestyles, they have positive attitudes and interest towards social robots and they are willing to accept social robots.

The older adults that participated in the user study as well, have advanced technological knowledge, independent life styles, are willing to accept social robots.

These findings reveal that is necessary to consider different users and segmenting older adults. As older adults are not only a category with physical or health problems.

This study draws attention to the finding that robot´s gender has no influence in the emotions elicited by the robot in the participant or in the perception of trust towards the robot. Nevertheless, one case, in the user study and one case in the post survey, both females' participants, expressed that they would prefer a robot of the same gender.

This study highlights that differences between user study and experiment were found:

- In the user study, the main emotion about Furhat was curiosity while in the experiment it was fun followed by happiness.;
- In the user study it was identified that users would not trust the robot while in the experiment participants expressed trust.

These findings suggest that user study and experiments result a valid combination to evaluate findings. Additionally, underlines the significant differences between questionnaires without experiments and experiments followed by questionnaires. This demonstrates evidence on the relevance of user experience in human robot interaction evaluations.

This study reveals one case presenting a difference in terms of trust as factor of engagement. The participant to the experiment associated trust to the context in which a user might meet the robot opening a potential area of research. Context is not factor introduced in the Three Factor Model of Human-Robot Trust presented subcapter 2.6.

This study demonstrated that after the experiment half of the participants changed their perception about social robots. The chance of perception was related to the positive experience in terms of natural interaction and anthropomorphic embodiment of the robot. Suggesting evidence that positive user experience has an impact on acceptance of social robots and that anthropomorphic embodiment reinforces the acceptance of social robots. The perceptions that did not change were those of the users who had experience with robot who reported positive previous experiences.

6.3 Theoretical implications

The theory discussed in this study in relation to the design of social robots' results bounded to the robot and robot capabilities excluding user´s mental model. As examined in subsection 2.2.1, user mental model influences users´ believes, preferences and expectations about robots impacting the way humans interact and communicate with robots (De Graaf, M. 2016).

As this study is focused on a human centered approach, an experimental framework considering user mental model is proposed.

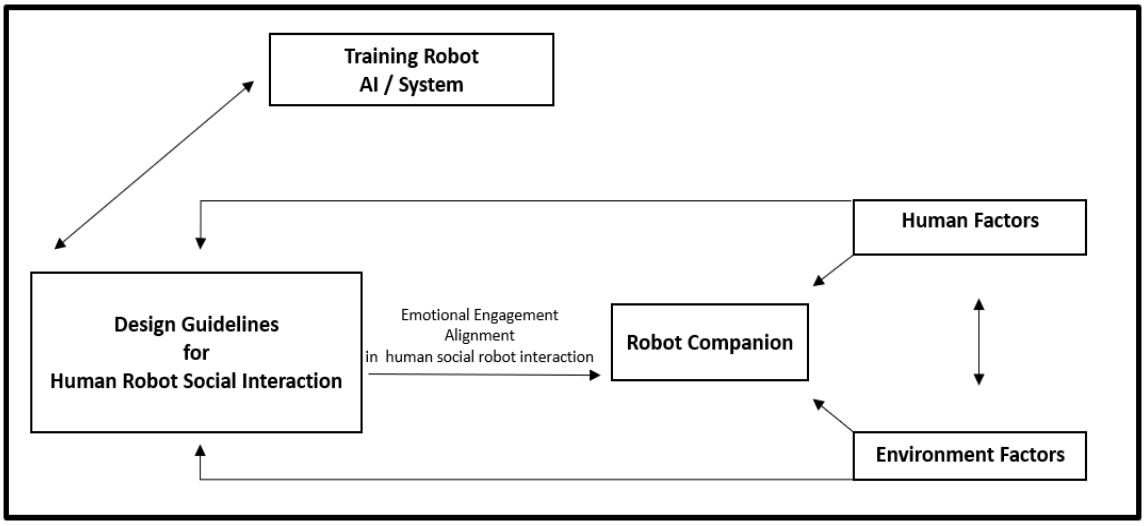


Figure 11. Proposed Design Framework elaborated by author of this thesis

The proposed framework is based on the theories of this study but considers user mental model and aims to be user centric.

The human factors in this framework are composed of user age, gender, personality and user mental. User mental model involves user prior experiences with robots, expectations about robots, attitudes towards robots, perceptions about robots, user preferences, needs

and emotions. Bearing in mind that user needs as well as, the emotions experienced by the user constantly change and are influenced by several factors including environmental factors.

Environmental factors in this framework are represented by context, task, physical environment and user requirements. Both human factors and environmental factors impact the design guidelines nevertheless, human factors in a human centric framework have priority. Additionally, these two factors (human and environment) constitute the inputs to the system (robot).

The design guidelines involve principles of individuality, trustworthiness, adaptability and flexibility but most importantly, calibrate the design of the robot companion through emotional engagement factors. Subsequently, they support the training of the system through emotional engagement. Specifically, the artificial intelligence is trained according to a personalized emotional engagement model with user specific data for training the model.

The system is briefly discussed as it is out of the scope of this study nevertheless, remains as suggestion for future research.

To conclude, this framework promotes a natural social human robot interaction responding to users ´needs.

6.4 Design Implications

Based on the findings, relevant theory and in reference to the proposed framework, a set of design guidelines was created by the author of this thesis.

The design guidelines are user centric and aim to provide guidance during the design of robot companions for Finnish older adults.

6.4.1 Design guidelines

An anthropomorphic robot companion designed for a Finnish older adult should be individual, trustworthy and adaptable.

Individual refers to the user having the possibility to customize the robot enabling the user to feel in control;

Adaptable refers to the capability of the robot to recognize user´s changing emotions and adapt as well as adapt to context. Furthermore, the robot should be able to interact with user through topics that interest the user and be able answer to the user questions;

Trustworthy refers that the robot should be reliable, safe and cause no harm;

Personality refers to the robot being friendly, having good sense of humour, eliciting joy and happiness in users as well as, being entraining and able to provide informed opinions. The robot by sharing opinions creates connection with the user;

Communication refers to the robot having natural voice with appropriate pitch and not synthetic, responses should not lag and the robot ability to communicate should be at least in Swedish and Finnish. Additionally, the robot should be able to communicate in other languages based on user preference. An emotional process to communication by the capability of recognize user´s emotion should be introduced in the robot´s system.

Movements refers to the robot´s natural movements, natural eye movements, expressive eyes, natural smile and head movements;

Embodiment refers to the physical form of the robot and should not fall into the “Uncanny Valley”;

Functions refers to the tasks the robot should perform. Social in terms of conversational, informative and entertaining as well as able to listen to users. Provide reminders and keep company to the user.

6.4.2 Design guidelines limitations

The proposed design guidelines present the following limitations:

- The study was limited to single interaction (user robot and not multiple users);
- Task is limited to social and the preferences emerge from user insights;
- The personality suggested for the robot emerges from the study according to users´ preferences;
- The embodiment in this study was by default anthropomorphic therefore, these guidelines are limited to anthropomorphic social robot companions.

- The form of the robot used in the study was a robotic head therefore, suggestions in terms of “body” of the robot related to height and size cannot be made nevertheless further studies should be conducted;
- Environment was not studied and was limited to experimental context (experiment set-up).

6.5 Limitations of the study

Due to the experimental nature of the study, there are some limitations. Among these there were limitations related to the number of participants and experimental setup. Reliability and validity of the results are also evaluated.

6.5.1 Amount of participants

The group for the user study was randomly selected and it is not entirely representative due the fact that most of the respondents were females and only one respondent was male.

The number of the experiment participants was limited as it is difficult to recruit a large number of older adults in a short period of time. This led to the inability to obtain statistically significant results that could have supported strong conclusions

6.5.2 Experiment set-up

To examine with accuracy whether the interaction has a positive effect and gather accurate data related to emotional engagement as well as trust, the set-up should be a natural environment such participants homes. Furthermore, the study should not be limited only to the first interaction but should examine long term, repeated, interactions.

6.6 Reliability and validity of the study

In subsection 2.3.2 the limitations of the methodologies were discussed.

Observational studies are limited therefore, was implemented a composite methodology (Champney & Stanney 2007) that involved experiment and post survey with open-ended questions as subjective measurement.

The observation utilized an observational scheme elaborated according to theory nevertheless, due to the experimental nature of the study and lack of quantitative research no strong final conclusions can be made nonetheless, preliminary conclusions to support future studies are presented.

7 Conclusion

This study considered gaps in research implementing a human centered approach through the integration of user experience in human robot interaction. Furthermore, factors involved in emotional engagement between Finnish older adults and social anthropomorphic robot, the emotions experienced during the interaction with the social robot, gender of the robot influence in the emotions experienced and the facet of trust were examined.

Based on the findings of this study, it was revealed that emotional engagement in anthropomorphic social robots refers to users´ affect and emotions in terms of happiness, interest, curiosity and trust. These factors are reinforced by positive experiences and emotions during the interaction with anthropomorphic robot.

The main emotion experienced during the interaction with the robot was fun related to happiness in terms of comfort and satisfaction with the interaction as well as, with the robot including pleasant robot embodiment. Trust has a strong impact on emotional engagement and users related it to trustworthy information and trustworthy Nordic source of information.

Additionally, the study demonstrates that gender of the robot does not influence the emotions experiences during the interaction and does not influence users´ perception of trust. This study demonstrated that after the experiment half of the participants changed their perception about social robots. Suggesting evidence that positive user experience has an impact on acceptance of social robots.

There were found differences between user study and experiment related to emotions felt for the robot and perception of trust. These findings suggest that user study and experiments result a valid combination to evaluate findings and demonstrate evidence on the relevance of user experience in human robot interaction evaluations. The subjects that participated to the experiment had advanced technological knowledge, positive attitudes and interest towards social robots and they are willing to accept social robots. Representing a group of older adults that has not been studied further yet.

According to these findings and theory a design framework was proposed and design guidelines for anthropomorphic social robots for Finnish older adults were defined.

7.1 Future Research Suggestions

Given the small size sample of participants further similar studies with larger sample to gather quantitative data are suggested.

Future studies related to expand and properly define the construct of emotional engagement in social robots are recommended.

Studies that examine long term repeated interactions in natural environments such as users´ homes would be beneficial to evaluate if the environment changes perceptions in terms of emotional engagement and trust.

Studies that investigate context as factor influencing trust in human robot interaction are Proposed.

Furthermore, to better define design guidelines further studies related to users´ preferences in terms of height and size of the robot would be beneficial as well as, users´ preferences related to level of autonomy of the robot and studies related to users´ preferences in terms of robots´ tasks should be considered.

Additionally, exploring frameworks to train the system according to personalized emotional engagement models with user specific data are advised as topic of future research.

Finally, user centric evaluation frameworks for observation in human robot interaction experiments should be explored and defined.

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Appendices

Appendix 1. Experiment Design Part 1 – Interaction

Factor Influencing Interaction	Factor Classification
Physical Proximity	**Proximate interaction:** Participant and robot are collocated face to face in a table, simulating a face to face conversation.
Group Structure	**Individual** Each participant interacts alone with the robot.
Task Nature	**Social Oriented** The task is to reproduce a social interaction similar to when you meet someone for the first time.
Task Structure	**Social Oriented** Conversation.
Duration of interaction	**Short** One interaction with duration of 15 min.
Motivation of the interaction	**Spontaneous** Participants are asked to engaged in a relaxed, friendly interaction with the robot.
Information Exchange	**Wide Variety of Media Exchanged** Information is exchanged between human and robot through speech and natural language, the robot displays basic facial movements, head rotation. Shared understanding between a human and robot is the use of Finnish Language. Topics of conversation vary however, sensitive topics such as politics are avoided due to ethical concerns.
Autonomy Level	**Controlled** The robot is controlled following Wizard of Oz Technique (WOZ).
Embodiment	**Natural** Furhat is an anthropomorphic robot head that utilizes facial animation

Appendix 2. Script Dialogue

Participant: Hi, Furhat. I am …

Robot: Nice to meet you…!

Participant: Nice to meet you, Furhat!

Robot What brought you here?

Participant: I was invited to participate in this study / I was curious /I have nothing to do

Robot: Have you talked to a Robot before?

Participant: Yes / No

Robot: What did you expected me to look like?

Participant: Not human like.

Robot: talking to robots is not very common, right?
Participant: Not very common.

Robot: by the way do you like books Are you reading something that you would suggest me to read?
Participant: Yes / no open answer

Robot: continues conversation (topics: weather, holidays, places visited, food, tV shows, art, music)

Robot: What are some small things that make your day better?

Participant: open answer

Robot: What's the best way a person can spend their time?

Participant: open answer

Robot: What do you hope never changes?

Participant: open answer

Robot: Do you have any question for me?

Participant: open answer

Robot: Our time is over. Thank you for coming, it was nice talking to you!

Participant: open answer

Robot: By the way, would you talk to me again?

Participant: open answer

Appendix 3. User Study

Perceptions about Social Robots

A social robot is a robot that should have capabilities to talk, form social relationships and understand the user. Examples of such robots are: care robots, cleaning robots in our homes, service desk robots at an airport or mall information desk, robots in a cafeteria or home robots as assistants that can read the news, reminds you of your appointments, make calls for you, talks to you or keeps you company.

Generally speaking, after reading the definition of a social robot, what view or opinion do you have about social robots? Choose one.

positive
negative
Undecided

How willing would you be to accept social robots? Choose one.

Very willing
Willing
Not willing

What type of physical shape would you prefer in the social robot? Choose one.

Abstract
Human like
Pet like

Would you give a gender to a Robot?

Yes -No

If yes, what gender would you give to the robot?

Male
Female
Why - type here your answer -

Perceptions about Furhat

What type of emotion brings in you this social robot?

Joy
Happiness
Anger
Fear
Disgust
Curiosity

How comfortable would you feel talking to this robot? Please, choose one.

Very comfortable
Fairly comfortable
Not comfortable

What would you talk to this social robot about? Please, tick as many boxes as you need.

I would do small talks about topics like news and weather.
I would talk about books, art, music.
I would talk about life and how things have changed in world.
I would talk about myself, about how I feel and about my problems.
I would ask the robot to talk to me about what is new in the world, what is going on, what am I missing.
I would talk about everything, but not feelings or emotions.
I would not talk at all to it
Other topics ..... Type here the topics you would like to talk

Would you trust this Robot?

Yes - No
Why – please type here your answer –

What would help you to trust this robot?

Please, type here your answer

Would you trust more this Robot if it would be male?

Yes -No
Why -Please, type here your answer

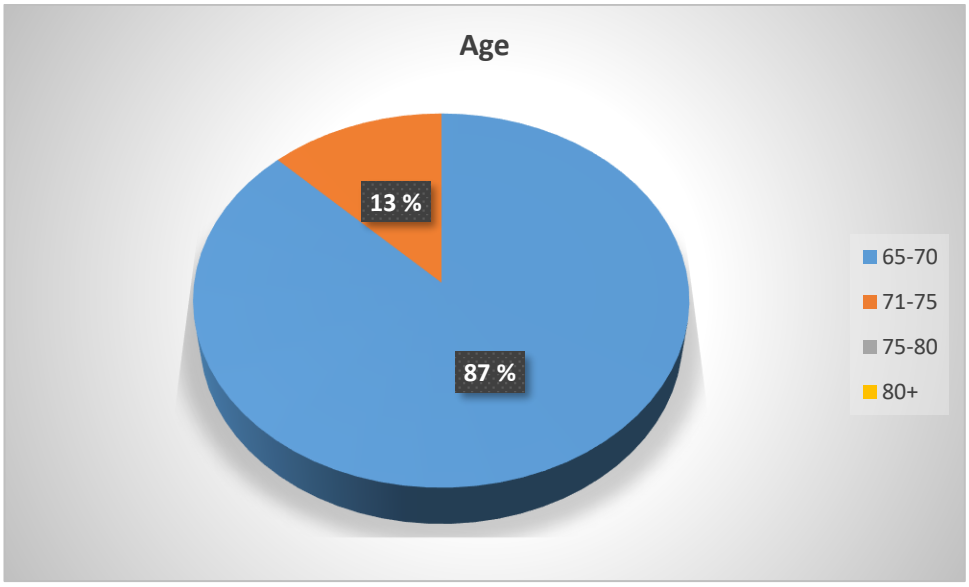
Would you trust more this Robot if it would be female?

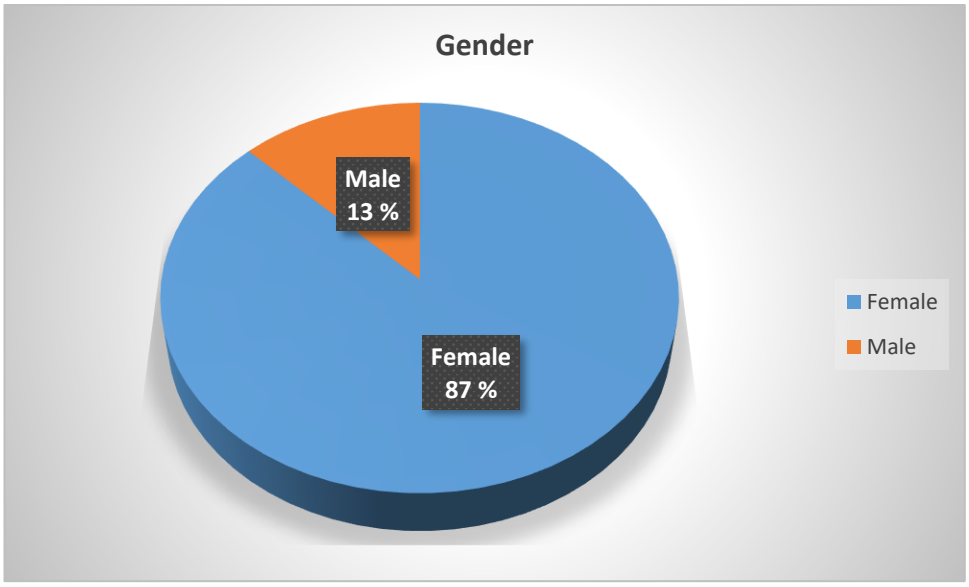
Yes -No
Why -Please, type here your answer

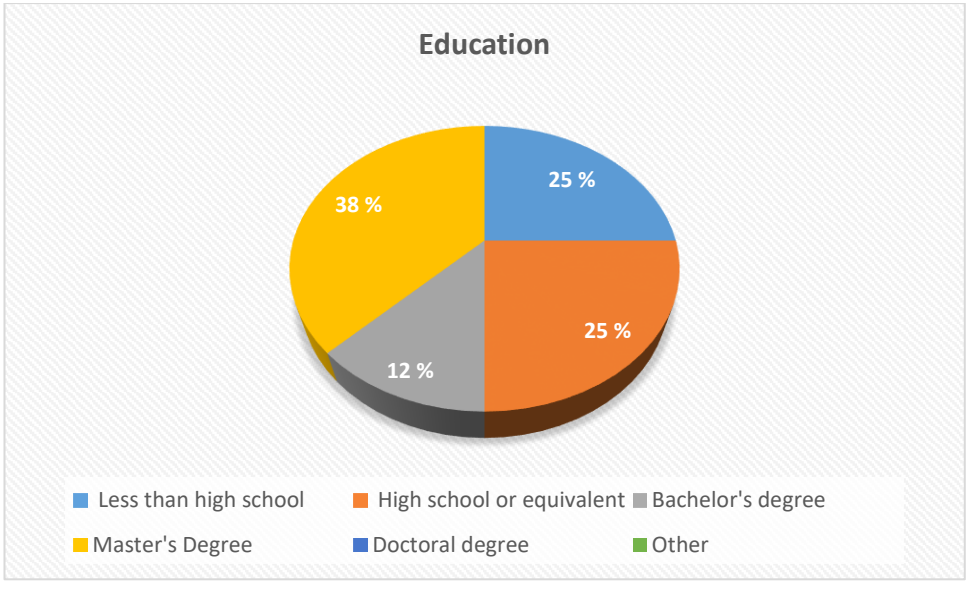
Open question

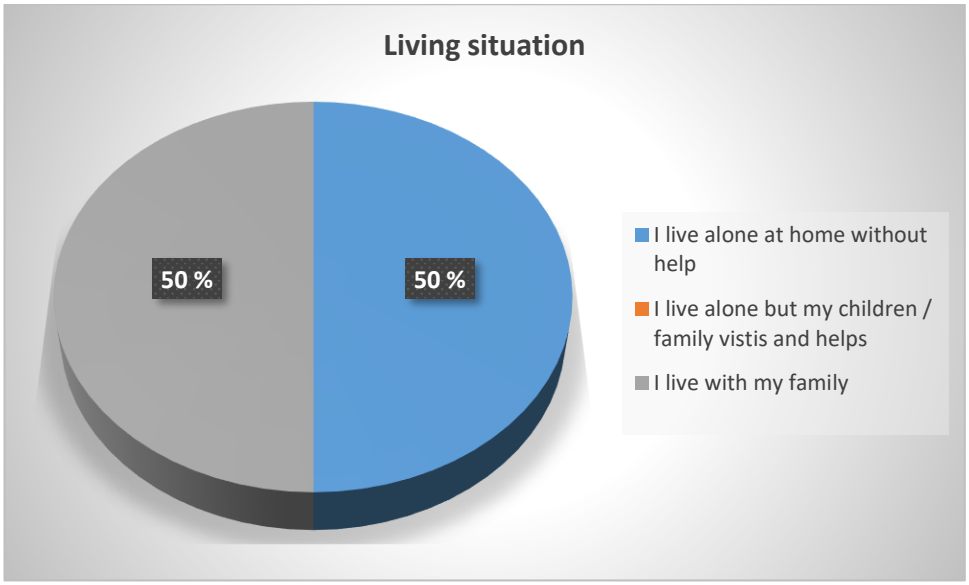
What is your own personal idea about social robots and how social robots can help the elderly in Finland?

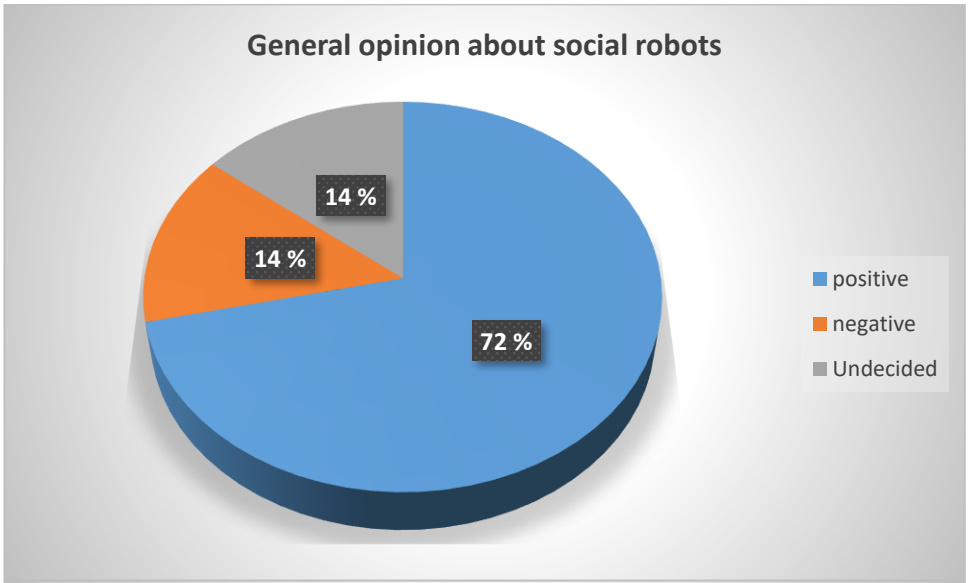
Appendix 4. User Study Results

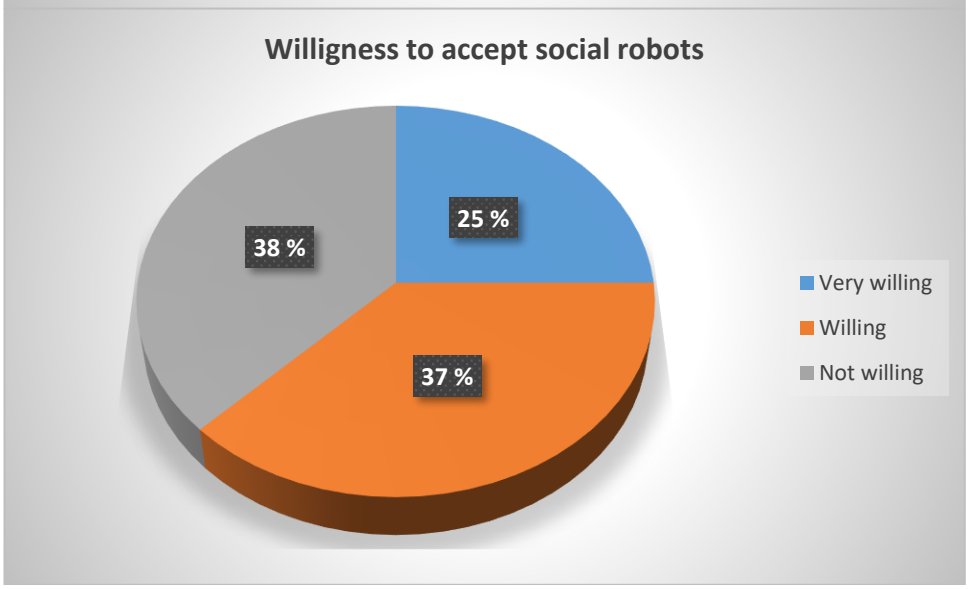


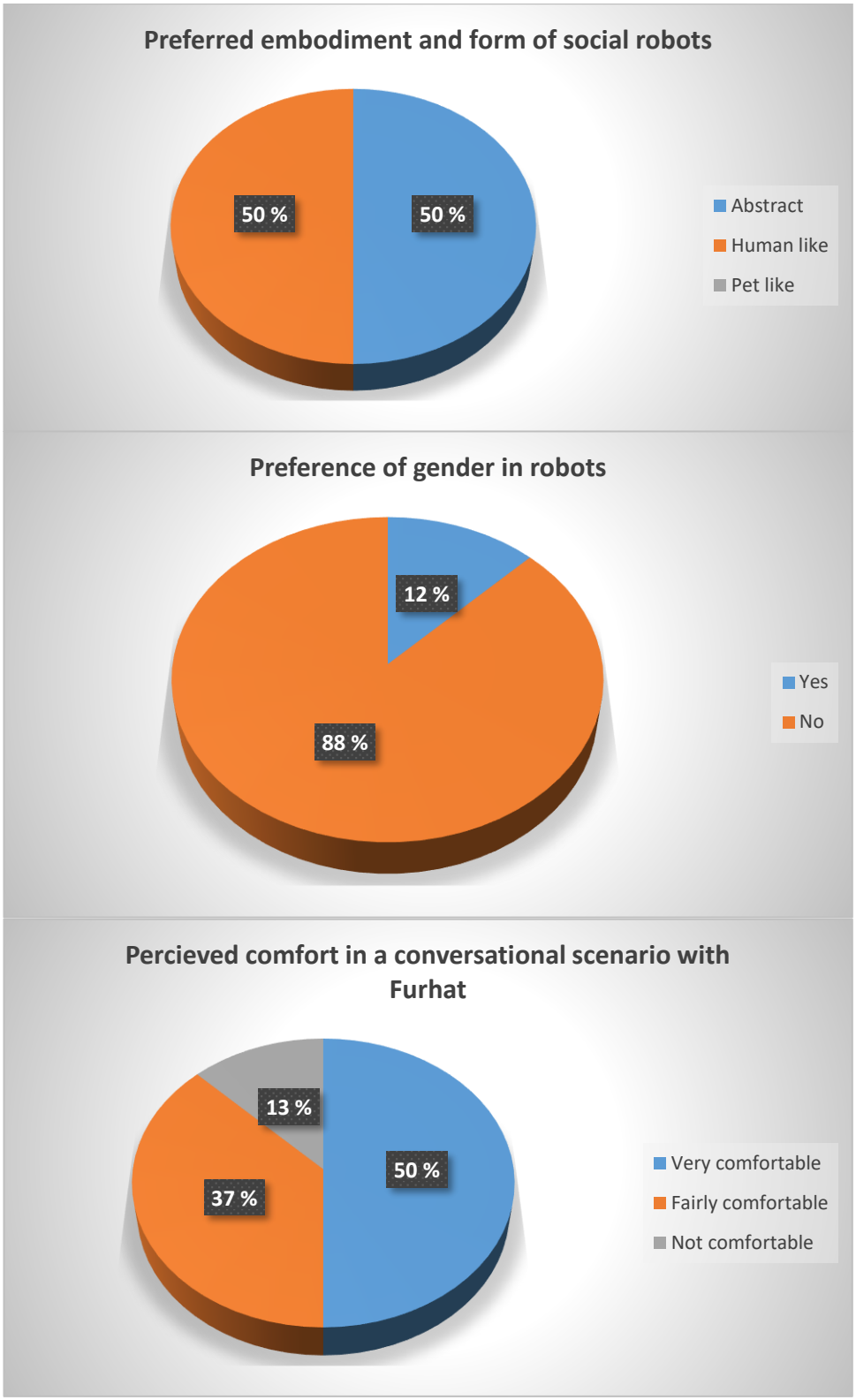


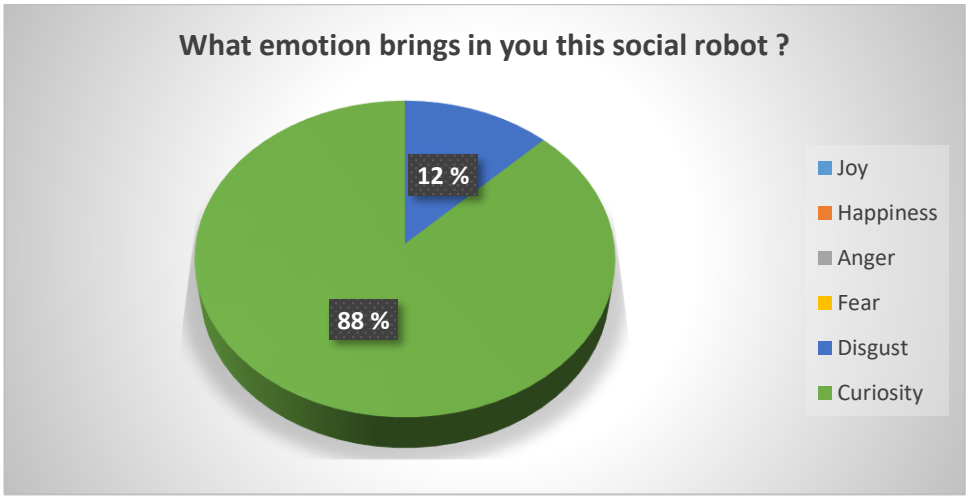


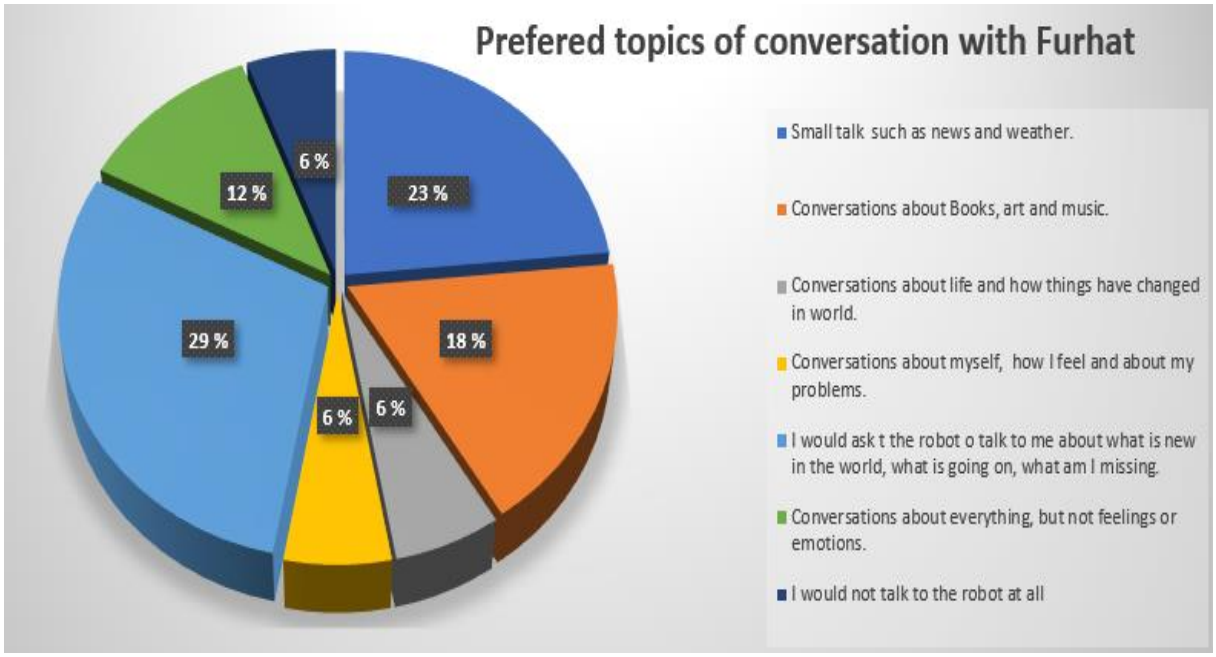

Living situation
50 %
50 %
I live alone at home without help
I live alone but my children / family vistis and helps
I live with my family

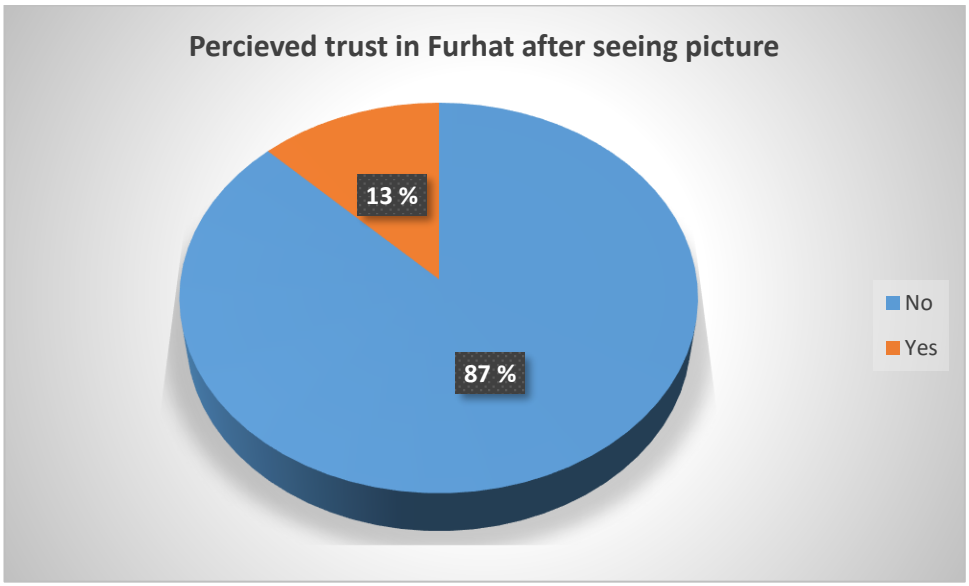

General opinion about social robots
14 %
14 %
72 %
positive
negative
Undecided

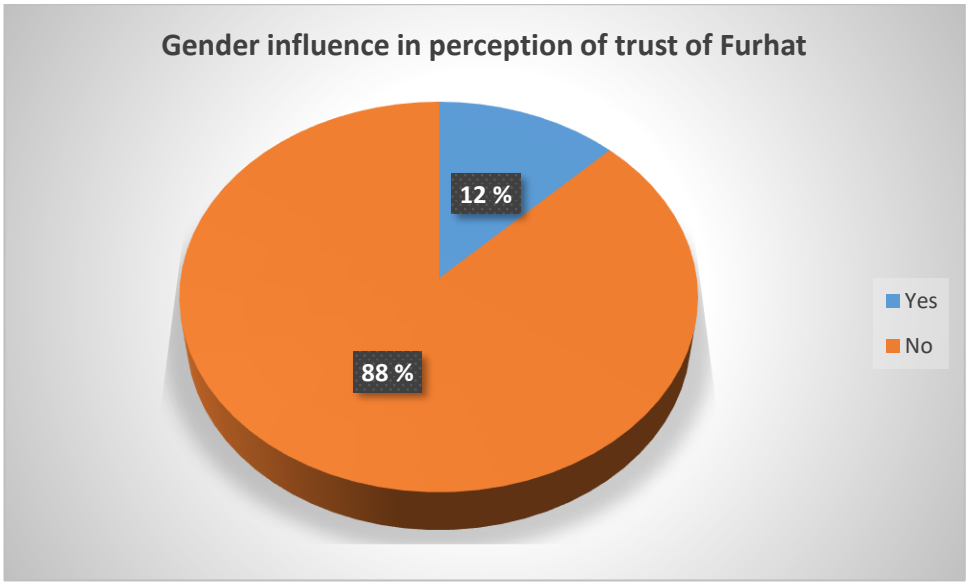

Willigness to accept social robots
25 %
38 %
37 %
Very willing
Willing
Not willing


Preferred embodiment and form of social robots
50 %
50 %
Abstract
Human like
Pet like
Preference of gender in robots
12 %
88 %
Yes
No
Percieved comfort in a conversational scenario with Furhat
13 %
50 %
37 %
Very comfortable
Fairly comfortable
Not comfortable


What emotion brings in you this social robot ?
12 %
88 %
Joy
Happiness
Anger
Fear
Disgust
Curiosity


Prefered topics of conversation with Furhat
6 %
12 %
23 %
29 %
18 %
6 %
6 %
Small talk such as news and weather.
Conversations about Books, art and music.
Conversations about life and how things have changed in world.
Conversations about myself, how I feel and about my problems.
I would ask t the robot o talk to me about what is new in the world, what is going on, what am I missing.
Conversations about everything, but not feelings or emotions.
I would not talk to the robot at all


Percieved trust in Furhat after seeing picture
13 %
87 %
No
Yes


Gender influence in perception of trust of Furhat
12 %
88 %
Yes
No

Appendix 5. Observational Scheme

Obsservational Scheme

General Category	Sub- Category	Specific Category	Results
		Happiness	
		Sadness	
		Anger	
Emotions		Fear	
		Disgust	
		Surprise	
		Leaning Away	
		Closeness	
Non- verbal communication	**Body language**	Face Touching	
		Crossing arms	
		Raise eyebrows	
		None	
		Direct gaze	
Gaze		Maintained gaze	
		none	
		Smile	
Facial Expressions		Laugh	
		Frown	
		Inexpressive	

Observations:

Appendix 6. Post Survey

Background Information

What is your gender?

☐ Male
☐ Female

What is your current living situation?

☐ I live alone at home without help
☐ I live alone but my family visits and helps
☐ I live with my family

What is the highest level of education you have completed?

☐ Less than high school
☐ High school or equivalent
☐ Bachelor's degree
☐ Master's Degree
☐ Doctoral degree
☐ Other

What technologies do you use, or do you know how to use? Tick as many boxes as needed

☐ Email
☐ Text Message
☐ Video Call
☐ Social Media
☐ Home Assistant (Alexa, Siri, Cortana, Echo)

What kind of devices do you use? Tick as many boxes as needed

☐ Computer
☐ Smartphone
☐ Tablet
☐ Smart watch
☐ Other

Previous Experience with Robots

Please, circle the number that best describes your answer

Do you have previous experience with robots? (1 Not at all experienced – 5 Very experienced)

1 2 3 4 5

If you have previous experience, how would you rate your previous experience? (1 Very negative – 5 Very positive)

1 2 3 4 5

If you have previous experience, what kind of experience do you have with robots? Please, write your answer

Interaction with Furhat

What emotions did you experience during the interaction with the robot? Tick as many boxes as needed

☐ Happiness
☐ Fun
☐ Distrust
☐ Anger
☐ Disgust
☐ Fear
☐ Frustration

How would you describe your interaction with this robot?

☐ Awkward

☐ Boring
☐ Fun
☐ Entertaining
☐ Pleasant

Please, circle the number that best describes your answer

After the interaction with this robot, how satisfied are you about the robot? (1 Very unsatisfied – 5 Very satisfied)

1 2 3 4 5

How comfortable did you feel talking to the robot? (1 Not comfortable at all – 5 Very Comfortable)

1 2 3 4 5

What were your expectations about the robot? Please, write your answer below

Do you think this robot met your expectations?
☐ Yes ☐ No

Why? Please, write your answer below

What did you like the least about the robot? Please, write your answer below

If you could change something about this robot, what would it be? Please, write your answer below

Could this robot meet your expectations as interaction gadget?
☐ Yes ☐ No

Have your opinion about robots changed after today´s interaction?
☐ Yes ☐ No

Why? Please, write your answer below

Trust

Please, circle the number that best describes your answer

Would you trust this robot? (1Very unlikely – 5 Very likely)
1 2 3 4 5

Why? Please, write your answer below

Does the robot´s gender influence your perception of trust?

☐ Yes ☐ No

Why? Please, write your answer below

What could help you to trust this robot? Please, write your answer below

Older Adults Challenges

In your opinion, what are the challenges older adults face? Tick as many boxes as needed**.**

☐ Isolation
☐ Social exclusion
☐ Depression
☐ Loneliness
☐ Lack of empathy

☐ Lack of social activities
☐ Difficulties keeping in touch with friends and family
☐ Difficulties understanding new technologies
☐ Difficulties keeping up with technological advancements
☐ Other

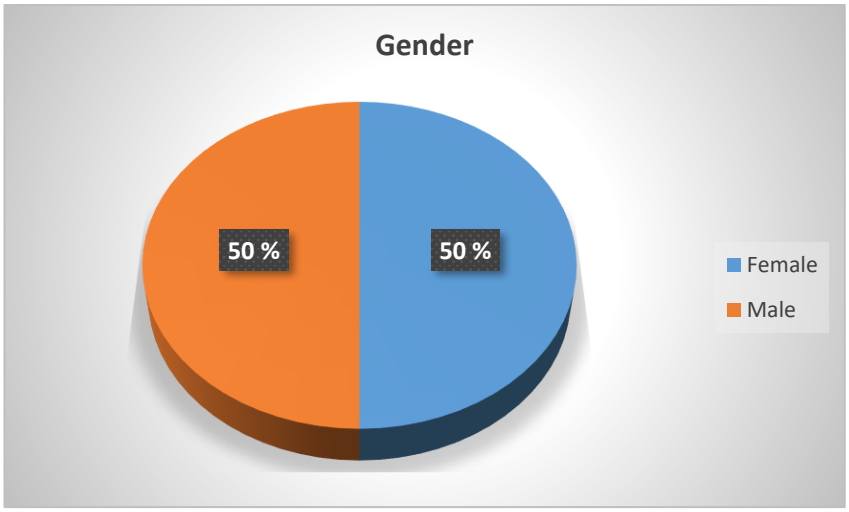
What is your opinion about social robots and how they can help older adults in Finland?

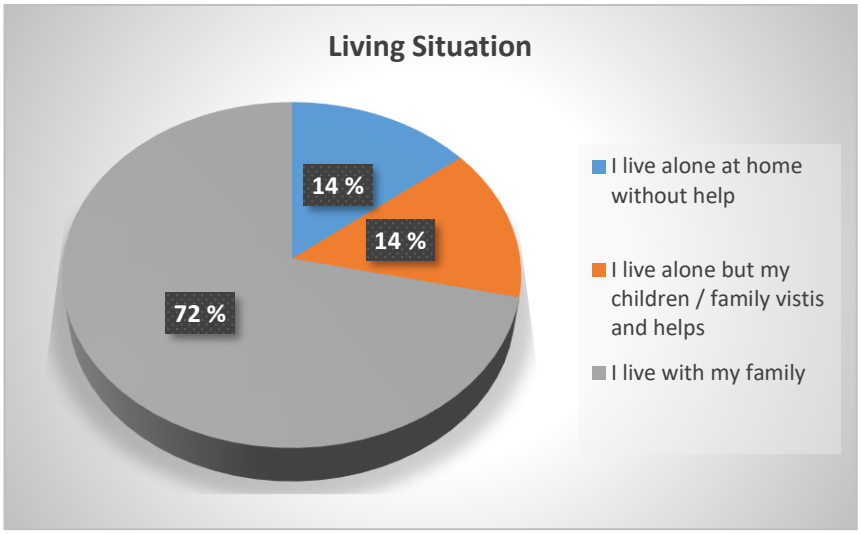
Please, write your answer below

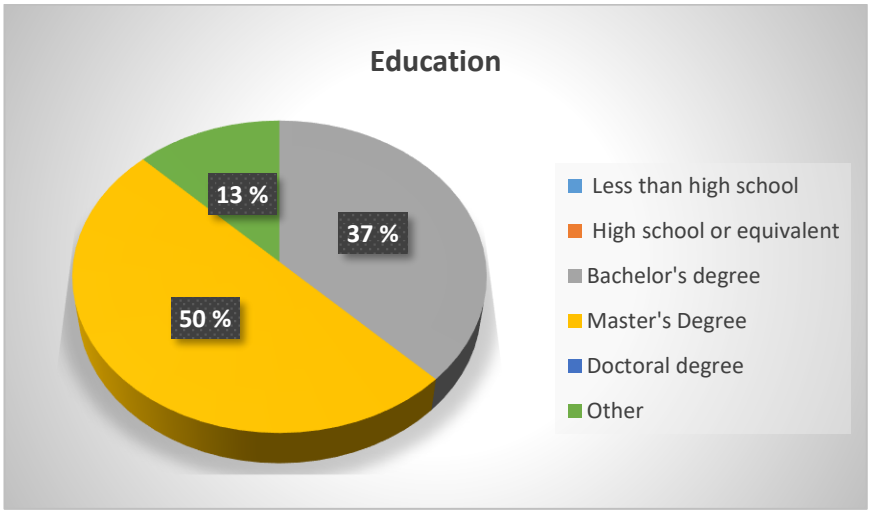
Experiment likeability

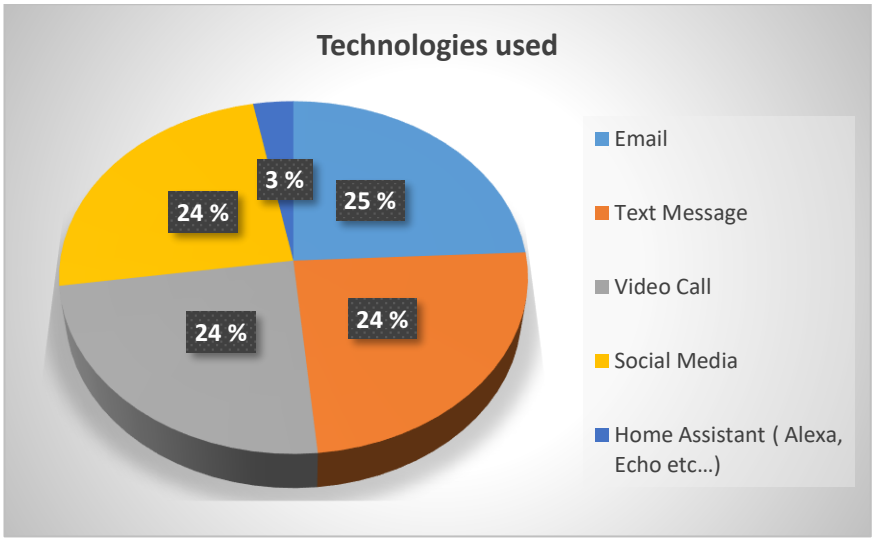
Questions	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Would you repeat this experiment?					
Would you recommend this experiment?					

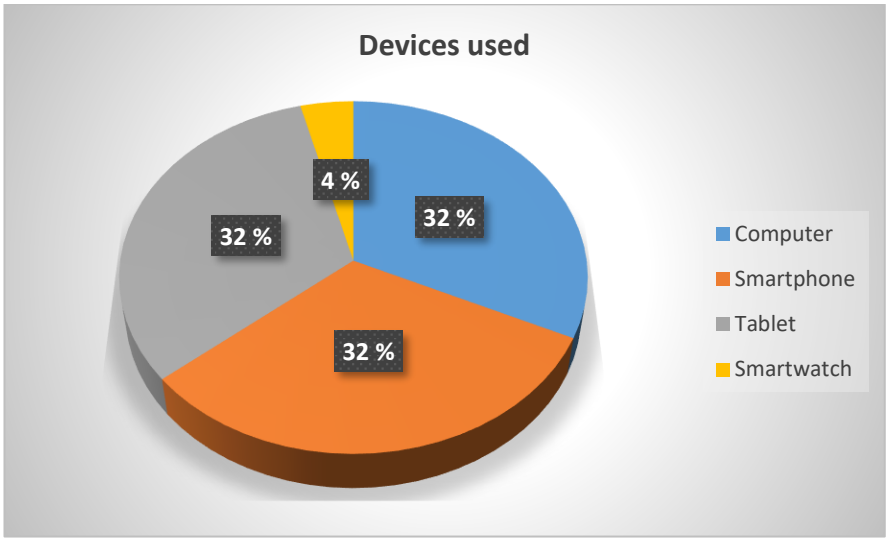
Appendix 7. Post Survey Results

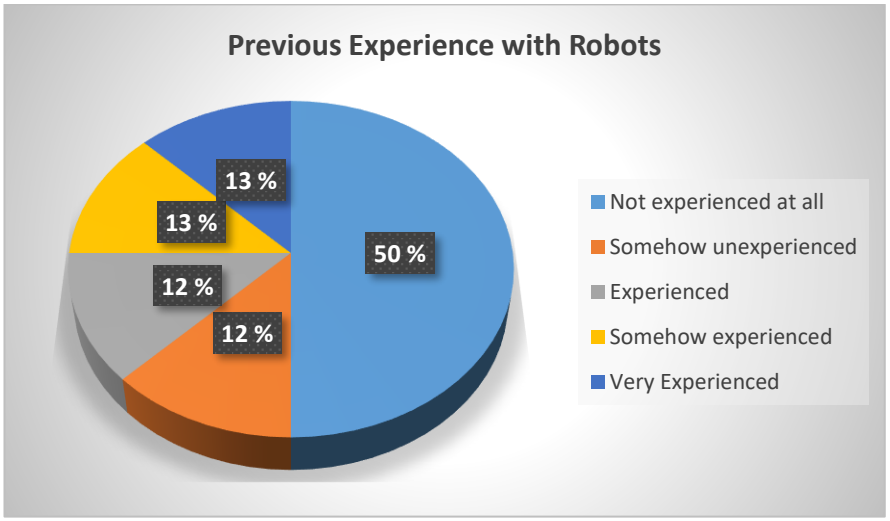


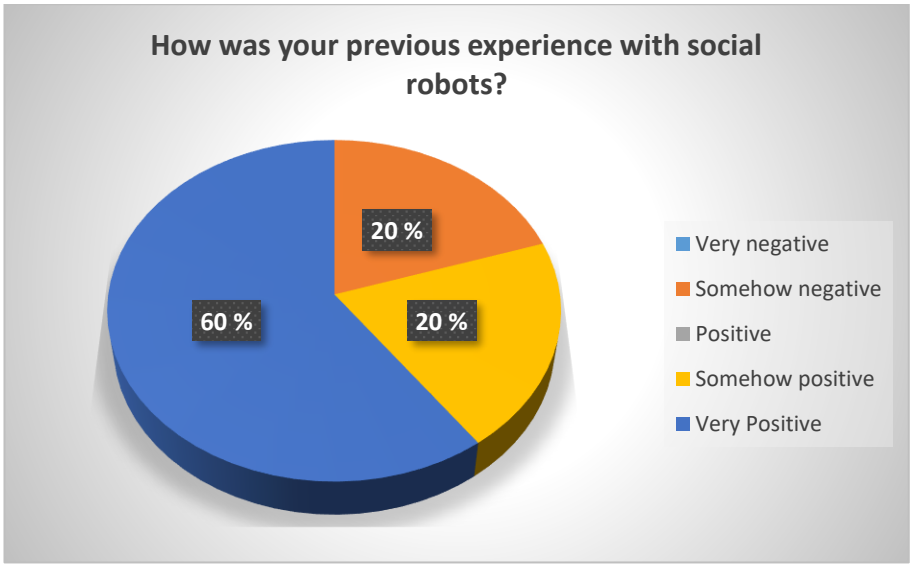


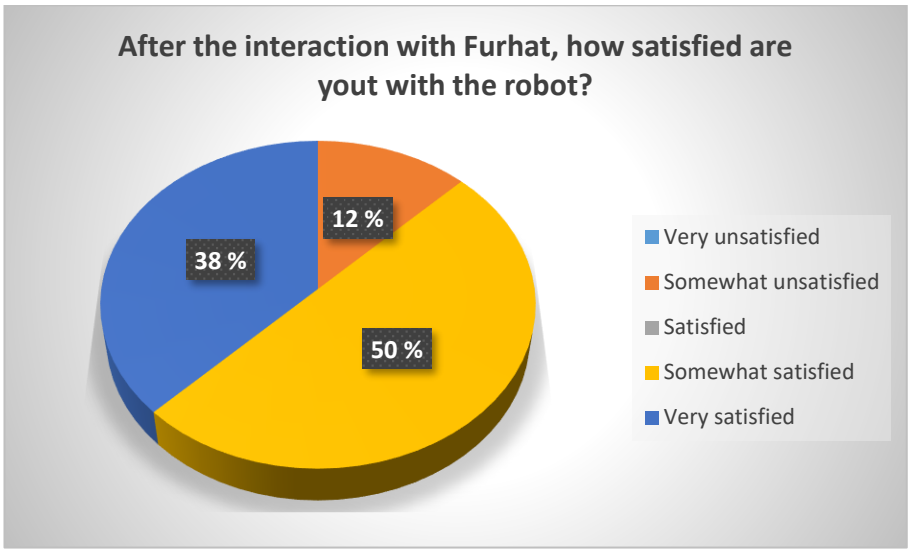


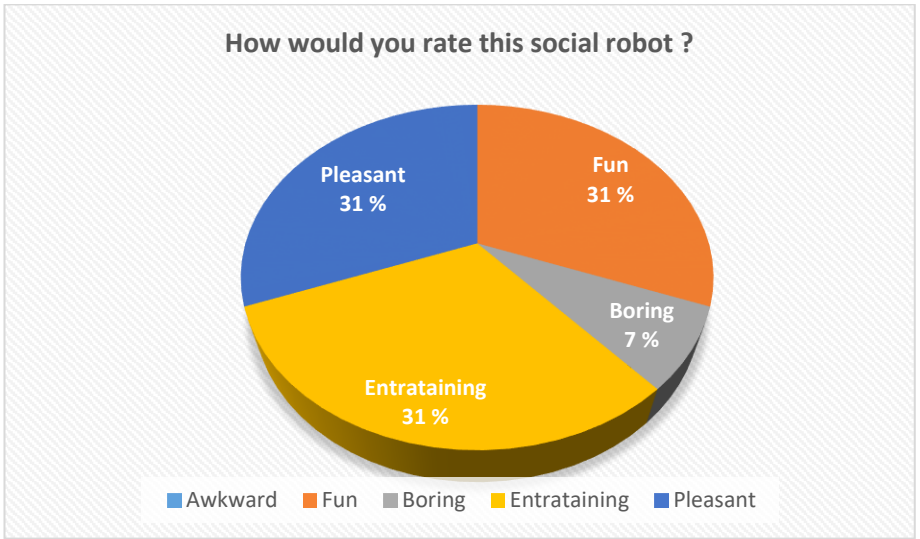

Technologies used
3 %
25 %
24 %
24 %
24 %
Email
Text Message
Video Call
Social Media
Home Assistant (Alexa, Echo etc…)

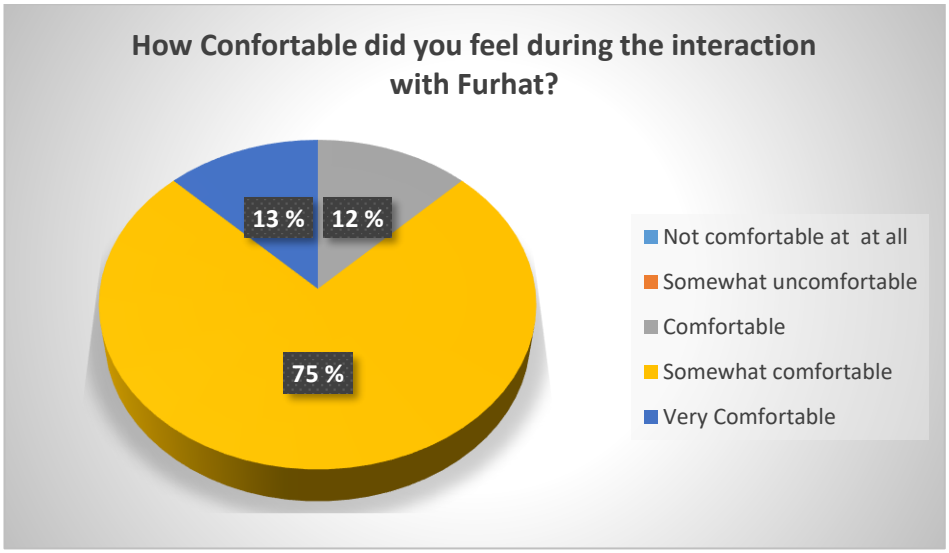

Devices used
4 %
32 %
32 %
32 %
Computer
Smartphone
Tablet
Smartwatch

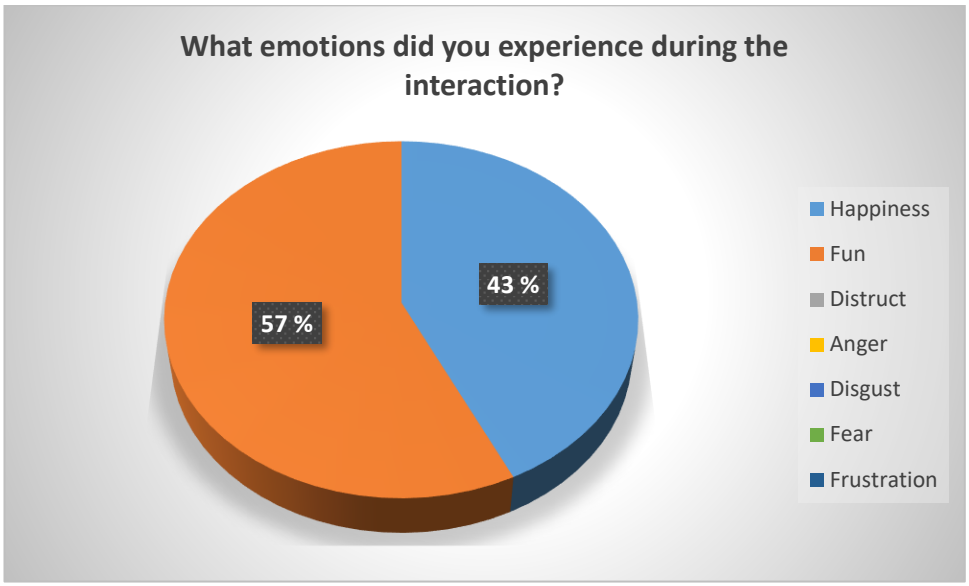

Previous Experience with Robots
13 %
13 %
50 %
12 %
12 %
Not experienced at all
Somehow unexperienced
Experienced
Somehow experienced
Very Experienced

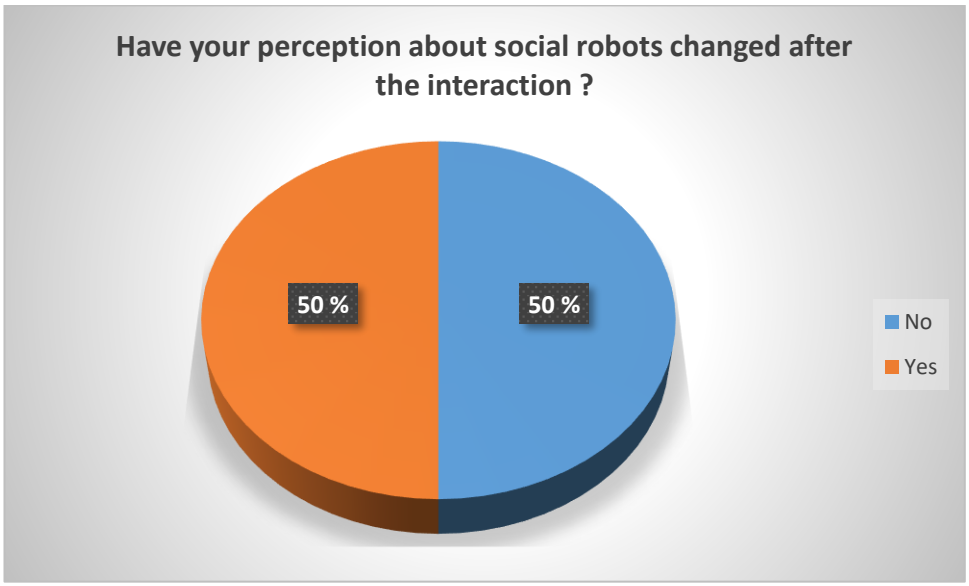

How was your previous experience with social robots?
20 %
20 %
60 %
Very negative
Somehow negative
Positive
Somehow positive
Very Positive

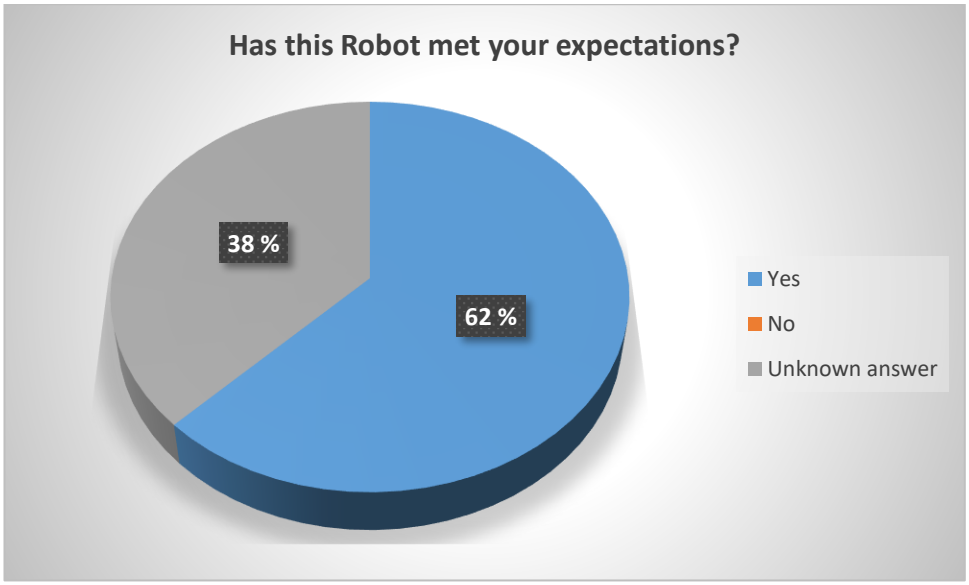

After the interaction with Furhat, how satisfied are yout with the robot?
12 %
38 %
50 %
Very unsatisfied
Somewhat unsatisfied
Satisfied
Somewhat satisfied
Very satisfied

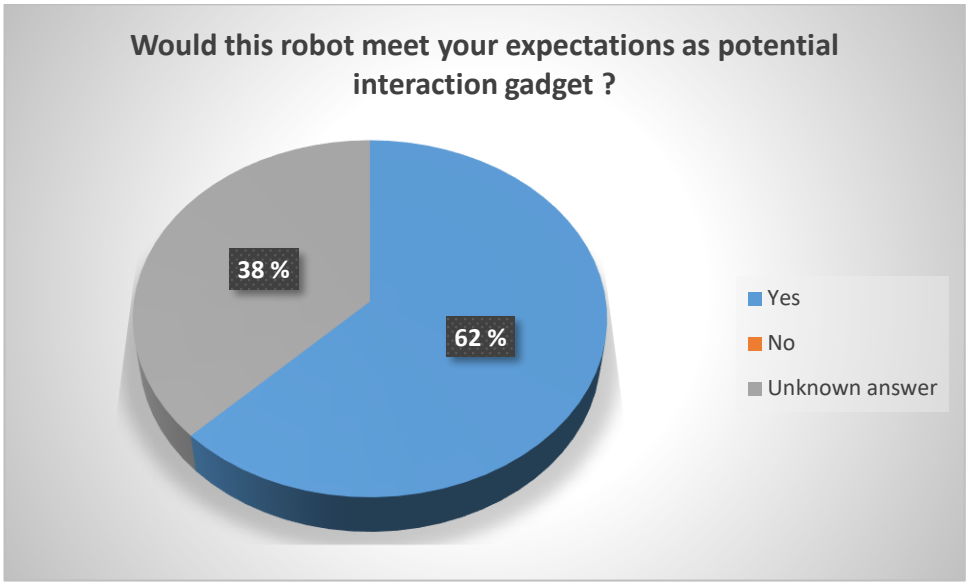

How would you rate this social robot ?
Pleasant
31 %
Fun
31 %
Boring
7 %
Entrataining
31 %
Awkward
Fun
Boring
Entrataining
Pleasant

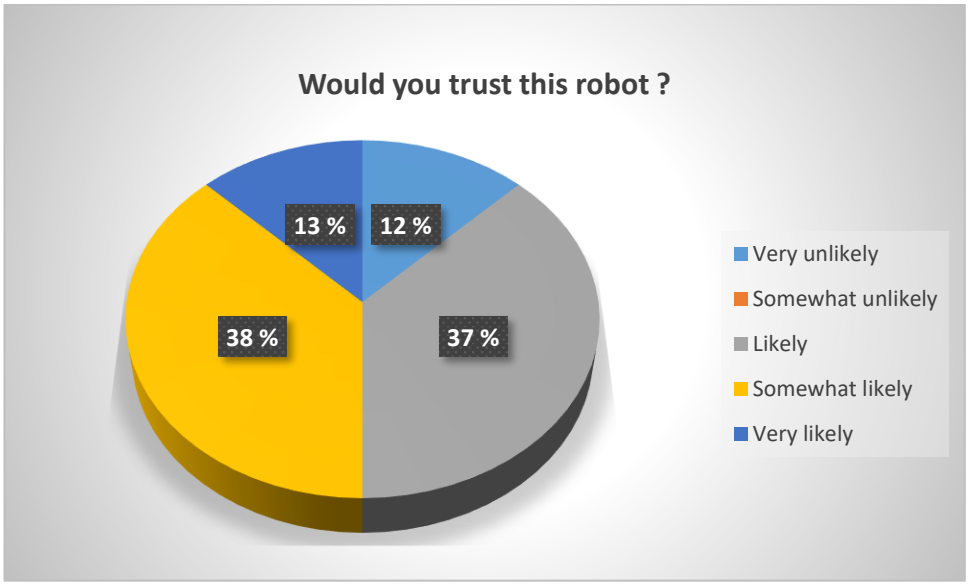

How Confortable did you feel during the interaction with Furhat?
13 %
12 %
75 %
Not comfortable at at all
Somewhat uncomfortable
Comfortable
Somewhat comfortable
Very Comfortable

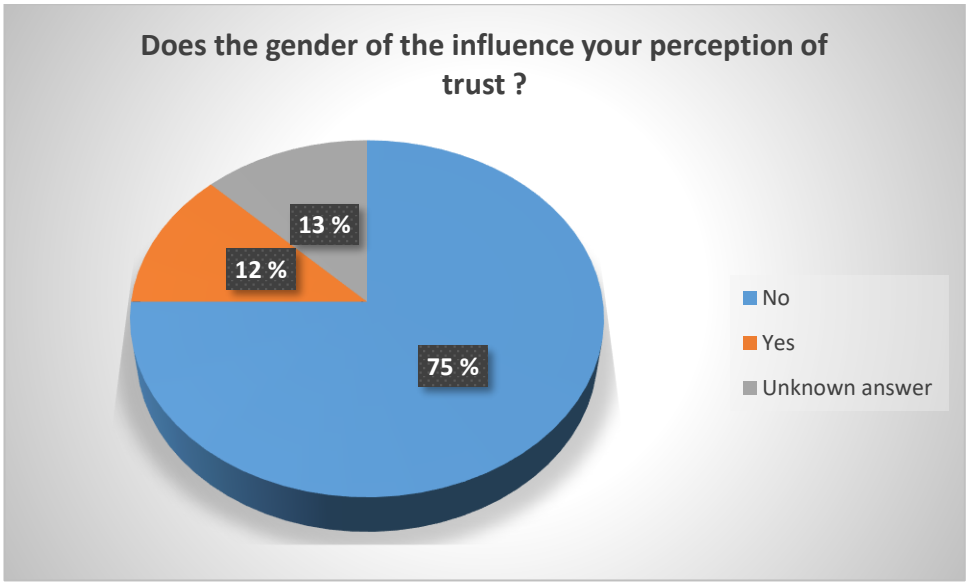

What emotions did you experience during the interaction?
43 %
57 %
Happiness
Fun
Distruct
Anger
Disgust
Fear
Frustration

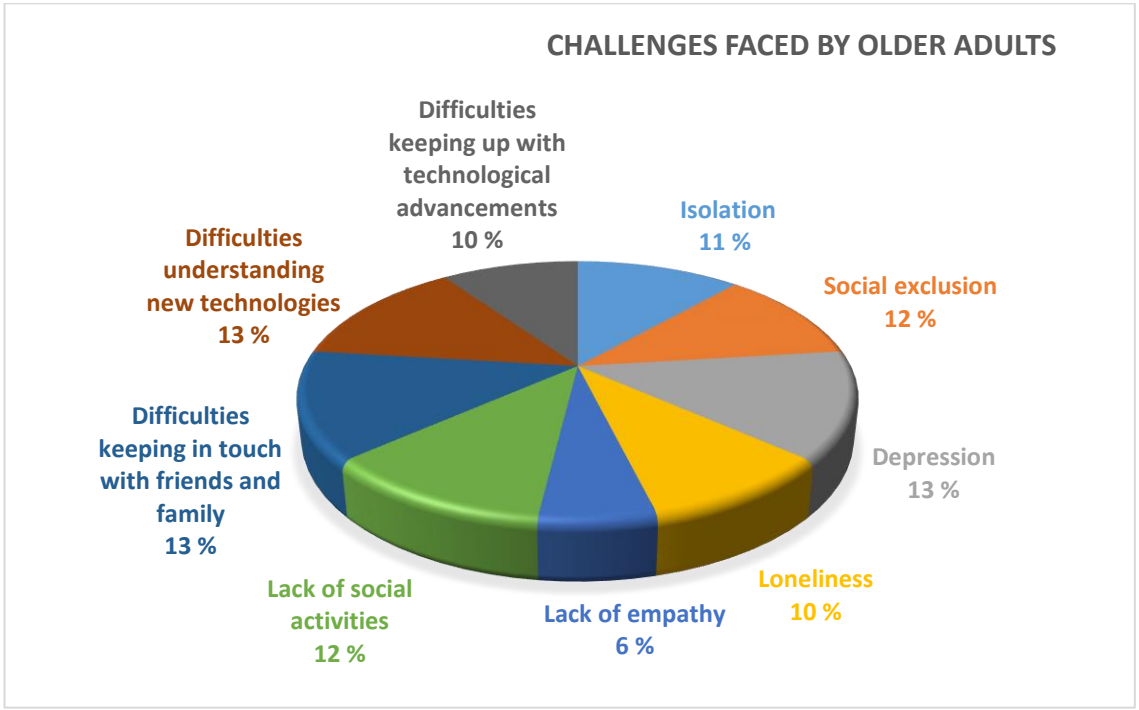

Have your perception about social robots changed after the interaction ?
50 %
50 %
No
Yes

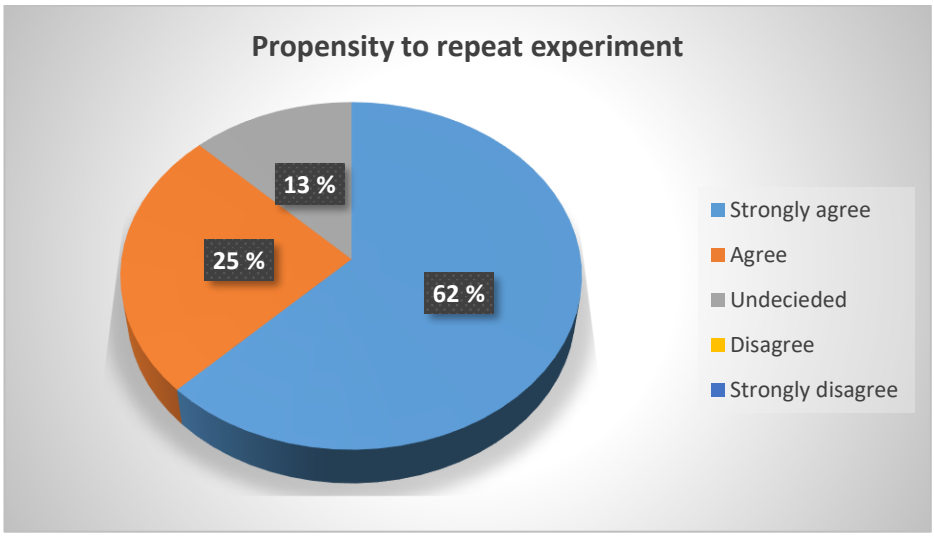

Has this Robot met your expectations?
38 %
62 %
Yes
No
Unknown answer

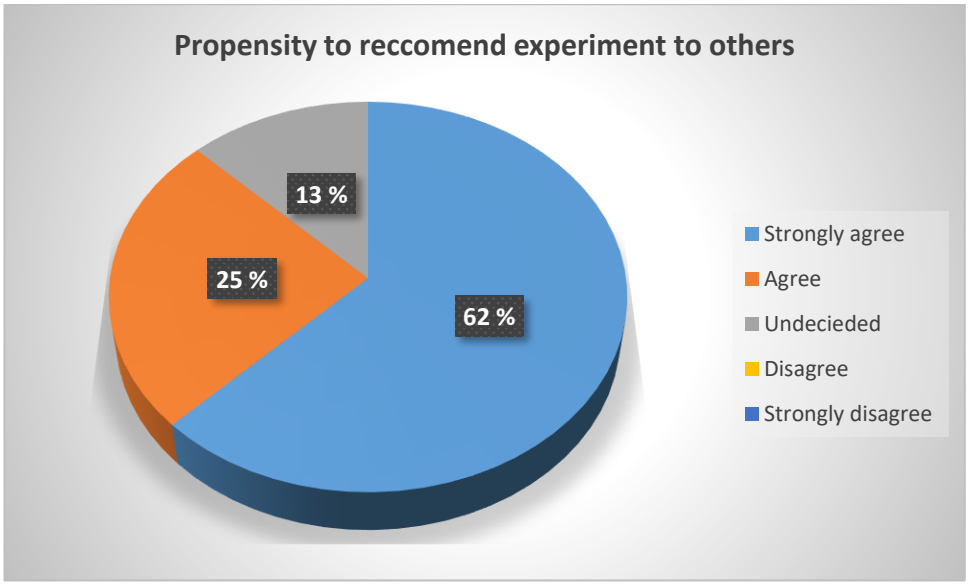

Would this robot meet your expectations as potential interaction gadget ?
38 %
62 %
Yes
No
Unknown answer


Would you trust this robot ?
13 %
12 %
38 %
37 %
Very unlikely
Somewhat unlikely
Likely
Somewhat likely
Very likely


Does the gender of the influence your perception of trust ?
13 %
12 %
75 %
No
Yes
Unknown answer


CHALLENGES FACED BY OLDER ADULTS
Difficulties keeping up with technological advancements 10 %
Isolation 11 %
Social exclusion 12 %
Depression 13 %
Loneliness 10 %
Lack of empathy 6 %
Lack of social activities 12 %
Difficulties keeping in touch with friends and family 13 %
Difficulties understanding new technologies 13 %


Propensity to repeat experiment
13 %
25 %
62 %
Strongly agree
Agree
Undecieded
Disagree
Strongly disagree


Propensity to reccomend experiment to others
13 %
25 %
62 %
Strongly agree
Agree
Undecieded
Disagree
Strongly disagree