Robots in Service and Nursing Care

An Investigation into Japan's Robot Use and Development

Markus Kolstad

Supervisors

Professor Ankica Babic

Associate Professor Yoko Nishihara

University of Bergen,

Department of Information Science and Media Studies

December 1, 2019

Acknowledgments

I am extremely thankful for the participation, engagement, support and motivation from everyone that has helped me in my work.

I want to thank my main supervisor Ankica Babic for the optimism, encouragement, knowledge and hours spent supervising my research.

I want to give another special thanks to Ritsumeikan University and my Japanese supervisor Yoko Nishihara for taking me into your laboratory, spending a lot of time helping, assisting, teaching and encouraging me for the six months I got to do my research in Japan. I was lucky to get you as my second supervisor and thanks to you and your assistant Sato for helping me fund, get in touch and schedule my interviews with professors, robot developers and nursing facilities.

Another special thanks to my fiancé Natsu Yamaguchi for assisting me with interviews, transcription and translations.

This research would never have been possible without the help and hard work from any of you.

Thank you to –

- All participants of my experiment and case study groups.
- Nursing facility managers and workers for inviting me to your nursing facilities for tours, interviews and great insights.
- Professors for inviting me to your offices for interviews and sharing your great knowledge and valuable insights.
- Robot developers and company spokesmen from FUJI SOFT INCORPORATED, Robo Garage Co. Ltd. and TOGO SEISAKUSYO CORPORATION for sharing your unique perspectives on robot development.

どうもありがとうございました

Markus Kolstad

Abstract

We are currently seeing a rapid growth in the investment and development of robots to assist or replace human workers and efforts in many aspects of life. Due to Japan's proportionally large and growing elderly population along with a shrinking workforce, the Japanese government has chosen to promote the research, development, and use of robots in fields such as nursing care. Other countries are also facing the same problems as Japan but have not chosen to promote the alternative futuristic solution to the same extent. In a pursuit to better understand the impact that robots already have and will have on society and everyday life, we have researched the topic of assistive robots in the service and nursing care context.

Through a design science framework and mixed methods approach, performing semi-structured interviews with robot developers, professors in robotics and nursing care staff, observations on the use of robots in real-life settings, case studies, and one experiment, we have developed a comprehensive analysis and understanding of the research problem.

To analyze the data, content analysis and the grounded theory were used. An experiment and two case studies were used to investigate attitudes, perceived benefits, and disadvantages of using robots. Furthermore, interviews and observations were conducted at nursing care facilities to investigate the possibility of assisting or even substituting humans with robots in settings that usually require a sense of human warmth and care. Previous research often focusses on individual robots or on literature review without field data. It would seem like the literature is lacking a deeper perspective, while at the same time, painting a wider picture of the domain itself. Therefore, this research investigated the development and experiences with robots that already exist and have been tested in real-world settings.

The findings of the study summarized the literature on robots in nursing care, attitudes towards robots across countries and Japan's strategy for further integrating robots into their society. Other results include real experience with the use of robots in nursing facilities and theories grounded in the ideas and thoughts behind the development of robots commonly used today.

An experiment exploring empathy towards robots demonstrated the distinctiveness of robots, as compared to dolls, in enhanced empathy towards them. Two case studies captured views from university students and primary school pupils based on interaction with the humanoid robot Pepper. Pupils found Pepper to be useful and likable, while university students found the interaction to be fun, but frustrating at times.

Based on the field studies, we could conclude that Japanese robot developers and researches recommend robots to be inferior to users in terms of intelligence and relationship, but also capable of easy interaction and ideally reading between lines in communication. In nursing care, robots are currently taking the role of pets (*Paro* and *Qoobo*), a child (*Pepper*, *Paro*, *PALRO*, *RoBoHon*, and *Smibi*) and even as a staff member (*Pepper*), capable of entertaining and accompanying elderly to help with mental well-being.

There might be a current lack of ethical and safety standards for such robots. However, safety and ethical issues are considered by developers and professors in terms of privacy, deception, attachment, mechanical safety. Current robots have different levels of cognitive capacities depending on purpose and interaction style. Goals for the future include improvement on aspects such as intelligence, marketing strategies, and educating users on robots' capabilities and limitations.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

Many countries around the world are currently facing rapid growth towards a proportionally large elderly population. Combining this with low birthrates means that more people will need nursing care while at the same time facing a shortage of workers. Some countries argue that immigration might be the solution to this problem, while Japan has decided to invest in alternative futuristic ways of coping with its changing demographics. According to the United Nations (UN) demographic statistics, Japan's population has decreased since 2009, holding about 128,500,000 residents at the time [1]. Japan's population today (2019) is about 126,800,000 and is forecasted to keep decreasing down to 108,800,000 by 2050.

This potentially means that Japan will have roughly 18 million people less in 30 years, which is equivalent to about 3.3 times the current population of Norway. As of today, around 27% of Japan's population is 65 years or older, meaning a total of about 35 million people over the age of retirement (65 years). At the same time as the workforce is shrinking, the required number of caregivers will rise dramatically [2]. According to the World Health Organization (WHO), the world's collective population of people aged 60 years or older is expected to more than double from about 900 million people in 2015 to 2 billion by 2050 [3].

Everyone gets older and thus most people will to some degree be affected by the methods used in nursing care. However, robots as one alternative solution to be used in care are still a rear sight in most countries. This research aims to investigate robots used in nursing care settings to see what effect they have on people. It aims to take a closer look at what types of robots currently exist and whether they are being successfully used. Japan was selected for the study as the most prominent country that explored the possibilities of developing and engaging robots for this purpose.

1.1 Research Questions

Research questions were developed to investigate the possibilities and difficulties of assistive robots from development to usage. The following research questions form the foundation of the research:

RQ1: What do Japanese robot developers and researchers consider when developing robots?

RQ2: What are the benefits and disadvantages of using nursing care robots for everyone involved?

RQ3: What are the safety and ethical issues and concerns connected to robots and their usage in the nursing care context?

RQ4: What is the human-robot interaction like with current robots?

1.2 Outline of Research Project

The following is the outline of this research project:

Chapter 2 Literature review investigates and summarizes the already published literature on the robots, starting from medical theory, attitudes towards robots, various robots, Japanese robot strategy and the use of robots in nursing care.

Chapter 3 Methodology and Methods describes and justifies the methodology and research methods used in this research project that includes design science and mixed methods design.

Chapter 4 Requirements describe expectations, ethical considerations and the participants involved in the research project.

Chapter 5 Results presents the results and findings of the research, such as Case Studies, The Grounded Theory, and Experiment on empathy towards robots.

Chapter 6 Discussion goes through the methodologies and methods used, looks at the achieved results, and answers the research questions.

Chapter 7 Conclusion and Future Work summarizes and concludes the research and suggests recommendations for future work.

Chapter 2

Literature Review

This chapter presents a literature review in order to gain a perspective and to better understand robots, the robot industry, usage of robots in nursing care, human-robot interaction and relations. The literature review investigates what already exists on the topic and creates a background for the research project.

2.1 Medical Theory

Everyone is aging throughout their lives, but as people get older and closer or beyond the age of retirement, the risk of experiencing several health issues increases. Some of the common health conditions related to aging include hearing loss, sensory impairment, back and neck pain, mobility disability, incontinence, depression, cognitive aging and dementia [4] [3]. Healthy aging is defined by WHO as "*the process of developing and maintaining the functional ability that enables wellbeing in older age*" [5]. This process may involve everything from a certain diet, physical and mental exercises, relationships, independent living, tackling isolation and loneliness, maintaining values and meaning, etc. to provide a better quality of life and to prevent or slow down the development of different age-related health conditions.

Han et al. released a study in 2015 about "psychosocial factors for influencing healthy aging in adults in Korea" [6]. The study had a total of 171 Korean participants aged between 45-77 years, filled in self-reporting questionnaires about psychosocial factors related to healthy aging. The study found that the greatest influencer of healthy aging was depression with a negative correlation of -.595 ($p < 0.05$). This basically means that as depression increases, healthy aging decreases, indicating a strong negative relationship between the two. However, the study also found several strong positive relationships between healthy aging and factors like self-esteem, participation in leisure activities, perceived health status and self-achievement. Depression was found to have a strong positive relationship with loneliness, besides a strong negative relationship with participation in leisure activities, and a moderate negative relationship with self-achievement. These findings suggest that healthy aging can be increased through controlling depression, which can be achieved by higher participation in leisure activities and other forms of self-achievement.

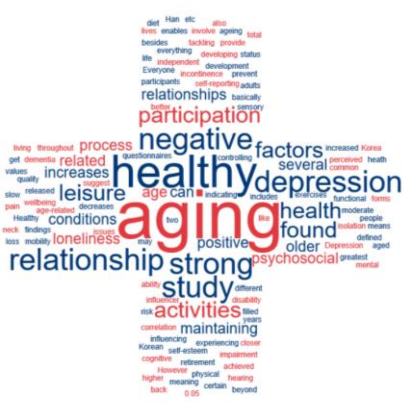

Figure 1. Word cloud of the medical theory findings on aging.

2.2 Related Works

2.2.1 Industry and Types of Robots

The robotics industry is rapidly growing. According to the International Federation of Robotics (IFR), the global robotics turnover was about 48 billion US$ in 2017 [7]. The currently biggest "category" is still industrial robots; however, the service robot market is also growing and is predicted to grow even more over the next years. At the IFR press conference held in Tokyo in 2018, the federation claimed that the value of sales in regards to professional service robots in 2018 was 8.7 billion US$ and predicted the value to increase to 37 billion US$ from 2019 to 2021 with logistics field as the main driver of value growth.

To narrow the statistics further down, personal/domestic service robots had an estimated value of 2 billion US$ in 2017 whereas 1.4 billion belonged to household robots and 0.4 billion to entertainment and leisure robots. These numbers were also forecasted to have a significant growth from 2019 to 2021, reaching the total value of 13.1 billion US$ (11.1 billion US$ for household robots and 2 billion US$ for entertainment and leisure robots) [7]. Figure 2 also shows the expected growth for robots within the medical domain.

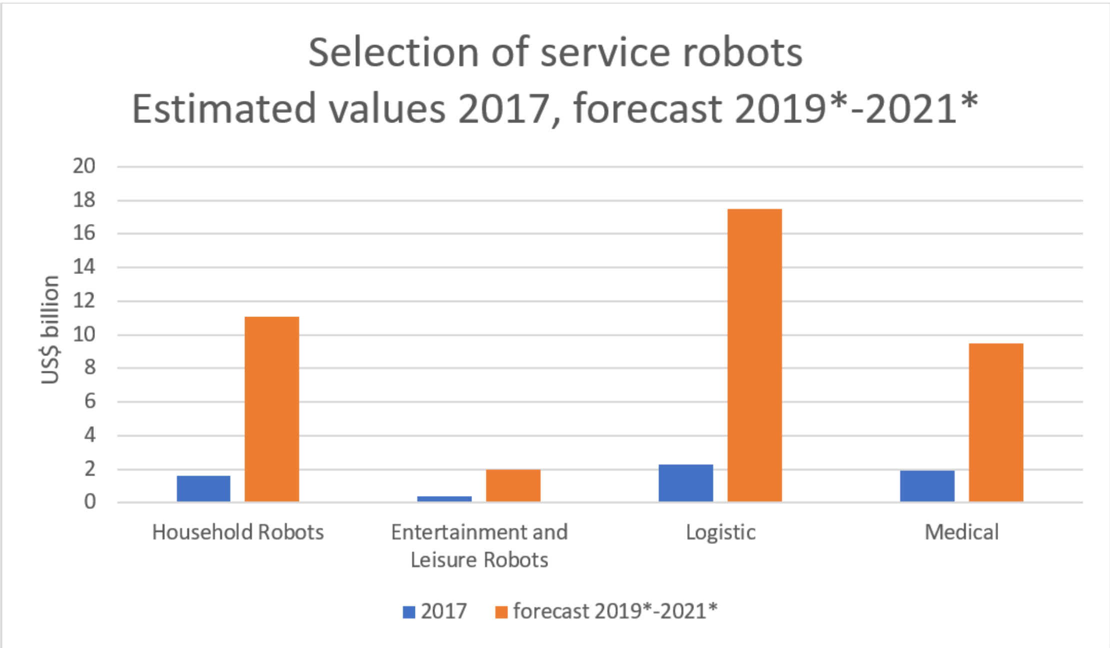

Figure 2. Estimated values and Forecasts on a Selection of Service Robots. Source [6].

These numbers are general, they do not really specify or define what types of robots could be expected in the different domains. However, we do know that "*service robots for personal and domestic use are mainly in the areas of domestic (household) robots, which include vacuum and floor cleaning, lawn-mowing robots, and entertainment and leisure robots, including toy robots, hobby systems, education and research*" [8]. In addition, another strongly growing sector is public relation robots. Public relations robots are described as being "*increasingly used in supermarkets, at exhibitions, in museums, etc. as guides or information providers*" [8]. One of the most famous robots that fit this definition is SoftBank's Pepper. However, there are many examples of Pepper being used in Japanese homes and could, therefore, fit into the household robot as well as into the entertainment and leisure robot categories.

Examples of robots in healthcare include robots surveying everything from hospital beds, wheelchairs, surgeons and exoskeletons. Sales of medical robots increased by 73% from 2016 to 2017 with the most important applications being robot-assisted surgery or therapy [8].

2.2.2 Attitudes Towards Robots

The European Commission published a report in 2012, investigating it's at-the-time 27 member states' "public attitudes towards robots" [9]. The research was conducted through surveys on a total of 26.751 participants and the results were analyzed both as a European average and at a country-by-country socio-demographic level. The survey found that even though 87% of the participants had no personal experience with robots, 70% had a positive view of them. The positiveness, however, was highest with students and found to decrease with age. However, the views also differed from country to country, showing that some cultures might be more accepting of robots than others. The European citizens' image of a robot was found to closer corresponded to an instrument-like machine (81%) rather than a human-like machine (66%). When asked about areas of which robots should be banned from, 60% answered in care of children, elderly, and the disabled, followed by 34% on education and 27% on healthcare. Not only did the majority think that robots should be banned from care of children, elderly, and the disabled, but "*on average, 86% would feel 'uncomfortable' about having their children or elderly parents minded by a robot (in fact, 66% chose point 1 'totally uncomfortable' on the scale)*" [9].

Nursing care robots are off to a bad start judging by the residents of the European Union's attitude towards them. However, the survey was from 2012 and in addition to being answered by people whereas 87% had no personal robot experience, a lot might have changed within both the industry and people's attitudes since then.

In 2006, Bartneck et al. performed a study to see "The influence of people's culture and prior experiences with Aibo on their attitude towards robots" [10]. The study had a total of 467 participants from 7 different countries fill in "*the negative attitude towards robots scale survey which consists of 14 questions in three clusters: attitude towards the interaction with robots, attitude towards social influence of robots and attitude towards emotions in interaction with robots*" [10]. The study found that the members of the Aibo (Sony's robotic dog) community had significantly more positive attitudes towards robots than non-members. This could suggest that people with more robot experience will have a more positive attitude towards robots, although being a member of the Aibo community indicates a special interest in robots to begin with. In contrast to the idea that Japanese people in general love robots, the study also found that the Japanese scored the highest on negativity towards the emotional aspect and only the third-highest on the social aspect of robots out of all seven countries. In fact, Japan scored higher on the negativity scale than both the UK and the USA on all three aspects.

Studies have found that people seem to find it less desirable having robots taking care of living creatures. Both a study from 2008 [11] and a study from 2014 [12] show that people find it desirable having robots perform tasks like vacuum cleaning, lawn mowing, watching over the house and so on, while tasks like having robots babysit, playing with children or take care of animals was found among the least desirable things a robot could do. Interestingly enough, "*having a robot taking care of me when I'm old*" is found somewhere in the middle of the lists, showing mixed feelings either in favor of or strongly against robots. When asked about a robot's appearance, both studies seem consistent in the idea that most people prefer robots looking like a big or small machine, something that goes well with people's desire for robot vacuum cleaners. Resembling humans, animals or creatures was found to be something robots should not look like. One of the studies found no statistical difference in these opinions between European and Japanese people.

The Japanese Cabinet Office did a survey back in 2013, asking 1,842 Japanese people of age 20 years or older about their attitudes towards caring robots [13]. The survey found that 65.1% of the participants wanted to use robots in nursing care, while 29.3 % did not. When asked about important points on choosing nursing care robots, the most important point was found to be “easy to use” (74.4%), followed by “reasonable price” (68.6%) and “safety license” (54.6%). Only 6.4% said that the robot had a “nice design” was important. The charming points of using robots was found to be the “decrease of mental and physical burden” (63.9%) followed by “not having to hesitate to receive care” (41.5%), “being able to do more things by themselves” (35.8%) and “to prevent the patient from being mentally and physically weak” (21.0%). Out of the total 1,842 participants, 696 people had experience or had family members with experience of performing nursing care at home. When these people were asked about the most difficult points about nursing care, 62.5% answered “changing diaper and toilet assistance”, 58.3% on “assisting taking baths”, 49.1% on “assisting with meals” and 48.3% on “transferring/carrying the patient from/to their bed, wheelchair, toilet, bath, etc.”. Other answers include assisting with walking, dementia, monitoring, preventing falls at night and rehabilitation. Even though the use of robots was found to be most desirable, both in mental and physical aid, physical tasks seem to be the area of which robots are most wanted by the caregivers.

Nomura et al. performed a pilot study in 2005 on “People’s Assumptions about Robots: Investigation of Their Relationships with Attitudes and Emotions toward Robots” [14]. The study surveyed 106 Japanese participants on their assumption of robot type, work and situations by choosing from lists of predefined options. The survey found that 78% checked humanoid as the type of what they first recalled when hearing the term “robot”, followed by “Pets such as dogs and cats” (24%), “Factory Robots” (24%), “Computers” (19%), “Others” (6%), and “Animals except from pets” (2%). When asked about assumptions about tasks regarding robots, 66% answered: “Physical tasks”, followed by “Service tasks for humans” (23%), “Housework” (19%), “Office work” (19%) and “Others” (10%). Even though people assumed robots to be of a humanoid type, it was found no relationship between humanoid robots and physical tasks when looking at the coefficient correlation between the choices in assumptions between types and tasks. Humanoid robots had the highest, yet a negligible relationship with housework. In fact, the only strong relationship found between types and tasks were between computers and office work. As Nomura et al. put it “*there was no trend that the assumption of ‘humanoid’ was related to specific situations and tasks. This implies the possibility that humanoid robots have no realistic meanings related to concrete situations and tasks as yet, although individuals do assume it*” [14].

2.2.3 Robots and Gender

Nomura published a study in 2016, investigating published research on gender in human-robot interaction [15]. Nomura investigated and summed up several studies that have been done on this topic and it turns out to be rather complicated. Nomura illustrates several factors that affect psychological and behavioral reactions towards robots, mainly human factors, robot factors, situational factors, and gender stereotypes. To simplify, a person’s own gender might influence one’s attitude and reaction towards robots, and it might differ depending on the robots’ perceived gender, the situation of the interaction, including tasks and culture, and stereotypes related to all the formerly mentioned factors. Appearance vise, males were found to be more attracted to mechanical-looking robots, while females preferred more human-like robots. Many of the studies used gender-neutral robots before applying slight gender manipulation through male and female names and/or masculine and feminine voices. Even though the robot was fundamentally the same, people seemed to prefer one gender manipulated robot over the other for tasks that stereotypically belongs to one or the other gender. For example, male perceived robots were found to be more suitable for security-related tasks than healthcare and vice versa. However, stereotypes might differ between cultures. Since people seem to accept robots more easily when gendered according to a task's gender stereotype, ethical issues should be considered, possibly in order to prevent reinforcing such stereotypes. The problem with non-gendered humanoids, however, is that people tend to assign a gender to the robot regardless.

2.3 Robots

The following is an overview and introduction to some of the robots mentioned in this research. The information on weight, size, and price gives a rough overview of what might be expected in care-related instances, and what amount of money could be invested in each of these robots. The prices displayed are for new robots taken from each robot's official selling site with the cheapest possible solution. The prices are displayed as JPY (Japanese Yen), including a Japanese tax and might be subject to change. Prices were noted in August 2019.

PEPPER

Characteristics		*Description*
Price:	*1,094,184 JPY (Three-year deal)*	Social humanoid robot
Size:	*Height 120 cm*	SoftBank's Pepper is a social humanoid robot, first introduced in 2014 and available for purchase from 2015. "*Pepper was optimized for human interaction and is able to engage with people through conversation and his touch screen*" according to the official website.
Weight:	*28 kg*	
Actuators:	*20*	
Website	https://www.softbankrobotics.com/emea/en/pepper https://www.softbank.jp/robot/pepper/consumer/	

RoBoHon (ロボホン)

Robot Phone

Characteristics		*Description*
Price:	*85,320 JPY*	Human-like robot-phone hybrid
Size:	*Height 19 cm*	RoBoHon is a human-like robot-phone hybrid developed by Robo Garage Co. Ltd. CEO Takahashi in collaboration with SHARP.
Weight:	*390 g*	
Actuators:	*13*	
Website	https://cocorostore.sharp.co.jp/robohon/body/sr-05m-set	

PALRO (パルロ)

Pal Robot

Characteristics		*Description*
Price:	*375,840 JPY*	Conversational humanoid care robot
Size:	*Height 40 cm*	Palro is developed by Fuji Soft Inc. Palro is a tiny robot capable of conversation, walking, network connection and has an AI to learn.
Weight:	*1.8 kg*	
Actuators:	*23*	
Website	https://palro.jp/en/feature/spec.html	

PARO (パロ)

Characteristics		*Description*
Price:	*388,800 JPY*	Seal-type therapeutic robot
Size:	*Length 57 cm*	Paro is a seal-type therapeutic robot developed by AIST, first exhibited in 2001 and available for purchase since 2004-5. PARO was certified as the most therapeutic robot in February 2002 and entered the World Records in the 2003 edition.
Weight:	*2.7 kg*	
Actuators:	*9*	
Website	https://www.aist.go.jp/aist_e/list/latest_research/2004/20041208_2/20041208_2.html https://www.daiwahouse.co.jp/robot/paro/products/about.html	

SMIBI (スマイビ)

Smiling Baby

Characteristics		*Description*
Price:	*73,440 JPY*	Healing baby robot
Size:	*Height 44 cm*	Smibi was developed by Togo Seisakusyo Corporation and has been on the market since 2016.
Weight:	*1.2 kg*	
Actuators:	*4 (not confirmed)*	
Website	http://www.togoh.co.jp/products/care-smiby.html	

2.3.1 Japans New Robot Strategy

In 2015, The Headquarters for Japan's Economic Revitalization released a 91-page long document titled "New Robot Strategy" stating Japan's vision, strategy and action plan for the future [16]. The document mentions problems that Japan currently faces in terms of low birth-rates and an aging population, two factors that brings labor shortage and work overload for the shrinking working population. In a "drastic transformation of robots and Japan's future", it is expected that robots will "*advance into the area of routine communication tools and contribute to provide life support such as assistance in household choirs as well as safety and comfort*" [16]. In fact, Japan aims for a "Robot Revolution" and states that the revolution refers to three main points:

- turning what used not to be positioned as robot in conventional manners into robots through the advancement of sensor and AI technologies (e.g. automobile, household appliance, mobile phone or housing will be considered a type of robots);
- utilizing robots in the actual site of manufacturing as well as various scenes of daily life which will lead to;
- forming a society where new added value, convenience and wealth are created through the reinforcement of global competitiveness in the field of manufacturing and service as well as settlement of social issues.

Although robot innovation, development, research, and deployment are at the core of the revolution, the new robot strategy also calls for a transformation of society and its structure to fully take advantage of robots. To achieve a "robot barrier-free society" in Japan, it is crucial to meet the requirements for humans to coexist with robots and be able to achieve cooperation between robots and humans of all ages. This "ideal" state of the future is then thought to achieve a higher life quality, as well as safety, comfort and a deeper individual appreciation of robots. The "New Robot Strategy" also wants to take advantage of Japans hosting of the Tokyo 2020 Olympic Games as a "*driving force of 'robot revolution' in which people's daily life is changed by robots*" and to "*transform its society ahead of the world*" [16] to showcase Japan and Tokyo as a place which is strongly integrated and surrounded by robot technology. The robot development is, therefore, to be accelerated until the worldwide covered event.

In terms of nursing care, it is reported that 70% of nursing care workers in 2015 suffered from backache, calling for "*mitigation of the workload at care-giving sites*". "*The basic policy is to help people continue their self-sustaining lives in a region they are familiar with even when they have reached the age at which they need nursing and medical care*" [16].

The strategy is clear on wanting to maintain the "*basic concept that care is given by human hands*" while making and utilizing the best robotic equipment and technologies to create working environments that can provide services with satisfaction, enhance work efficiency and be able to reduce the number of workers needed. It is important to keep in mind that robotics does not threaten the jobs of nursing care workers but supplementing the shortage of the workforce and preventing work-related injuries and pain.

Japan's strategy also includes aiding research to identify specific needs and development of practical equipment. In addition, the strategy identifies "important fields" where the use and development of robots should be pushed. The important fields, mainly in nursing, are "transfer support" which includes wearing type, non-wearing type, outdoors and indoors, "excretion support", "bathing support" and "watching over those who have dementia", both for institutions and homes.

The strategy claims that as a result of the mentioned goals being achieved, both the willingness to use robots while providing and receiving care will rise to 80% from what was found in the cabinet office's survey from 2013 [13]. In addition, the risk of caregivers "*suffering a backache will be lowered to zero by using nursing robots for helping the aged transfer*" [16].

The Japanese Ministry of Economy, Trade and Industry (METI) has presented six priority areas collectively holding 13 items to which robot technology is to be introduced in nursing care, namely Lifting aids, Mobility aids, Toilets, Monitoring and communication systems, Bathing and Nursing-care services [17]. This paper focuses on communication robots, being one of the newest items introduced to the government's priority areas in 2014 and supported for development since 2017.

The "International Medical & Elderly Care Expo 2019" in Osaka showed that technologies for bathing support included a large bathtub machine/equipment, lifting aids included exoskeletons, transfer support included a robotic walker and electric wheelchairs with tank-like belts. Robotics will likely come in all shapes and sizes and forms that are not resembling humans.

2.3.2 Use of Robots in Nursing Care

Animal therapy has for a long time been an idea in nursing care. However, animals may come with certain problems such as allergies, bacteria, bites, and scratches.

Kanamori et al. published a "Pilot study on improvement of quality of life among the elderly using a pet-type robot" in 2003 [18]. The pet-type robot used was using Sony's robotic dog AIBO. The study had a total of six participants, whereas five participants (mean age of 72.8 years) lived in a nursing home and one participant (84 years) who lived at home but used the day service of the nursing home. In short, the experiment found that the loneliness score measured through an Ando, Osada & Kodama Loneliness Scale (AOK Loneliness scale) had a significant decrease (meaning feeling less lonely) after 6 weeks of the treatment with AIBO. In addition, it was found a significant increase in "emotional words", "amount of speech" and "satisfaction" as compared with the measurement at the start of the experiment. The results of the study "*suggested that the activities with pet-type robot could prepare the way to communicate with other people or be a lubricant for better human relationship for the elderly who tended to withdraw into themselves*" [18]. In addition, through techniques like "Salivary Chromogranin A" (CgA) used to measure stress through saliva, it was found that "*CgA decreased after activities with pet-type robot in all the subjects, suggesting that activities with robots could reduce stresses*" [18].

Takanori Shibata and Kazuyoshi Wada, Shibata being the creator of Paro, published a mini-review on robot therapy as a new approach for the mental healthcare of the elderly in 2010 [19]. According to Shibata et al, "*Interaction with animals has long been known to be emotionally beneficial to people. In recent years, the effects of animals on humans have been researched and proved scientifically*" [19]. In fact, animal-assisted therapy and activities (AAT and AAA) are expected to have three effects: "*(1) psychological effect (e.g., relaxation, motivation); (2) physiological effect (e.g., improvement of vital signs), and (3) social effect (e.g., stimulation of communication among inpatients and caregivers)*" [19]. However, due to the restriction on the use of real animals at nursing facilities in Japan, Shibata et al.'s mini-review aims to introduce and discuss robot therapy's potential to care for elderly people and "*explain the required functions for therapeutic robots and the seal robot, Paro*" [19].

Shibata et al. state that "*Human-interactive robots are designed for entertainment, communication (social activity), guidance, education, welfare, mental therapy, and other purposes. Various types of robots, such as humanoid, animal, and robots with unique appearance, have been developed*" [19].

However, these robots are not only evaluated in terms of objective measures on performance etc. but also in terms of "*subjective measures for interacting with humans, such as providing comfort and bringing joy*" as shown in Figure 3.

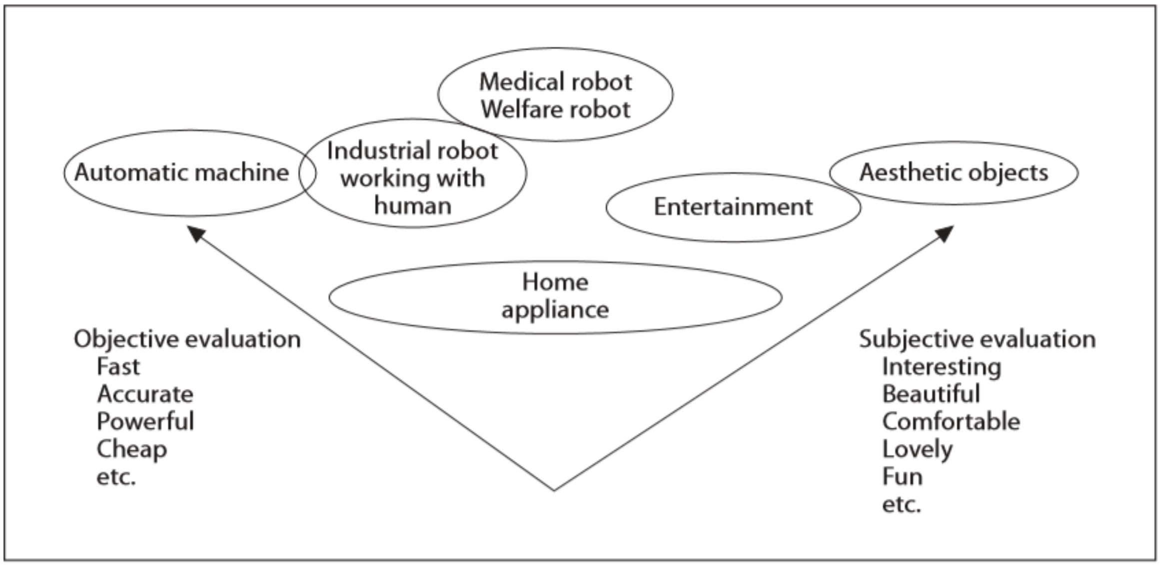

Figure 3. Objective and subjective measures for evaluating artifacts. Figure taken from [18] p.380.

The "seal-type mental commitment robot" Paro, developed by Shibata himself, was developed for robot therapy and as a substitute for animals in AAT and AAA. Shibata et al. state that research has revealed robot therapy to have the same effect on people as AAT, but that it is important to "*stimulate people's knowledge and experiences of animals through interaction with the robots and to bring out their feelings when they are interacting with animals. Therefore, shapes, feelings of touch, autonomous behavior, and responses that mimic animals are the features that are required to be present in the robots*" [19]. In fact, in order to model the liveliness and cuteness of a baby harp seal in Paro, "*the baby harp seal was ecologically investigated*" and "*actual baby seal calls were sampled and used*" [19]. However, the shape of animal robots can be classified into three categories, namely "*(1) familiar animals (e.g., dog, cat); (2) nonfamiliar animals (e.g., seal), and (3) imaginary animals or characters*" [19]. Shibata et al. refer to another study of his, capturing subjective evaluations of both cat and seal robots. This study revealed that even though both robots were valued highly, the cat robot received complaints about its softness and reaction compared to the participants' knowledge of real cats. On the other hand, due to the participants lacking knowledge and experience with seals, the participants were unable to compare the seal robot to that of a real seal. This resulted in the seal robot being evaluated higher after the interaction. Thus, revealing the favorable acceptance of unfamiliar animal shapes.

In terms of robot therapy and its target group, Shibata et al. further state that since many elderly experience a decline of their physical strength and healing capability due to aging and illness, the robots should be "*easily accepted by people and also be harmless and hygienic*" [19]. Therefore, the robot's safety must be considered as the intended close and physical interaction through hugging and touching could otherwise potentially be harmful. Safety measures such as giving the robot antibacterial and dirt-resistant fur, providing an electromagnetic shield to the internal circuit to prevent it from affecting heart pacemakers, in addition to a "*withstand voltage test, drop test, 100,000 times stroking test, and a long term clinical test*" [19] were taken in order to assure that Paro was safe and durable.

Paro can also be referred to as a mental commitment robot. A mental commitment robot is described by Shibata et al. as a robot that is "*not intended to offer people physical work or service*", but that their function is to "*engender mental effects, such as pleasure and relaxation, in their role as personal robots*" [19]. Like living organisms, these robots receive stimulation from the environment, and thus "*actions that manifest themselves during interactions with people can be interpreted as if the robots had hearts and feelings. Mental commitment robots can stimulate the different senses of human beings through physical interaction. Therefore, the primary characteristic of mental commitment robots is nonverbal communication*" [19].

Since these robots would be used by doctors, nurses, therapists, caregivers, and volunteers whenever they want, "*the robots are designed in such a manner that anyone can operate them, and that no specialized knowledge is required to do so*". In addition, Paro can learn the name of which users apply to it. This allows its users to "*gradually build a relationship with it, thus preventing them from losing interest and in turn encouraging them to show their affection for Paro*" [19].

As a result of a long-term experiment conducted in 2003 with approximately 10 elderly people interacting with Paro for 1 hour, twice a week, the feelings of the participants had improved over the year, measured level of depression had reduced, caregivers had reported an increase in laughter and activity among the elderly, facial expressions had changed and become brighter, the participants had been looking forward to each interaction with Paro and people who were usually withdrawn had willingly come out of their room to join the interaction. In addition, the interaction with Paro had encouraged communication between the elderly and the caregiver as it had become a common topic of conversation. At the time of writing the article (2009), Shibata states that approximately 1,500 Paros had been sold worldwide "*(about 1,300 in Japan, 100 in Denmark, and 100 in other countries)*", that Paro was highly accepted and that similar psychological effects had been shown in each country. Moreover, cross-cultural studies with data obtained from over 1,800 respondents from seven different countries (Japan, UK, Sweden, Italy, Korea, Brunei, and the USA) provided overall high scores on the subjective evaluation of Paro, which further revealed that "*the seal robot could be widely accepted despite cultural and religious differences*" [19]. However, he also mentions cultural differences on acceptance of Paro in which Paro would be more accepted as a therapeutic tool in Europe, as a companion in Japan and as both in the USA. Thus, "*it is important to introduce Paro in a suitable manner based on the cultural differences*" [19].

In 2002, Shibata et al. published the research "Robot Assisted Activity for Elderly People and Nurses at a Day Service Center", looking into the use and effect of animal type robots through applying them to a day service center for a period of six weeks [20]. The experiment had 26 female participants (73-93 years old) of whom 10 had some degree of dementia, ranging from low to high, while 16 showed no sign of dementia. The robot interaction activity evolved around groups of 8 people or less seated at a table with the robot placed in the center. The interaction time was between 20-40 minutes, depending on the will of the participants.

In their research, animal type robots that give mental value to human beings are referred to as "mental commit robot". The effect of the interaction was measured through a face scale representing their internal emotional state on a range from 1 (most positive mood) to 20 (most negative mood), a manipulated "Profile of Mood States" (POMS) questionnaire and comments from the nursing staff. The face scale and POMS were given to the participants before and after each session interacting with the robot. As a result, the experiment found that the face scale average varied between the scores 3.0-5.3 before the interactions while measuring a constant of about 3.0 after the interactions over five weeks. The POMS score showed an increase of vigor and that "*most elderly people didn't feel high tension-anxiety or depression-defection in this investigation*" [20]. As for the comments given by the caretakers, it was mentioned that the robot interaction showed an increase in conversations between the patients, a brighter mood, and a willingness to stay longer than usual at the day service center. In addition, six care workers were investigated throughout the experiment using a burnout scale questionnaire to see how the robot activity affected them. The experiment obtained statistically significant changes showing that the "*mental poverty of the nursing staffs decreased by robot-assisted activity*" [20].

In 2015, Masayoshi, the creator of Babyloid which is the "prototype/predecessor" to Smibi, published an article called "A Robot as 'Receiver of Care' in Symbiosis with People" [21]. According to Masayoshi, Human symbiotic robots are required to have features divided into four categories, namely functionality, stability, robustness, and usability. Human symbiotic robots must be able to "*coexist in the environment in which people live and have an interactive relationship with people*" [21]. In terms of therapeutic robots, the robot must have an "*interaction-oriented design that strongly appeals to a person's feeling*". The relationship must go both ways so that both the robot and the human can process the information received from the other. Masayoshi states that a robot having the function for "*prompting emotional responses is called a therapeutic robot*" [21]. Masayoshi describes Babyloid as "*a baby robot designed to be incapable of doing anything on its own. It can have a therapeutic effect by inducing in an elderly person a feeling of wanting to take care of it and of having something to live for by doing so*" [21]. The Babyloid differs from typical human-robot interaction in the way that, like real babies, the robot is the care-receiver. Babyloid does not try to understand the human's "*emotions and requests*", but the human must understand the robot. Basing Babyloid on a human baby allows for the one-way interactions, being a symbol of a care recipient and a simplistic way of conveying information through expressions and noises.

In contrast to what might be expected to hear from parents with young children, Babyloid's purpose is to "*relieve the psychological stress of elderly people and patients needing long-term care by having them take care of it*" [21]. Like real babies, Babyloid expresses its psychological and physiological "instabilities" and discomforts through facial expressions, movement, and noise, which allows the caregiver to observe, understand and take means of action to improve the robot's condition. Masayoshi wanted to arouse and use this instinct, urge or perhaps the joy of taking care of someone in Babyloid's Human-Robot Interaction (HRI). Thus, the aspect of "helplessness" has influenced the design of the robot through its appearance and visual lack of features such as having no legs and short arms. Furthermore, Babyloid's face has been based on the motif of a beluga whale, thus personifying a "neutral" animal in an effort to restrain unpleasant expressions and eliminate bias. As for its body, Babyloid was made soft and to exude warmth. The Babyloid prototype was about 44 cm long and about 2.2 kg in weight, making it slightly smaller than an average human baby to compensate for reduced strength in elderly people. Babyloid has LED's in its cheeks and a speaker to show emotions, motors in its arms, neck, mouth, and eyes, a variety of sensors including an accelerometer, temperature sensor and touch sensors in its arms, stomach and back, in addition to a camera and microphone to recognize its surroundings.

The robot was evaluated in terms of acceptance and rejection in an experiment with five elderly female participants with no cognitive impairment according to a Mini-Mental State Examination (MMSE), at a welfare facility. Their mental state was examined as "*impaired cognitive functions include (1) easily accepting non-living objects, and (2) having difficulty becoming tired of doing something as a result of forgetting what one has done*" [21]. The participating subjects were evaluated through a Geriatric Depression Scale (GDS) before and after the test period of two weeks, Face Scale after every time the subjects used the robot, interview survey after the test period, behavioral observations through the robots sensor data, and MMSE before the test period. As a result, a statistically significant difference was found in the GDS, suggesting the interaction with Babyloid could reduce depression. No significant difference was found in the face scale, although their mood seemed to be very good after the interaction. The time spent interacting with Babyloid each time was 7 minutes on average and participants often spent more than one hour every day with no indication of decrease over a two weeks long study period. Four out of five evaluated Babyloid positively with a suspicion that the one negative evaluation was due to the experimental conditions and not necessarily the robot. Words such as "healing" and "fun" were used to describe the experience, and interactions with Babyloid included singing to the robot, watching television together and sharing personal thoughts among other things. Masayoshi stated that "*From these evaluations, there is the possibility that for three subjects, Babyloid was not simply a 'babymodel robot', but existed as a type of life partner who could transform daily life into a fulfilling one"*, and that *"Babyloid is expected to promote greater psychological exchange in people than baby dolls*" [21].

A study from 2018 looks at the use of Pepper for elderly care and rehabilitation [22]. The results from "*observation, actigraphy and heart rate variability (HRV) […], suggested that persons with dementia showed positive correlations between activity level of the sympathetic nerve and activity count of actigraph in a wakeful state*". "*This suggests that the Humanoid robot might be able to stimulate improvement of the quality of life of elderly people*" [22]. Thus, the presence and engagement of Pepper has documented beneficial effects, although the study does not mention the number of participants.

José Rocca published research in 2017, analyzing relevant underlying theories, the empirical literature, and the commercial products available for state of art care robots in order to understand requirements to provide "*good quality of life to their users in a home-based environment*" [23]. Although there are different ways of defining robots, Rocca defines a robot as a "*computer system that is physically embodied and present some level (partial or full) of autonomy*", and a care robot as "*a robot designed for use in home, hospital or other setting to assist in, support or provide care for sick, disabled, young, elderly or otherwise vulnerable persons*" [23].

Among several robot categories such as enabling robots that per definition "*enable or enhance the performance of an action by the human*" and replacement robots which try to "*substitute a human by executing the task by itself*", Rocca states that we can find two sub-categorizations to assistive robots which "*aid the human to execute some task without the direct control or input from the human*". "*On one hand, there are rehabilitation robots that help a patient to overcome some kind of physical impairment, for example intelligent wheelchairs, artificial limbs or exoskeletons [...] On the other hand, there are social assistive robots which give companion like pets or provide services to cue the patient to take their medicines*" [23].

Rocca's research tries to answer three main research questions on whether there should be one multipurpose robot or multiple robots for different purposes, whether robots should be close and personal or cold and distant, and potential ethical issues connected to Care robots. As there are advantages and disadvantages to having both multipurpose robots or multiple robots, a multipurpose robot is generally much more expensive, while multiple robots have a lesser notion of presence and create less attachment, something that can be advantages in terms of potential ethical issues. As for the kind of relationship users will have with robots, Rocca states that "*in order to generate empathy and a strong connection with the user, the robot should adapt its behavior to the user routine by creating an internal model of the user. More complex interactions, ones of social kind, will require more information about the user, less complex interactions and capabilities, will require less information*" [23].

Finally, regarding the ethical issues, Rocca identified safety, privacy, loneliness, and autonomy as among the most important issues from the literature. In addition, he suggests that the development should be more user-centered since the current "*robotic industry is capability focused and this is generating big gaps with the final user needs*" [23].

2.3.3 Do people feel empathy towards robots?

An article from 2014 investigates "empathy towards humans and robots using fMRI" [24]. Functional magnetic resonance imaging (fMRI) was used to study and objectively measure subjective brain activity associated with emotional processing and reactions in the brain. This method was used in order to "*directly compare neural activation elicited by human and robot stimuli*" [24]. In addition, fourteen participants aged between 20-30 years old were asked to self-report their emotional state. The experiment exposed participants to videos of three conditions being human (Human-Human Interaction "HHI"), Ugobe's Pleo baby dinosaur robot (Human-Robot Interaction "HRI") and a cardboard box (Human-Box Interaction "HBI") being treated both nicely/affectionately and violently.

The fMRI results indicated that the participants reacted emotionally to both the affectionate and violent behavior shown in the videos of all three conditions. This was further supported by the participants' self-reported measurements that showed feeling more positive after watching the affectionate videos and more negative after watching the violent videos. Being a significant difference in the negative affect for both the Human-Human Interaction (HHI) and Human-Robot Interaction (HRI) condition. It was not found any significant difference in terms of activation patterns from the fMRI results between the different treatments of the human, robot or the box. However, there was found "*significant differences in the right putamen when exclusively comparing the negative interaction video sets (HHI-neg > HRI-neg)*" [24]. The right putamen being a structure of the brain that according to the article, can be associated with empathy and emotional distress. This supports the self-reported results that people evaluated the HHI violent video more negatively compared to the HRI condition.

The article also mentions that "*further investigations on empathy towards robots should feature different kinds of robots, especially humanoid robots, because we do not know how the robots appearance and abilities might influence participants' empathy towards it*" and that "*if the torture of the robot had been performed live in front of the participants their reactions could have been different. This would be a very interesting research question for future studies using self-report and psychophysiology*" [24].

Another study was published in 2012 titled "Subjective Evaluation of Use of Babyloid for Doll Therapy" [25], Babyloid being the predecessor of Smibi. Doll Therapy is another type of effort to slow down the progression of dementia by interacting with a baby doll. The act of nursing a baby can evoke old memories or reimagining the childcare experience. This will create "*feelings that activate their thinking and reasoning processes*" [25]. For this study, elderly people were asked to fill out an evaluation survey of both Paro and Babyloid in a nursing home back in 2010. The results found that Paro and Babyloid were rated similarly on *appearance*, *enjoyable* and *impression* (favorable or unfavorable), but Babyloid was rated significantly lower on *movement* (natural or mechanical), *feel better* (playing with the robot made me feel better) and on *wanting to take care of it*. However, some people prefer babies over animals and vice versa, so the robots might have different advantages for different people.

2.4 Japanese Robotic History and Culture

Japan has a history with "robots" that goes back more than 200 years to the Edo period (1603-1868). "Karakuri puppets" are traditional Japanese mechanical "wind-up" puppets and a prototype to robots, that run without electricity, but on coil springs and gears. The Karakuri puppet pictured below (left) was used to serve tea, driving towards a person until the teacup sitting on the serving board are lifted. When regaining the extra weight pressure from the teacup, the robot will start driving again, turn around and go back in the direction of which it came from.

Figure 4. Karakuri Puppets

For some reason, robots have merged successfully with Japan's modern culture and are often used as a mean of advertisement. In addition to raising statues and dedicating coffee shops to popular robots from anime, Japanese companies are using and associating robots with the popular sushi chain Hamasushi (はま寿司), taxi companies and nursing homes to name a few. The temple Kodaiji located in Kyoto has even gone as far as preaching Buddhist teachings through an android priest. As for the other big religion in Japan, it should be mentioned that Shintoism involves the belief that everything can be possessed by a god, and some argue that this "animistic" belief is related to Japan's acceptance of robots, although this is still just speculation.

Figure 5. Pepper working at the sushi restaurant chain Hamasushi.

Figure 6. RoBoHon on a poster as a concept for a taxi company.

Figure 7. Statues from Gundam (animation show) in Expo city - Osaka.

Figure 8. Poster for the android priest used at a temple in Kyoto.

Chapter 3

Methodologies and Methods

To acquire knowledge about the use of robots, several sources of information were considered. For that purpose, we needed several methods in order to properly gather information and analyze it. This chapter presents and explains the methods used in this study.

The framework used in this study is Design Science which responds to questions from the real environments and offers practical answers and solutions for the research questions.

Design Science has three cycles, environment, Design Science Research and knowledge base [26]. Environment refers to the environment using robots, mainly in nursing care, while the knowledge base concerns the methods and expertise used to build the artifact(s). The main artifact was a theory about robots, what makes them appreciated with users and what is considered during their development. This study had to combine several methods to outline the theory and paint the bigger picture.

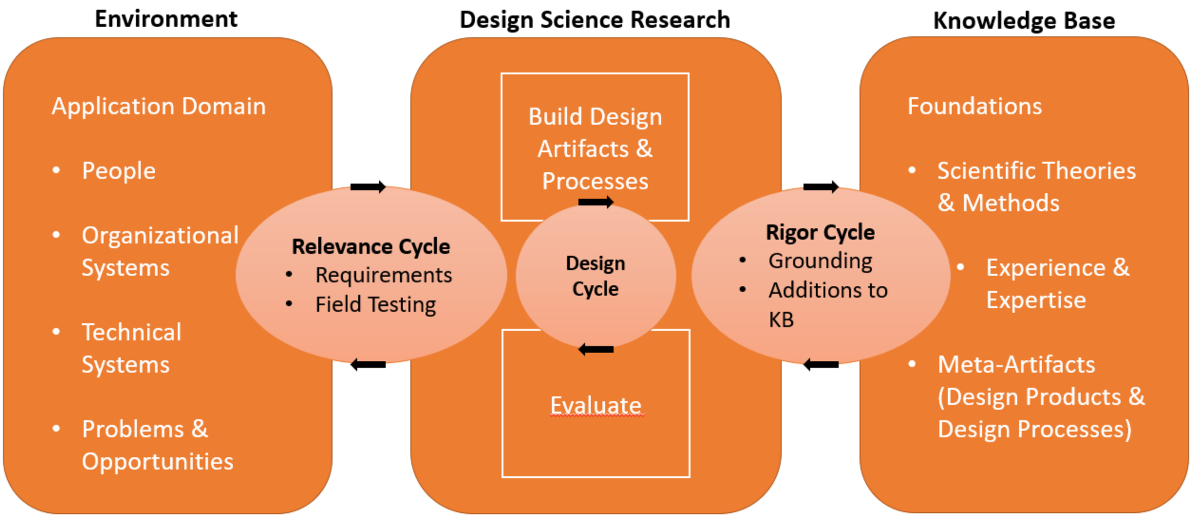

Figure 9. Design Science Research Cycles

3.1 Mixed Methods Study Design

Typically, a researcher needs to select one out of three research strategies, namely quantitative, qualitative or mixed methods study, each holding their own set of pros and cons. A quantitative study is good for large data sets and often deals with the data through numbers and statistics. Methods such as experiments and surveys are popular within a quantitative study, but often consist of close-ended questions with little room for further exploration or discoveries. A qualitative study, on the other hand, is good for gaining depth and detail through methods such as semi-structured interviews or case-studies.

This project investigates robots, human-robot interaction and their role in Japanese society with a special focus on nursing care. Since people outside of Japan know rather little about this topic and it is a big field of research, it was important to carefully define research goals. Generally, topics on robots are very interesting and futuristic by many standards, but rather demanding. The research goal was to collect knowledge from all the relevant sources such as researchers, developers, and users of such robotic entities, which influenced the choice of both qualitative and quantitative methods. Therefore, we considered using methods such as semi-structured interviews, case studies, experiments, and observations.

Mixed Methods Design is a combination or integration of both quantitative and qualitative research and data [27]. This approach allows us to build onto, build into, explain or explore one database with the other, meaning that one could apply a qualitative approach to follow up, further validate or explain quantitative results or vice versa. The study does not need to put equal or unequal emphasis on either of the phases.

There are different models to follow within the mixed method design and this research follows the "Exploratory sequential mixed methods" model. This model initially starts with qualitative research and uses its data to identify important information and categories that can be further analyzed in depth through quantitative studies.

In the fieldwork, the "Convergent parallel mixed methods" model was also applied to allow merging quantitative and qualitative data coming from different methods that were performed in parallel. For example, semi-structured interviews were carried out in parallel with experiments and case studies. The merging of the methods enabled a comprehensive analysis of the research problem. This meant that qualitative and quantitative research could be performed separately or parallel to compare or relate the results into an interpretation [27].

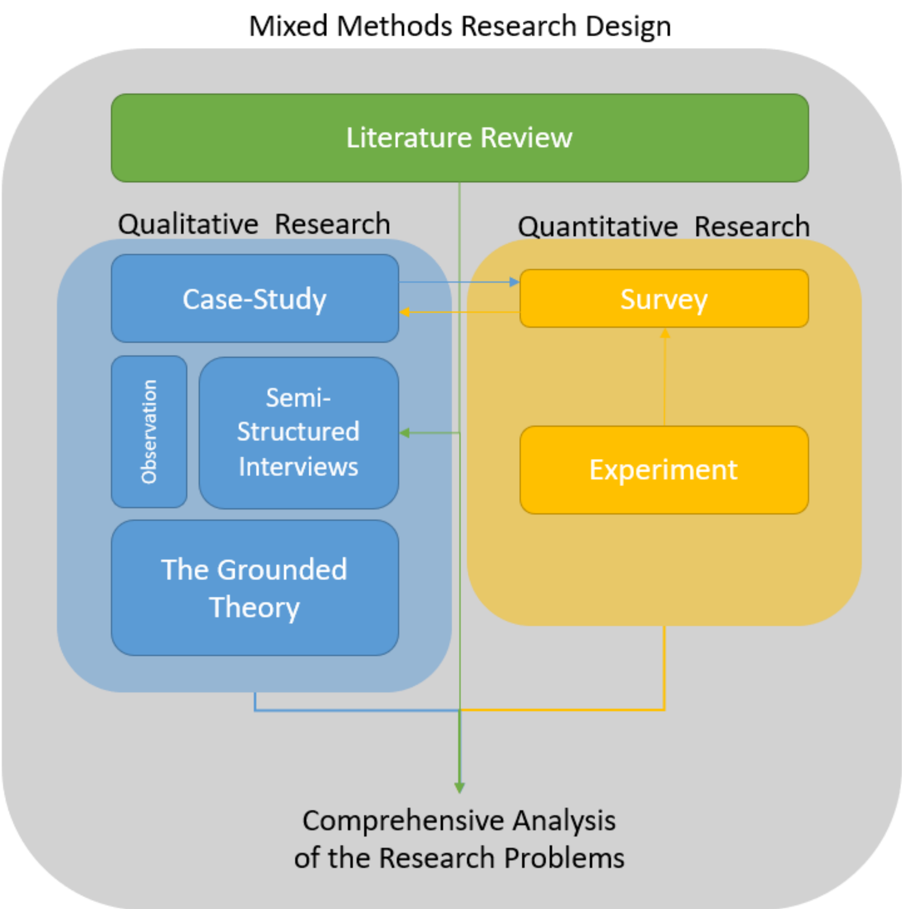

Figure 10. The outline of the methods used within this research study's Mixed Methods Research Design.

3.2 Data Gathering

Data gathering is no easy task in a foreign country with a foreign language and alphabet. Every survey, interview, participation informed consent, etc. had to be translated from English to Japanese and then back to English in order to obtain, process and analyze the data. A mix of both qualitative and quantitative methods has been applied within this research project. In order to learn about how robots are made, how they are used and what effect they have on the people involved, qualitative methods were applied. Information and data for the qualitative research methods have been gathered from university professors, university students, nursing home managers, workers, and patients as well as robot developers and company spokesmen with a translator present during half of the data inquiring sessions. However, it can be challenging to get in touch and schedule interviews with the relevant sources, which in this case involved a lot of traveling for face to face meetings. Quantitative research methods, on the other hand, often involve less time-consuming data gathering, especially with the help of closed-ended questionnaires answered by a larger number of participants.

3.2.1 Literature Review

A literature review is searching through, collecting and analyzing already published literature on the research topic [28]. This method usually involves searching through online libraries using keywords in order to find articles, books or other relevant documents. The resulting summary presents what is already known, documented and what research methods have been applied, but also gives a sense of what is missing regarding the research questions and topics.

3.2.2 Semi-Structured Interview

Semi-structured interviews are interviews that gather qualitative data and often involve a pre-prepared interview guide with a set of topics or questions that can be asked and answered openly depending on each interviewee's knowledge and/or willingness to disclose information. Pre-planned questions or topics can often be used for comparable data but can also easily generate new or follow-up questions that were not planned in detail. Depending on the talking points as well as on the interviewees, the interview can often last from 30 minutes to several hours.
In this study, all interviews were recorded and later transcribed manually after the informed consent was signed. Since interviews were held with company spokesmen and nursing facility managers, we could anticipate some bias due to business interests. The interview guides used in the research followed the guidelines of the Norwegian Center for Research Data (NSD) [29] and the method was used for interviews with professors, developers and nursing facility workers. An interview guide can be found in Appendix A.

3.2.3 Data Analysis in Qualitative Research

Since the data gathered from the interviews are so dense, the data must be "winnowed", "*a process of focusing in on some of the data and disregarding other parts of it*" and aggregated into a smaller number of themes [27] (p.195). This is the main approach in Qualitative Data Analysis that looks for patterns, most significant information and eventually how the resulted data are related.

3.2.3.1 Qualitative analysis of semi-structured interviews on integrating socially assistive robots into Japanese nursing care

We visited three different Japanese nursing facilities in order to see how robots are being used, what impact they made on the nursing care and what positive or negative experiences the elderly and staff could share. The interviews focused on communication robots, being one of the newest items introduced into care as one of the government's priority areas in 2014 and whose development has been supported since 2017 [17].

The three nursing facilities were chosen as the study sites from a public list of nursing facilities using the robot *Paro* published by a company selling *Paro* [30]. Potential study sites were contacted via e-mails or letters. Two nursing homes in Hyogo prefecture and one day care center for elderly in Kyoto agreed to participate; all relatively close to the Ritsumeikan University Biwako Campus. The interviews were not limited to *Paro* exclusively but rather aimed at acquiring information on all interactive robots used at each facility (*Paro* was used at all 3 facilities, *Pepper* at two, and *Qoobo* at one). The interviews were primarily held with the facilities' managers, nursing staff, or both, to canvas opinions and experiences on using and integrating the robots into the care. Brief conversations were held with patients, but not recorded due to privacy and ethical concerns. Two of the interviews were conducted in Japanese and one in English. The interviews were transcribed and analyzed using open coding as a part of the qualitative data analysis.

Both the robots Pepper and Paro can be found in Section 2.3. *Qoobo* is essentially a round furry tailed cushion weighing approximately 1 kg [31], originally developed for elderly people living in facilities that do not allow pets. *Qoobo* responds to non-verbal interactions such as stroking and petting and sells for 180 USD [31].

3.2.3.2 Content Analysis

In short, "*qualitative content analysis is defined as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns*" [32]. The content analysis within this study refers to the analysis of transcribed interviews, where the goal was "*to provide knowledge and understanding of the phenomenon under study*" [33] (p. 314).

3.2.3.3 Coding

Coding is a central and important part of the analysis and refers to the process of going through documents or texts to create and label smaller categories. When going through long transcripts from qualitative interviews, it could be helpful to break down the content and sort different pieces of data under appropriate categories, topics, questions or importance. Some of the codes might describe the same thing or be related to other parts, thus multiple iterations through both text and codes can help to better sort, connect and group data. On the downside, however, when cutting and moving data fragments, the context and social setting could be lost in the process. We can distinguish between three types of coding in a grounded theory approach, namely open coding, axial coding and selective coding [28]. Each practice builds upon the previous starting with open coding. Open coding is the initial process of "*breaking down, examining, comparing, conceptualizing and categorizing data*" [28]. Axial coding is putting the data back together in new ways by making connections between categories through linking codes to context, causes, etc. The final practice is Selective coding which is the "*procedure of selecting one core category, systematically relating it to other categories, validating those relationships, and filling in categories that need further refinement and development*", whereas a core category is a "*central issue or focus around which all other categories are integrated*" [28] (p.568-569).

3.2.3.4 Self-developed Content Analysis Tool - *Konta*

A content analysis tool "Konta" was developed for the purpose of categorizing data according to the content analysis specification. The tool imported all coded interview transcripts and converted each part of the text into an object holding the interviewee's name, assigned codes and the original text. All text segments holding the same code could then be easily organized to a list, allowing the user to access and only focus on the segments under a chosen code. This means that all text with the same code from multiple interviews were automatically grouped together. Since one segment of text could hold several codes, for example a sentence talking about both the design and interaction (codes: design, interaction), the program allowed to register individual summaries for each code. In other words, the part of a sentence specifically talking about design could be saved as a summary under the "design" code, and the part of the sentence talking about interaction could be saved as a separate summary under "interaction". However, the full original text would still be available in order to preserve the context.
The tool was developed in Java using Eclipse (Eclipse IDE for Java Developers Version: 2018-09 (4.9.0)).

3.2.3.5 The Grounded Theory

"*Grounded Theory is a design of inquiry from sociology in which the researcher derives a general, abstract theory of a process, action or interaction grounded in the views of participants*" [27].

Grounded Theory is a research method "*appropriate for studies seeking both rigor and relevance*" [34], that tries to build up a theory from a dataset, or a theory grounded in the data. "*While grounded theory is mainly used for qualitative research, it is a general method of analysis that accepts qualitative, quantitative, and hybrid data collection from surveys, experiments, and case studies*" [34]. In total, the transcripts made from all the interviews resulted in tens of thousands of words to be processed and analyzed in order to build a theory. This process usually starts with open coding which refers to finding and assigning codes (names) to pieces of information that later evolves into categories as the process continues throughout the input data. The "*nature of Grounded theory is a powerful and satisfying feature of the research method; it allows flexibility and continuous sharpening of emerging constructs via deep familiarization with data, validation, and progressive expansion of knowledge and skills*" [34].

3.2.4 Experiment on Empathy-level Comparison Between Smibi and Paro; Doll and Robot

This somewhat sensitive experiment aimed to explore differences in empathy towards robots and dolls (robot when turned off) when exposed to mistreatment. Mistreatment refers to holding hands over the robot's eyes, holding it upside down, poking it with a pencil, chocking it with a plastic bag, etc.

The two robots Paro and Smibi (Figure 11) were used for this purpose, the participants were divided into four groups based on the robot's order of introduction as shown in Table 1. After each introduction, the participants were asked to fill out a questionnaire/self-report of how the mistreatment affected their feelings.

Figure 11. Picture of Smibi (left) and Paro (right). The picture in the top right corner shows an example of mistreating the robot.

Paro, which is a robotic baby seal, can move its head, mouth, eyelids, flaps, and tail and make seal-like sounds. Paro responds to being petted through moving and making sounds but have no other display of emotions. Smibi, on the other hand, is a human whale hybrid baby robot capable of moving its head, mouth and blinking its eyes. Smibi can display sad, neutral or happy emotions through a large library of actual real baby sounds and simple animations like crying or blushing on its face. Besides, to see whether humans have empathy towards robots, the experiment also aimed to investigate the degree of which the movement and sounds will affect people's level of empathy towards it. Assuming that people have empathy towards robots, the experiment had two hypotheses to explore:

- People will score higher on empathy and feel a stronger need to take care of a robot rather than a doll.
- The human voice, laughter and crying sound in Smibi will have a greater effect on the participants' empathy than the relatively neutral emotions of Paro.

Both Paro and Smibi are essentially dolls/stuffed animals with motors and sensors. Both robots and dolls are being used for therapy in nursing homes. However, there is a big price difference between the two. By switching the robots on, we hypothesized that the animation will bring more life to the entity, thus resulting in a higher score on the empathy scale. Since therapeutic robots are things, it can be assumed that there is something about robots that makes people feel a greater need to care for as compared to ordinary dolls.

The independent variables of the experiment were the robot type (*Paro* or *Smibi*) and state (*ON* or *OFF*) of the robots. The dependent variable would be the degree of empathy towards the robot. The experiment had a total of thirty-four (N=34) participants who were randomly divided into the different groups holding 8 or 10 participants. Each group was assigned an order in which the robots would be introduced to the participants as shown in Table 1, to secure the validity of the experiment. The participants would partake in the experiment in smaller groups of two or three people being called into a private room (four iterations for each group) and asked to sit down in front of a table. The participation time was about 15 minutes, demanding approximately 4-5 minutes for each robot.

Group 1 Participants: 8	Group 2 Participants: 8	Group 3 Participants: 8	Group 4 Participants: 10
Baseline Questions	Baseline Questions	Baseline Questions	Baseline Questions
Smibi OFF	Paro OFF	Paro ON	Smibi ON
Questions	Questions	Questions	Questions
Paro ON	Smibi ON	Smibi ON	Paro ON
Questions	Questions	Questions	Questions
Smibi ON	Paro ON	Paro OFF	Smibi OFF
Questions	Questions	Questions	Questions

Table 1. Empathy Experiment and Group Structure

"Baseline Questions" concern empathy towards people, "Questions" concern empathy towards robots.

Empathy can be a difficult thing to accurately measure but using the same "empathy measurement" questionnaire for the robots when turned ON and OFF, would allow for comparing the answers and conclude thereafter. The questionnaire used in the experiment is based on the "Toronto empathy Questionnaire" [35]. However, in order to apply this questionnaire to robots, it had to be modified and certain questions had to be removed. At the baseline, each participant was first asked to fill out a questionnaire closer to the original "Toronto empathy questionnaire" regarding people in general. The participants did not witness any mistreatment towards real humans before filling out the baseline questionnaire. After establishing the baseline, the participants were introduced to the first robot and offered to hold it before witnessing its mistreatment. After witnessing the mistreatment of each robot, new questionnaires were then given to the participants. Lighter mistreatment was continued while the participants were writing down their answers.

The scoring system for each question ranged from 0 to 4 points, with 4 points being the most empathic. In addition, two more statements separate from the empathy questionnaire were included and had a scoring system from 0 to 2. The participants where discouraged from discussing the answers with each other and were meant to fill out the questionnaire individually.

The experiment was executed as a laboratory experiment within a controlled environment. The advantage of conducting a laboratory experiment is that the experimenter gets to have greater control over the experiment, as well as making it easier to reproduce. However, a laboratory experiment could be inferior to a field experiment and can result in a poor ecological validity in which the findings might not apply to any real world setting or context [28] (p.55). The participants knew that they were in an experiment, but not what was going to happen, nor the aims of the experiment. However, most participants understood what was going when asked to fill out the second questionnaire after witnessing the mistreatment of the first robot. The participants in this experiment were young students and not exactly the target group for the robots used (elderly, patients with dementia), but we assumed that anybody could have empathy towards robots. Younger people like students could easily follow the experiment instructions while being aware that the experiment did not mistreat real creatures (animals or babies), thus avoiding any potential and genuine distress that elderly and demented could experience.

As for internal validity, we must assure that potential changes in the dependent variable is the result of changes in the independent variable, rather than something else [28] (p.50). Therefore, the experiment went through several repercussions to validate the results as much as possible. Even though the experiment was held over several days, each participant was brought in during normal work hours. To prevent social desirability (answering questions in a way that puts the participant in a better light), each participant was given a group number and an id for anonymity. Each questionnaire was self-completed on paper and quickly collected to avoid sharing answers among the experiment group members.

To deal with any potential order effect, each group was presented with the robots in a different order. If the participants were all presented with a turned-on robot in the beginning, there might be a risk of that experience influencing their answers on the next robot that is turned off. Thus, having groups with different orders would help avoid bias in evaluation.

As for external validity, all participants were university students, and their answers would likely differ from elderly or people suffering from dementia. However, the group consisted of both Japanese and Chinese students, both male and female to better generalize the results. There might also be differences found between cultures across the world.

3.2.5 Case Study

A case study is a research method that is typically used to study or develop a detailed and in-depth analysis of one entity, a person, a group or a specific or isolated case [27] [28] (p.66,709).
Two separate case studies were conducted, one investigating human robot interaction with students and the other investigating the role of humanoid robots in education with pupils.

3.2.5.1 One-Shot Case Study - Chatting up with Pepper

The one-shot case study design "*involves an exposure of a group to a treatment followed by a measure*" [27]. The study was designed so that a group of participants were individually exposed to a human-robot interaction with the robot Pepper. Shortly afterwards, they were asked about how they felt about the interaction.

A total of 17 participants (N=17) were recruited, ranging from 21 to 28 years (mean: 22.23, median: 22), of which 11 were male and 6 were female, 12 were Japanese and 5 were foreign students. All students had at least a basic level of Japanese knowledge as the interaction/conversation with Pepper could only be held in Japanese. All participants were recruited from different laboratories within the Information Science and Engineering Faculty building at Ritsumeikan University Biwako Campus.

To avoid bias, each participant went through the study individually. The total number of 17 participants were deemed representative of the student group.

The "case" in this research focused on the attitude, challenges and opinions of the students concerning interacting with SoftBank's social robot "Pepper", one of the most popular and commonly seen robots in Japan. Pepper operated in "demo mode", meaning the default mode of Pepper without any extra applications installed. There was no specific practical task to be completed other than shaking hands and having a chat with Pepper.

Each participant was given between 5 to 10 minutes of interaction time with Pepper, followed by an interview and a questionnaire. A total of 20 to 30 minutes was therefore spent on each participant.

Here are the study instructions as given to the participants:

1. Introduce yourself to Pepper.
2. Try to shake Pepper's hand.
3. Ask Pepper two questions of your own choosing.
4. Ask Pepper two questions about Pepper (itself) of your own choosing.
5. Make small talk.

If a participant did not understand how to interact with Pepper, an expert would step in to explain how Pepper displays his attention through the change of color around its eyes.

During the interview, the participants were asked about both good and bad things concerning the interaction, as well as personal views, experiences, hopes, and worries around robots now and in the future. A possible limitation could be the request to make conversation while being observed as it could be anticipated that some participants would be uncomfortable and hesitant to eagerly engage in the conversation. However, this study did not allow for a more elaborate study setup but had relied on the fact that Pepper should be intelligent enough to conduct a chat.

The robot had to be restarted several times due to technical difficulties. However, today's robots are not perfect and the fact that the robot did not work perfectly can arguably be an accurate example of what the interaction with a robot might be alike. Thus, this situation was not considered to be a complete failure as people are used to resetting computers and other technical devices.

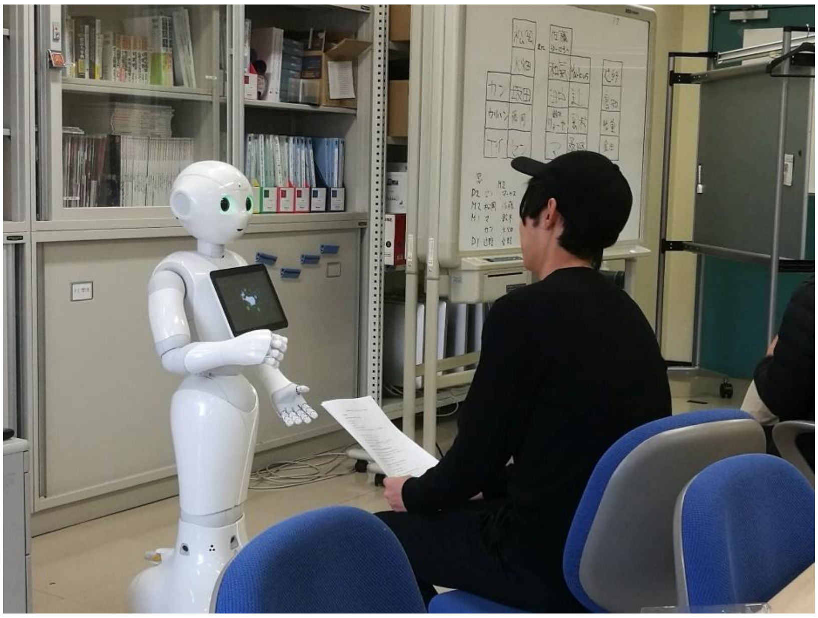

Figure 12. Interaction between a student and Pepper in the "Chatting up with Pepper" Case Study.

The purpose of the questionnaire was to make the participants give a score to different factors about Pepper and the interaction. The score ranged from one to five, one being the lowest/most negative rating, 3 being neutral and 5 being the highest/most positive rating. The numbers would then ideally be useful to find connections and hidden values in and between the different factors such as design, trust, frustration and so on, using coefficient correlation.

When analyzing the coefficient correlation results, keep in mind that a positive relationship means that two variables are moving in the same direction and that the scores given could be both high (positive) and low (negative). As for negative relationships, this means that two variables are moving in the opposite direction, meaning that if one variable score high, the other variable is likely to score low, or vice versa.

3.2.5.2 Case Study – Pepper in Primary School Education

We have joined a Japanese primary school's 6th-grade class and observed the use of five active Pepper robots simultaneously, spread throughout the classroom to assist the pupils in their programming class. A total of 9 pupils selected by the teacher participated in a group interview to investigate Pepper's role in the school. Questions were given with options and answered through the raise of hands. The pupils also got the chance to discuss or justify their answers. Since this was a group interview, a possible bias could be that the pupils could influence each other's answers. However, this seemed not to be the case and the pupils insisted on their individual opinions and reasons.

3.2.6 Observations

When visiting nursing facilities and robot developers, we got the chance to observe the robots in real life through a so-called in-field observation. In nursing facilities, we got to see patients interacting with the robots, the way they were used, and the way patients reacted to them. When meeting with the robot developers, we were shown a showcase of the robots, what functions they had and how the human-robot interaction worked. When visiting the primary school using Pepper for educational purposes, we have seen the utilization of robots in the classroom. The observation method was useful to gain a better understanding of how robots perform in real-life settings.

Chapter 4

Field Related Requirements

This chapter informs about the ethical considerations and the proper approval acquired to collect and use the data gathered from the study participants. The inform consent was handed out to all participants to explain necessary information about the research, their rights, privacy and the possibility to withdraw at any time. The Norwegian Centre for Research Data (NSD) approval can be found in Appendix A.

4.1 Target Group

The information that this research will disclose can be relevant for several target groups including researchers, robot developers, users, and future robot investors. The robots described within the study have their own specific target groups, and each additional application that the robots might support have their own separate target groups. Some of the robots might not be used by the person that has the robot in their possession, but as a surveillance tool for healthcare professionals or family.

4.2 Research Participants

This research has engaged a total number of 69 participants across all the studies as described below.

4.2.1 Experiment and Case-Study Participants

The participants for both the "Empathy-level Comparison Between Smibi and Paro; Doll and Robot" experiment and the "Chatting up with Pepper" case study were recruited through one of Ritsumeikan University's laboratories at the College of Information Science and Engineering. In both cases, each participant was given an ID for anonymity and only age and gender were registered. All participants were students at the university. The total number of participants in both these studies combined was 51.

In the case of the "Pepper as a Tool of Teaching in Primary School" case study, a total of nine pupils were chosen to participate by the subject teacher and no personal information was registered.

4.2.2 Academic Staff

Three university professors accepted to participate in this research and were contacted by the Associate Professor Nishihara based on their topics of interest and online publications. The professors worked at three different universities in Japan with their own individual research and different approaches to the field of assistive robots. All professors took part in semi-structured interviews held in English. The participating professors were Professor Kanda at Kyoto University, Professor Nomura at Ryukoku University and Professor Tejima at Ritsumeikan University.

4.2.3 Robot Developers and Company Spokesmen

The robot developers and company spokesmen participating in this research were located in different cities around Japan and represented companies producing the robots Smibi, PALRO and RoBoHon. They were recruited through email with the help of Associate Professor Nishihara. They took part in semi-structured interviews held either in English or Japanese with the help of a translator. Some of the answers given might be the participants' personal opinions and perhaps less representative of their companies' views or opinions.

4.2.4 Field Experts

The nursing facility workers or field experts consisted of the manager and one representative of the nursing staff located in different cities in Japan. They were recruited through letters and emails with the help of Associate Professor Nishihara and her assistant. They took part in semi-structured interviews held in Japanese with the help of a translator. In addition to the semi-structured interviews, we were given tours around the nursing facilities and introduced to the different robot technologies they used. We also had the opportunity to meet patients and observe their interactions with the robots.

Chapter 5

Results

This chapter presents results from the two case studies, one experiment, the content analysis and the grounded theory applied to analyze the data gathered throughout the study.

5.1 Chatting up with Pepper Case Study

The purpose of this study was to gather insight into human-robot interaction using Pepper. Table 2 shows a summary of the participants and parts of their evaluation regarding Pepper.

	Male		**Female**		**Total**
	Japanese	South East Asian	South East Asian	Japanese	
Total	8	3	2	4	17
Has Emotion	**3** **37.5%**	1 33.3%	0	0	4 23.5%
Has Personality	3 37.5%	2 66.6%	**2** **100%**	2 50%	9 52.9%
Would Like More Time	**8** **100%**	**3** **100%**	**2** **100%**	2 50%	15 88.2%
Pepper is Male	**6** **75%**	2 66.6%	1 50%	2 50%	11 64.7%
Pepper is Female	1 12.5%	**1** **33.3%**	0	0	2 11.7%
Pepper has no Gender	1 12.5%	0	**1** **50%**	**2** **50%**	4 23.5%
Iru	6 75%	2 66.6%	1 50%	**4** **100%**	13 76.5%

Table 2. Interaction with Pepper describing emotion, personality, perceptional gender, and perception of Pepper as a living creature, represented by frequency and percentage.

The results (Table 2) show that 88.2% of the participants would have liked more time to communicate with Pepper, even after giving a negative or neutral score to the robot. It was found that 64.7% of the participants considered Pepper to be a male robot, 23.5% considered Pepper as to not belonging to any gender, and only 11.7% (2 male participants) considered Pepper to be female. The data showed little consensual agreement on the gender of Pepper, also between the gender or nationality of the participants. The participants were also asked to motivate their choice of gender. The choice of "male", "female" and "none" had all in common the justification of Pepper's gender through the robot's voice as well as its way of acting. Both the "male" and "none" option was justified through the face.

Similarly, the participants were unable to agree on the reasons as to why they believed the robot to be one of three gender options. The genders assigned by the participants did not seem to significantly influence the likeability, perception of emotions, personality or any of the other factors asked about in the experiment. However, it is hard to generalize this finding since there were only 17 study participants, mainly young and acquiring high education.

When it came to assigning any form of life or soul to the animate humanoid robot, we found that only 23.5% (four male) participants felt that the robot was able to feel/had emotions and 52.9% felt like the robot had a personality. The "Iru" row of Table 2 refers to a question related to the Japanese language and how the words (verbs) "iru" and "aru" are ascribed to different entities based on the perception of the entity being alive or not. Basically, there are two different verbs used to indicate if something exists or not, one of them being "iru", often used for living creatures such as humans and animals, while the other one "aru" is being used for things, events, etc. However, the definition may slightly vary between the Japanese as some draw the line between animate and inanimate objects, while others restrict the use of the word "iru" to something that has a heart. The study found that 83.3% of the Japanese participants, or 76.4% of all the participants, would use the word "iru" for Pepper. It was observed that the majority would have liked to spend more time to answer the question.

One explanation could be that they were not entirely sure about the grammar of their native language, or that they might view a robot as something that is alive. After all, other objects like cars, computers, dolls, machines or even line tracer robots would be referred to with "aru". The "aru"/ "iru" choice was purposefully suggested to get an instinctive answer whether Pepper was alive or not. The question "Is Pepper in this room?" was asked in English while the participants were asked to answer it in Japanese. Ideally, this would be answered with a simple "iru" or "aru" without having to ask which of the two they would use. In case that participants answered "Hai" (Japanese for yes), they were asked to be specific.

Factors	Positive (High)	Neutral	Negative (Low)	Average Scores
Prior Expectation	4	**9**	4	3
Post Rating	6	**8**	3	3.17
Design	**13** **76.5%**	2 11.7%	2 11.7%	3.82
Trust	**6** **35.5%**	5 29.5%	**6** **35.5%**	3
Frustration	4 23.5%	6 35.5%	**7** **41%**	2.47 (1=most frustrating)
Intelligence	4 23.5%	**10** **58.8%**	3 17.6%	3.11
Safety	**16** **94%**	1 6%	0	4.35
Likeability	**11** **64.7%**	5 29.4%	1 6%	3.76
Total	**64** **47.0%**	46 33.8%	26 19.1%	3.33

Table 3. Distribution of giving positive, neutral or negative scores to factors regarding the interaction with Pepper.

After the interaction with Pepper, the participants were asked to rate certain factors and features of the robot such as "*prior expectation*" (how high expectations they have towards the robot prior to the interaction), "*post rating*" (how they would rate the robot after the interaction), "*design*" (Peppers appearance), "*trust*" (trust that the information Pepper provides is correct), "*frustration*" (level of frustration from the interaction like having to repeat questions etc.), "*intelligence*" (how smart Pepper was), "*safety*" (how safe they felt that pepper would not hurt or injure them) and "*likeability*" (how much they liked Pepper overall) as shown in Table 3. As previously stated, each factor was rated on a 5-point scale, 1 being the most negative/displeased and 5 being the most positive apart from *frustration* which was inverted. Table 3 shows the score distribution categorized into negative (1-2), neutral (3) and positive (4-5) scores.

Overall, Pepper was scored mostly positively with 47% high, 33.8% neutral and only 19.1% of the scores being low scores. However, only *safety* had a clear average high score, frustration had a low average and the rest being neutral. During the interaction, Pepper believed the current date was two years back in time. This is a limitation to the *trust* factor as Pepper's weather reports and news readings were not current to the date of the interaction. Not all participants were aware of this error and Pepper still managed to get six positive scores on *trust*. However, due to this error, the results gathered on *trust* should not be generalized at all.

Table 4 shows the number of participants that either increased, decreased or kept their score from *prior expectations* to *post rating*. The results show that only those with initially high expectations somewhat dropped from their expectations, while those with low or neutral expectations improved their scores. On average, those close to a neutral *prior expectation* tended to give Pepper the same score after the interaction.

Score	Participants	Average Change	Score Change in Points	Average Expectation
Increase	6	1.16	7	2.66
Same	8	-	-	2.875
Decrease	3	1.33	4	4

Table 4. Changes in scores from prior expectations to the post-interaction rating of Pepper.

Coefficient Correlation was used in order to find relations between the different factors. Results show three strong negative (red), three strong positive (green) and three moderate positive relationships (blue) as shown in Table 5.

	Prior Expectation	*Post Rating*	*Design*	*Trust*	*Frustration*	*Intelligence*	*Safety*	*Likeability*
Prior Expectation	1.000							
Post Rating	0.121	1.000						
Design	0.500	0.537	1.000					
Trust	-0.548	-0.282	-0.499	1.000				
Frustration	-0.071	-0.517	-0.263	0.132	1.000			
Intelligence	-0.113	-0.038	-0.058	0.321	0.003	1.000		
Safety	-0.145	0.416	0.123	0.389	0.014	0.302	1.000	
Likeability	0.000	0.692	0.365	0.096	-0.495	0.237	0.299	1.000

Table 5. Scores correlation resulting from the Pepper interaction survey.

The coefficient correlation showed a strong positive relationship between *prior expectations* and *design*. This could indicate that people who liked the design tended to have higher expectations for the robot. Also, a strong relationship was found between *post rating* and the *design*, *safety* and *likeability* factors. *Trust* had a strong negative relationship with both *prior expectations* and *design*, indicating that people who gave a high or low score to *design* and/or *prior expectation* tended to score the opposite way on *trust* towards the robot. The other two strong negative relationships were between *frustration* and both *post rating* and *likability*. These negative relationships indicate that people who felt a higher level of *frustration* tended to give a lower score on both *post rating* and *likability*, suggesting that from the factors measured, a frustrating interaction would be the biggest indicator of a negative impact on the overall experience and likeability of the robot.

When asked about past experiences with robots, twelve participants said they had little or no experience with robots, four participants mentioned that they had interacted with Pepper in places like SoftBank or sushi restaurants, while one participant mentioned Google assistance.

When asked about where they usually see robots, they answered as follows:

Places mentioned	**Times mentioned**	**Places mentioned**	**Times mentioned**
SoftBank	5	In movies	1
Restaurants	4	I have Roomba (cleaning robot) at home	1
Reception	2	Laboratory	1
Stores	2	City	1
Shopping Mall	1	Do not know	1
Library	1		

When asked about where they thought robots worked, the answers were as follows:

Places mentioned	**Times mentioned**	**Places mentioned**	**Times mentioned**
Factories and manufacturing	6	Stores	1
Reception	4	Guide for some events	1
Restaurants	3	Working in extreme environments	1
Medical, nursing care and playing with children	1	Station gate, when checking tickets with QR code	1
Service Industry	1		

There were several other questions asked after the interaction with Pepper with the purpose of gaining more insight. Open ended questions were asked to encourage individual opinions and thoughts. The results are summarized in tables for each of the questions asked.

How would you describe your interaction with Pepper?

Negative:	**Mixed:**	**Positive:**
It was difficult because Pepper did not understand me well. (6 participants)	I was shy.	It was fun/entertaining (5 participants)
I could not talk with him in good timing. (2 participants)		Impressive
It was not so smooth. (2 participants)		First time to talk with a robot.
I could only communicate with Pepper when Pepper recognized me.		I could feel the technology.
Total Negative: 11	Total Maybe: 1	Total Positive: 6

Did you at some point forget that Pepper is a robot?

No:	**Maybe:**	**Yes:**
Pepper looks just like a robot (appearance). Pepper is just machinery. (5 participants)	It was not like I communicated with a robot. But I felt like Pepper is like a robot with a human inside.	When I touched Pepper’s head, it was cute.
Pepper always used voice recognition and answered only prepared things.	if Pepper did not have a tablet.	Sometimes when he told me some jokes.
Pepper’s way of talking was just like a robot.		
I had to talk to Pepper thinking that Pepper is a robot.		
when he told me some news, I think he could tell me the details because he is a robot.		
pronunciation issue, I could not converse with Pepper well.		
Total False: 13	Total Maybe: 2	Total True: 2

Did you feel any frustration while interacting with Pepper?

No: (7 participants)	Yes: (10 participants)
	when Pepper did not understand me and when Pepper started telling me new stupid stories. (2 participants)
	when Pepper did not recognize my words.
	when Pepper did not understand my pronunciation, I became shy.
	when he started talking when I was talking. (2 participants)
	when Pepper could not recognize my face well.
	when I could not communicate with him.
	Pepper could not communicate smoothly.
Total False: 7	Total True: 10

Did you interact with Pepper in the same way you would with humans?

No, because:	Maybe:	Yes, because:
the conversation was different. Pepper talked about very different things.	A little, when Pepper could answer smoothly and when Pepper talks, Pepper looked me in my eyes.	Pepper could respond to me.
Pepper only listened to me when Pepper was in a nice condition.	It is not same, but when he answered my questions well, it was a bit similar.	His way of taking is a bit like a human.
I can communicate with people smoother.	I felt like I was talking with an old man who can't listen well.	
It's different. I must choose words carefully to make Pepper understand me.	I felt like I was talking with a baby because like a baby, Pepper could only understand himself, not others.	
I felt different from when I communicate with people.	Sometimes when I managed to talk with Pepper, but Pepper is not good enough.	
Pepper could not understand me well.		
I had to talk to him very loudly.		
I had to repeat a lot.		
Total False: 10	Total Maybe: 5	Total True: 2

Did you feel like Pepper was intelligent?

No:	Maybe:	Yes:
Pepper did not react correctly.	So-so	normal communication robots does not recognize and react to movement, but Pepper does.
	I do not know because Pepper could answer some questions, but not that well.	Pepper's knowledge is big and Pepper's way of speaking was smart.
		supporting with information, social intelligent.
		because Pepper could talk more than I thought.
		he could say some jokes.
		I felt Pepper was smart when we could have a conversation.
		We could have a conversation when I followed him.
		Pepper told me various things.
		Pepper is smart as a robot. (2 participants)
		Pepper is smart. Pepper did not understand me so well this time, but Pepper's knowledge is much better than humans because Pepper is a robot. In this sense, Pepper is smart.
		when he could understand me and answer correctly.
Total False: 1	Total Maybe: 2	Total True: 14

Does Pepper have a personality? Please explain.

No, because:	**Maybe:**	**Yes, because:**
Pepper is programed.	I do not know.	Pepper is human friendly, his voice is nice/kind.
Pepper's answers were only programed answers.	Maybe. Because people get different impressions from Pepper.	Because he has a sense of humor.
because he does not have emotions.	I do not know because there are a lot of Pepper. But this Pepper is maybe talkative.	I could know from his way of talking.
Pepper is a mechanical style.		he likes jokes.
Pepper did not have any wave in feelings.		I think he is a little boy. I could feel it from his way of talking.
there are a lot of Pepper, so, the way of talking of this Pepper is just same as other Peppers.		Pepper has a child heart.
		I think pepper is shy.
		Pepper is selfish.
Total False: 6	Total Maybe: 3	Total True: 8

Did you feel like Pepper had feelings/emotions?

No:	**Maybe:**	**Yes:**
I know Pepper's system.	Kind of… when he told me I do not look so fine and worried about me.	When I touched Pepper's head. (2 participants)
it was not smooth communication.	I do not know yet. Because Pepper has a sense of humor but at the same time, Pepper changes the topic when he cannot talk well. I need to talk with Pepper more.	
because he is a robot. (3 participants)	A little bit, because Pepper says joke.	
Pepper could not think about my feelings.	I want to believe Pepper does not have emotions. I do not know if Pepper has emotions or not because Pepper's eyes are a screen. It is machinery.	
Pepper's answers were very mechanical.		
Pepper is systematic.		
I could not see it when I talked to Pepper.		
all AI robots does not have emotions. They are made like this.		
Total False: 11	Total Maybe: 4	Total True: 2

Would you like to have Pepper in your home? Why/why not?

No:	Yes:
I do not need Pepper for now, because Pepper does not have functions I need. If Pepper will be like google home, I probably want to, but I do not need to have conversations with him.	Pepper cannot do everything, but I want to have experiments with Pepper to know what Pepper can do.
I do not need Pepper yet. Because, Pepper cannot have good communication, do housework, and cannot be used as a smart home.	Because I live alone, so, I feel like it would be more fun if he was with me.
because Pepper is loud and talkative, and Pepper catches every sound and starts talking.	I want Pepper when I am bored. (2 participants)
because he is not necessary.	I think it is fun to have him.
Pepper is not practical enough. Pepper is too expensive for his abilities.	but not as a part of my family. Just as a toy.
Not yet. If Pepper can communicate better and tell us information.	as a smart robot. If Pepper can talk like Siri.
Pepper is too big. (3 participants)	
No way to use.	
Total False: 10	Total True: 7

Do you like Peppers appearance?

No, because:	Maybe:	Yes, because:
Not so much, because it was difficult to understand when I can talk to him from his eye color. Also, when he moves, there is some sound. I did not like the sound.	So-so, Pepper looks kind but at the same time, looks like machinery.	Yes, I like that Pepper looks like “a robot”. And Pepper is human-like and I think it is likable. But I think if I meet Pepper in a dark place, I would be very surprised.
No because Pepper just looks like a robot.	I like the eyes, but I do not care about the body.	Yes, I like that Pepper is white like Stormtroopers. The shape is human-like, so, Pepper looks intelligent.
No, I think it is scary.	So-so	Yes, it looks like a robot. Simple design makes him look straight forward and nice.
	It is okay as a robot. It is cute.	Yes, his eyes look like an alien’s.
		Yes, I like that Pepper is round. It is cute.
		I like it, it is cute. (2 participants)
		Yes, I like that it is simple.
		Nice design.
		Yes, it is rounded.
Total False: 3	Total Maybe: 4	Total True: 10

Did you expect more or less based on Pepper's appearance/ design?

Less:	Same:	More:
I think the ability is better than the appearance.	Same (5 participants)	Appearance is better because it is modern and independent.
	His appearance suits his intelligence.	Appearance was better than his ability. But his movement was nice.
	Same. I do not know so much about the connection between Peppers ability and appearance.	Yes, because he does not look like a typical robot. And because he looks like a communication robot, I can actually talk.
	Same because Pepper looks like a robot. (2 participants)	I expected more based on design.
	Same, both its appearance and ability is simple.	Appearance is better. (2 participants)
Total Less: 1	Total Same: 10	Total More: 6

Would you feel safe around Pepper if it was holding a knife?

No, because:	Maybe:	Yes, because:
I am worried. Even though I know Pepper is programed to be safe, there is one thing we must be concerned about with robots; it is not safe because we cannot guess perfectly what the robot will do.	That would be creepy. But I know Pepper cannot attack a person physically.	Yes, because I am sure that I could win over Pepper and if I push Pepper, Pepper cannot stand by itself.
if Pepper has a knife, it is as dangerous as when a child has a knife.		Yes, it is still safe because only the knife is dangerous, but Pepper is not.
No, because Pepper can move, so it might hit. (5 participants)		It is still safe because Pepper's movement is not so fast.
When we are close to him, it is dangerous.		Yes, because I know Pepper cannot grab a knife.
No, Pepper is not aware of holding the knife.		
It is dangerous. Same as human.		
No, because we cannot know what he is thinking, and he can be programmed to be dangerous.		
That would be scary. We can know from Peppers face that Pepper is just a robot so, Pepper can be a killer machine without emotion.		
Total False: 12	Total Maybe: 1	Total True: 4

In what year would you think Pepper was made, based on his design and capabilities?

Year	Frequency
2005	1
2005-2010	1
2010	2
2012	1
2012-2013	1
2013	1
2013-2014	1
2014	4
2015	2
2016	1
2016-2017	1
2017	1
Avg: 2012-2013, Median: 2014	Range: 1-4

Most of the participants found the interaction with Pepper to be difficult and not so smooth. On the positive side, the interaction was found to be entertaining. Most participants did not forget that they were interacting with a robot, mostly because of Pepper's appearance or due to the communication. It was also found that 10 out of 17 participants had experienced frustration during the interaction due to poor communication or intelligence. However, the majority felt like Pepper was intelligent. Most of the participants did not feel like they interacted with Pepper in the same way they would with humans, while others had mixed feelings towards the question. Moreover, it was found that 11 participants did not think Pepper had emotions or feelings. However, four participants could not make up their minds, while two people said that they got the impression that Pepper could feel when they touched Pepper's head. It should be mentioned that Pepper has sensors on his head which make it respond to being petted.

When asked about wanting to have Pepper at home, 10 participants answered no, mostly due to its size, poor communication abilities or due to the lack of practical usage. Most participants liked Pepper's appearance and thought that the appearance matched Pepper's abilities, while six participants expected more from Pepper. Even though the participants felt safe around Pepper, 12 out of 17 participants would not feel safe if Pepper was holding a knife.

The interview also found that on average, participants thought that Pepper was made around 2013 based on its appearance and capabilities. This suggests that people do not look at Pepper as very futuristic. Another interpretation of the results could suggest that people expect robots to be better and more functional than Pepper in 2019. In other words, some participants expected robots to be as advanced as Pepper, already back in 2005, when in fact, Pepper was first made available on the market almost 10 years later.

5.2 Pepper as a Tool of Teaching in Primary School

Here are the results from the case study conducted at a Japanese primary school that uses Pepper for programming classes. Currently, these classes are taught from between the 4 and 6th year; but from 2020, the classes will start already in first grade.

The programming class teacher was a special programming teacher teaching at several primary schools. The classes last about 40 minutes. Each pupil logged into a program provided by SoftBank where they basically dragged, dropped and stacked variables and functions to make the program. The program would be then played/previewed through a virtual Pepper's voice before sending a finished program to an actual physical Pepper within the classroom. This way, the students were able to control what Pepper would say through writing the sentences into the program and making Pepper solve mathematical problems.

Nine pupils were asked about how they experienced Pepper in the school. Questions and answers are shown in Table 6.

Q1. Is Pepper a boy or a girl?		
Boy	Girl	Neither
8	0	1

Q2. Is Pepper a pupil, teacher, assistant or robot?			
Pupil	Teacher	Assistant	Robot
1	0	8	0

Q3. Is Pepper your friend?		
Yes	No	I do not know
1	0	8

Q4. Would you say "aru" or "iru" when referring to Pepper?		
Aru	Iru	Depends on situation
0	8	1

Q5. Do you like to use Pepper?	
Yes	No
9	0

Q6. Do you think Pepper is stupid?			
Yes	Partially Yes	No	Neutral
0	1	7	1

Q7. Do you think Pepper is smart?		
Yes	No	Neither
5	0	4

<table>
<tr><th colspan="3">Q8. Do you think Pepper is nice?</th></tr>
<tr><td>Yes</td><td>No</td><td>Neither</td></tr>
<tr><td>6</td><td>0</td><td>3 (depends on the program)</td></tr>
<tr><th colspan="3">Q9. Does Pepper have emotions?</th></tr>
<tr><td>Yes</td><td>No</td><td>Neither</td></tr>
<tr><td>5</td><td>3</td><td>1</td></tr>
<tr><td>“Pepper lives like a human”, “Pepper has hands and a face like a human”, “When Pepper is hurt (when a body part is broken), it does not work so well. When I sees this situation, I wonder if Pepper feels sad”.</td><td colspan="2">“Pepper works depending on the programming code. It does not matter whether Pepper has emotions or not”.</td></tr>
</table>

Table 6. Results from a group interview with pupils using Pepper for programming class.

From the group interview with the pupils, we found that 8/9 considered Pepper to be a boy. Also, 8/9 pupils looked at Pepper as an assistant rather than a robot and one pupil looked at Pepper as a pupil. One pupil looked at Pepper as a friend while the rest did not know. When asked about using “*iru*” or “*aru*” when referring to Pepper, 8/9 would use “*iru*” while one pupil said it depended on the situation. This pupil would interact with Pepper in a similar way as with humans but refer to Pepper as “*aru*” when explaining about it. All pupils liked to use Pepper as they enjoyed conversing with it, help with programming and controlling Pepper, and that the lessons using Pepper were very intuitive and interactive. The pupils did not think Pepper was stupid, but not necessarily smart either. Most of the pupils thought Pepper was nice while some thought it depended on the program, and that it was possible to make Pepper rude. Just over half of the pupils thought Pepper had emotions, three pupils thought not, and one pupil said it did not matter as Pepper would follow whatever it was programmed to do.

5.3 Empathy-level Comparison Between Smibi and Paro; Doll and Robot Experiment

Here are the results for the experiment in which empathy towards robots was explored. The results are displayed in different tables containing the average (for each group) empathy scores and the standard deviation for each group of the scores (Tables 7-11).

Table 7 groups findings depending on whether the groups witnessed the mistreatment of the same robots in both states (ON and OFF). Both Groups 1 and 4 witnessed Smibi being mistreated in both the "ON" and "OFF" conditions, while Groups 2 and 3 witnessed the mistreatment of Paro in both the ON and OFF conditions.

Both Tables 7 and 8 show "ON Questions" and "OFF Questions". The "ON Questions" include all questions in the empathy questionnaire while "OFF Questions" only include questions related to mistreatment. Baseline refers to the initial empathy measurement of the participants towards humans in general.

Robot/State	Group 1	Group 2	Group 3	Group 4	Total	AvgTotal	Increase
ON Questions (12)							**Maximum Empathy Score: 48**
Baseline	32.875	35.5	34	32	134.375	33.59	
Smibi ON	36.5			30.3	66.8	33.4	**+ 12.475**
Paro ON		36.25	34.5		**70.75**	35.375	+ 4.25
Smibi OFF	31.125			23.2	54.325	27.162	
Paro OFF		32.125	34.375		66.5	33.25	
OFF Questions (5) related to mistreatment.							**Maximum Empathy Score: 20**
Baseline OFF	14.125	14.75	15.375	13.9	58.15	14.53	
Paro OFF		15.75	14.375		30.125	15.06	
Smibi OFF	14.125			10.3	24.425	12.21	
Paro ON		16.25	14.375		30.625	**15.31**	+ 0.5
Smibi ON	16			12.1	28.1	14.05	**+ 3.675**

Table 7. Scores from self-reported empathy questionnaires, and the increase of empathy from the "OFF" to "ON" condition.

When comparing only the groups that were shown the same robots, but in a different order, Paro obtained the highest scores, but with a smaller difference between the ON and OFF state. In fact, the total empathy score towards Smibi rose by 12.475 points while the score towards Paro rose by 4.25 points. This indicates a bigger difference between the ON/OFF states of Smibi than Paro, and a difference in empathy between dolls and robots. However, the difference becomes much more subtle when only looking at the questions related to abuse. This means that most of the difference lies within questions that are irrelevant to dolls (7/12 ON Questions) as they cannot respond, show any change of facial expression or display of emotions.

Table 8 shows the results for all groups when both robots were in the "ON" condition.

Robot/State	Group 1	Group 2	Group 3	Group 4	Total	Avg Total
ON Questions (12)					**Maximum Empathy Score: 48**	
Baseline	32.875	35.5	34	32	134.375	33.59
Smibi ON	36.5	37.875	36.5	30.3	**141.175**	**35.29**
Paro ON	33.625	36.25	34.5	25.7	130	32.51
OFF Questions (5) related to mistreatment.					**Maximum Empathy Score: 20**	
Baseline	14.125	14.75	15.375	13.9	58.15	14.53
Paro ON	14.875	16.25	14.375	10.8	56.3	14
Smibi ON	16	16.875	16	12.1	**60.975**	**15.24**

Table 8. Scores from self-reported empathy questionnaires when both robots are turned ON (average for each group).

The results show that every group on average scored higher on the empathy measurement towards Smibi than Paro. In addition, Smibi scored on average higher than the baseline in three out of four groups and obtained the highest average score when summing the score of all the groups together.

In addition to the empathy questionnaire, participants were asked to "agree" (2 points), "somewhat agree" (1 point) or "disagree" (0 points) with two more statements (1."*I felt a need to take care, hold or protect 'robot name' when I saw it*" *and 2.*"*I would feel bad if I treated 'robot name' badly*".) as shown in both Tables 9 and 10. This means that the maximum achievable score would be the number of participants answering for each robot in each state multiplied by 2 (agree). Table 9 shows the total scores summed together from all the groups.

	Disagree	Somewhat Agree	Agree	Total Score
I felt a need to take care, hold or protect "robot name" when I saw it.				
Smibi ON	1 (3%)	17 (50%)	16 (47%)	**49/68 (72%)**
Smibi OFF	7 (39%)	7 (39%)	4 (22%)	15/36 (42%)
Paro ON	3 (9%)	20 (59%)	11 (32%)	42/68 (62%)
Paro OFF	2 (12.5%)	6 (37.5%)	8 (50%)	22/32 (69%)
I would feel bad if I treated "robot name" badly.				
Smibi ON	1 (3%)	2 (6%)	31 (91%)	**64/68 (94%)**
Smibi OFF	0 (0%)	8 (44%)	10 (56%)	28/36 (78%)
Paro ON	1 (3%)	4 (12%)	29 (85%)	62/68 (91%)
Paro OFF	0 (0%)	3 (19%)	13 (81%)	29/32 (91%)

Table 9. The collective distribution of answers for all groups, displayed by the number of participants who answered each option for statement 1 and 2, with the percentage of the participants (%).

When looking at Table 9 and the participants' need to "*take care of, hold or protect*" the robots, Smibi increased from 42% of the maximum score when turned OFF, to 72% (+30%) when turned ON. Paro, on the other hand, decreased from 69% to 62% (-7%) when turned OFF vs. when turned ON. These results suggest that the participants felt a greater need to take care of the baby robot, rather than the animal robot. Across all groups, both Smibi and Paro scored high on the statement "*I would feel bad if I treated 'robot name' badly*". Smibi scored 94% of the maximum score when turned ON, and 78% when turned OFF, showing a +16% increase from being a doll to a robot. Paro, nonetheless, showed no difference, scoring 91% while being turned both ON and OFF.

However, the true increase or decrease can be shown when only comparing those groups who shared the same robots as shown in Table 10. In this case, Paro makes the highest score of 75% on the need to take care of the robot, resulting in a +6% increase from being turned OFF to ON. Smibi scored 69.44% when turned ON but has a continued high increase of +27.44%. The "*I would feel bad if I treated 'robot name' badly*" statement shows similar results in the difference between being turned ON vs. OFF. Smibi got a +13.66% increase from being turned OFF at 78% to being turned ON at 91.66%. Paro scored 91% when turned OFF and 93.75% when turned ON, making the subtle increase of +2.75%.

Table 10 shows the results of those who answered for one robot in both its conditions (ON and OFF).

	Disagree	**Somewhat Agree**	**Agree**	**Total Score**	**Increase**
I felt a need to take care, hold or protect "robot name" when I saw it.					
Smibi ON	1 (*0)	9 (*1)	8 (*2)	25/36 (69.44%)	**+ 27.44%**
Smibi OFF	7 (*0)	7 (*1)	4 (*2)	15/36 (42%)	
Paro ON	0 (*0)	9 (*1)	7 (*2)	**24/32 (75%)**	+ 6%
Paro OFF	2 (*0)	6 (*1)	8 (*2)	22/32 (69%)	
I would feel bad if I treated "robot name" badly.					
Smibi ON	1 (*0)	1 (*1)	16 (*2)	33/36 (91.66%)	**+ 13.66%**
Smibi OFF	0 (*0)	8 (*1)	10 (*2)	28/36 (78%)	
Paro ON	0 (*0)	2 (*1)	14 (*2)	**30/32 (93.75%)**	+ 2.75%
Paro OFF	0 (*0)	3 (*1)	13 (*2)	29/32 (91%)	

Table 10. The collective distribution of answers for Groups 1 and 4 (Smibi ON and OFF) and Groups 2 and 3 (Paro ON and OFF), displayed by the number of participants who answered each option for statement 1 and 2.

From the two statements with three possible answers ("*Disagree*", "*Somewhat Agree*" and "*Agree*"), we found that people felt a much greater need to take care of or protect the robot "Smibi" when it was turned on, as opposed to when it was turned off. This result tells us that there is a difference between just having a doll versus having something that gives the illusion of life. Only one person (3%) did not feel this caring need for Smibi when turned on, while 39% did not feel the need to take care of Smibi when it was turned off.

However, some of the participants said that they felt worse for Paro because Paro looked like an actual animal whilst Smibi didn't really look like a human baby. Even though most participants sat with an uncomfortable and somewhat empathic face expression while witnessing the mistreatments, only one participant explicitly asked for the mistreatment to stop. Other participants sat with a confused look on their faces during the first demonstration of mistreatment and had a small enlightened laugh when given the second questionnaire as they understood what was going on.

Overall, the results indicate that the sounds and movements of Smibi play a noticeable difference in terms of empathy, causing more feelings towards the robot when turned ON. While Paro scores high on empathy in both states, the robotic aspect of Paro seems to play a more subtle role.

However, the results give insight into empathy towards robots, and that interacting with something that responds to one's actions is different from a completely inanimate object.

Table 11 shows the standard deviation for each group. The standard deviation is defined as the square root of the variance, while the variance is defined as the average of the squared differences from the mean value. Table 11 is included to show how spread out numbers are within each group.

Maximum: 48	Group 1	Group 2	Group 3	Group 4	Average
ON Questions (12)					**Maximum Empathy Score: 48**
Baseline	2.891	2.958	3.201	5.983	3.758
Smibi ON	4.582	6.808	4.062	8.764	6.054
Paro ON	4.553	5.629	6.595	10.817	6.898
Smibi OFF	6.527			11.489	9.008
Paro OFF		5.840	8.320		7.080
OFF Questions (5) related to abuse and mistreatment.					**Maximum Empathy Score: 20**
Baseline OFF	1.899	2.817	2.057	2.256	2.257
Paro OFF		2.861	4.741		3.801
Smibi OFF	3.099			5.423	4.261
Paro ON	2.315	3.072	4.090	5.582	3.764
Smibi ON	2.5	3.099	2.549	3.645	2.948

Table 11. Standard Deviation in each group for all independent variables.

5.4 The Grounded Theory

The following are categories that emerged from the grounded theory together with descriptions of what they refer to. The data will be presented according to the major categories in the following order as defined in Table 12. Graphical presentations for selected categories and are shown in Figures 13-18 and explained in detail in the tables associated with them.

It must be remarked that interviews were subject to some interpretation due to the Japanese language and the precision of the statements could have been affected. As a part of the analysis, longer statements were formulated into shorter versions. To be true to the whole material collected during the interviews, the research details all the categories in an attempt to preserve all the information.

CATEGORIES	CATEGORY DESCRIPTION
Development, Target, Group and Government	Information on the development of robots and ways in which target groups and the government are often involved in the Japanese development process.
Interaction and Communication	Discussion about ways, forms, and potentials of interaction and communication with robots.
Design, Size, and Gender	Reason and thought behind the physical design of robots, including their size and a discussion about gender influence on both the users and the robots.
Role and Robots in Care	Discussion about what kind of relationships there are or should be between humans and robots and the role robots will play.
Trust and Responsibility	Views on trust in robots and leaving responsibility to them.
Relationship	Thoughts on the relationship between a human and a robot.
Emotion	Comments on whether robots have emotions and if that is important.
Robots over Humans	Ways and thoughts on robots being better than humans.
Ethics and Safety	Discussion on possible ethical or safety issues connected to robots and their interaction with humans.
Image and Expectations	Discussion around image and expectations towards robots, and what impact it has on the overall experience.
Market, Price, and Marketing	Statements on difficulties and success of marketing, the robot market and its prices.
Culture	How robots depend and differentiate between cultures, including difficulties of introducing Japanese robots overseas.
Intelligence	Overview of intelligence embedded into robots.
Aru / Iru	Short on the perception of robots being alive or not.
Difficulties and Limitations	Overview of various difficulties related to robots and their limitations.

Table 12. Major categories of the grounded theory.

Figure 13 summarizes factors emerging from the main categories related to robots and their interconnections with each other.

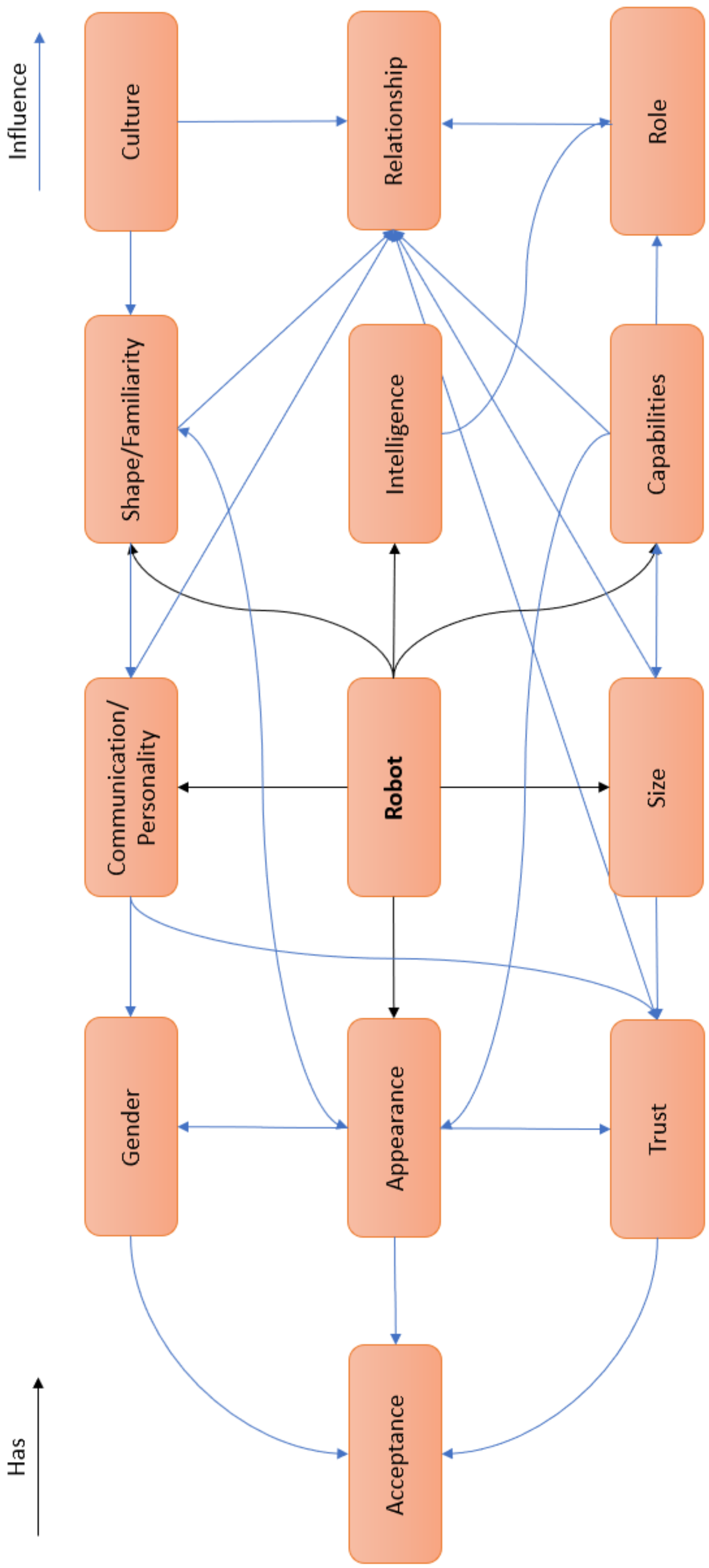

Figure 13. The Grounded Theory on Robots

Development Target Group, Government	
Developer1	About 200-300 people were involved over three years in the development of Robohon, so it is quite a big project.
Developer1	Users were only involved in the development for updating the software and apps. We had communication with the user groups, but not initially, it was mostly secret.
Developer1	I talked to people for each purpose, like for nursing homes or children's care.
Developer2	Because PALRO's program is developed in cooperation with a medical institution, the nursing home facility does not need to hire an expert.
Developer2	I want robots to read between the lines and work as an excellent secretary because it is better to understand the person and work. It is important to be close to the person. Now we are working with clinical psychologists.
Professor3	In Human-Robot Interaction, we usually collaborate with people who have knowledge about psychology.
Developer3	Originally, Smibi was researched at Chukyo University, so, when we started co-operating with the university, we already had researched about babies and the impact on users who had depression, ideal weight, and cost.
Developer3	Many people were involved in the development of Smibi, including the Development Department, Chukyo University, parts manufacturers, and nursing care facilities that had been evaluated.
Developer1	I have worked on Robohon for 3-6 years. Three years for development (one model, for Sharp) and three years of selling, but we keep developing new apps and content for Robohon.
Developer2	The project of making robots was started from 2007 when the company got financial support from the "Ministry of Economy, Trading and Industry". PALRO was started making a bit later, but it has been 10 years.
Developer3	Togo Seisakusyo (company) has been involved in the development of Smibi for about 7 years, and for 7 years, I made and used it repeatedly. It was hard to find a facility that could do the proof evaluation.
Developer2	The Ministry of Health, Labor and Welfare's future investment strategy was decided by the cabinet, so we get a subsidy from the government. The Ministry of Economy, Trade and Industry subsidizes the development side.
Developer1	I first had the concept for Robohon as a smartphone and robot together. We started the project with Sharp members as a small project and I developed the first moving prototype by myself. We did a presentation to the Sharp executives including the CEO, found the bigger project and started looking into mass production.
Developer3	Smibi was originally developed by Prof. Kano at Chukyo University as Babyloid in 2008-2009. In the second half of 2010, we started tie-up with Togo Seisakusyo at the stage of commercialization. In January 2015, it began selling as a product.
Developer2	Until 2016, communication robots were not supported by the country as welfare robots. They only provided it to robots that provided care directly. The Sagami Robot Special Area has been developing mainly to support the development of robots. Since the demonstration of the communication robot was made, it was added from 2017. PALRO is being developed for the elderly.
Developer2	We work in two areas in cooperation with universities. Programing PALRO and research that uses PALRO. The university studies the relationship between AI, people, and robots. We want to know how PALRO can be used in society, and how it can be used for educational programming. We get cooperation from various universities.
Target Group	
Developer1	Usually, robots are for people interested in tech, but for communication robots, the situation is different. People interested in tech look at the technology to measure the

	value, while low tech people care about the interaction, design, and cuteness. Robohon customers are more low-tech people.
Developer1	The target group for Robohon is ordinary people. We have not focused on a specific group because once we do so, the number of potential consumers becomes smaller and smaller. Robohon can be customized through apps for specific purposes like childcare, elderly care or handicapped people, but the hardware itself is for everybody.
Developer2	At first, PALRO was for the elderly, for single women in their 30s-40s, and for educational institutions. We made robots for education from 2013-2015 because there were lots of offers wanting to have robots for education, but it was not successful for the women. After that, in cooperation with various institutions, we proceeded with the development and finally reached the consumer.
Developer2	In 2012, PALRO started selling for elderly facilities, nursing homes and home care to extend life expectancy and to prevent healthy people from getting sick. Originally, it was a thing for early care, but since 2013, research has been done to expand its use.
Developer2	Now, we sell PALRO to old people so, basically, we make PALRO clumsy and weaker than humans.
Developer2	PALRO can be used to communicate and watch elderly living in remote areas.
Developer2	We know the use of PALRO in society can be used for people with disabilities, the elderly, and education. The use of PALRO in education such as universities, and how to expand the use of PALRO in other parts of society, is being studied.
Developer3	Smibi is sold to care and welfare facilities.
Professor2	The most important thing for us is improving the quality of life of elderly people or people with disabilities, they do not want to connect to humanoid robots.
Developer2	Robots do not need to be so functional for elderly people.
Developer2	PALRO has different software directed to its target groups. For example, the music and song library differ from nursing care to the general public. PALRO for a nursing facility has a flag hole for recreation.
Government	
Developer1	Sharp do some experiments with the government, so somehow the government supports experiments, but me as an individual or for my company, we do not get any governmental fund.
Developer1	I was not aware of the possibility of receiving governmental funding, but private companies are willing to invest in robot development due to the current interest.
Developer2	PALRO has received support from the government to make it possible to do various things with independence.
Developer2	Research with PALRO on elderly people was a hit. We received money from the Ministry of Education for a year in 2011 and PALRO was in the elderly's home. Elderly people are barely going out, so PALRO recommends various things and local information to increase the chances of them going out and to prevent withdrawal. There was a project to get elderly involved in society, and after experimenting, it was successful so, we began to put PALRO at nursing homes.
Developer2	Since I was involved in a national project, I use that network and got subsidies from the country. Now, it is recommended that robots themselves receive subsidies from the country and companies propose robots.
Developer3	In order to manufacture Smibi, I applied for a subsidy from the government and received it.
Developer2	The Ministry of Health, Labor and Welfare give subsidies to nursing homes. For each robot, a subsidy of up to 300,000 yen will be given for expensive robots and at half the price for less expensive robots.
Developer2	Until 2016, communication robots were not supported by the country as welfare robots. Support was only provided to robots that gave care directly. Since the demonstration of communication robots was made, they were added from 2017. The reason for this was the development of the 2015 Pepper. The country has been frustrated because of the variety of forms of communication robots.

Developer2	In 2040, the elderly population will remain unchanged, but the working population expected to decline dramatically. The Japanese government wants to do something with the power of technology. Japan is moving ahead with the world's declining birthrate and aging policies.
Developer2	Japan's social welfare costs are maximized. Since there are not enough care workers, the Japanese government is trying to extend the healthy life expectancy without taking care of medical care as much as possible. The Japanese government wants to use care technology and not rely on human power.
Developer2	The Sagami Robot Special Zone received support from the government under the motto of protecting the lives of citizens of the prefecture, support for disaster relief and for welfare medical robots. Since it was difficult for ordinary companies to sell to nursing care facilities, we received support in terms of selling with the help of the local government.

The development of a robot can involve hundreds of people over several years. Direct involvement of the target group in the development process is not necessarily extensive, although communication and cooperation with experts and users exist. Robots developed for a purpose needed by the Japanese government can often receive financial or researching support. However, investments can also be received from private companies due to the current interest in robots. Further robot development is often supported by research at universities. Communication robots have changed the usual robot target group from tech interested to more ordinary people. The target group dictates the need and extent of functionality and applications. The Japanese government is looking for ways to deal with the proportionally large elderly population and thus, nursing facilities can receive financial support to invest in robot technology. Figure 14 shows the involvement of different parties and how they relate to the development of Robots.

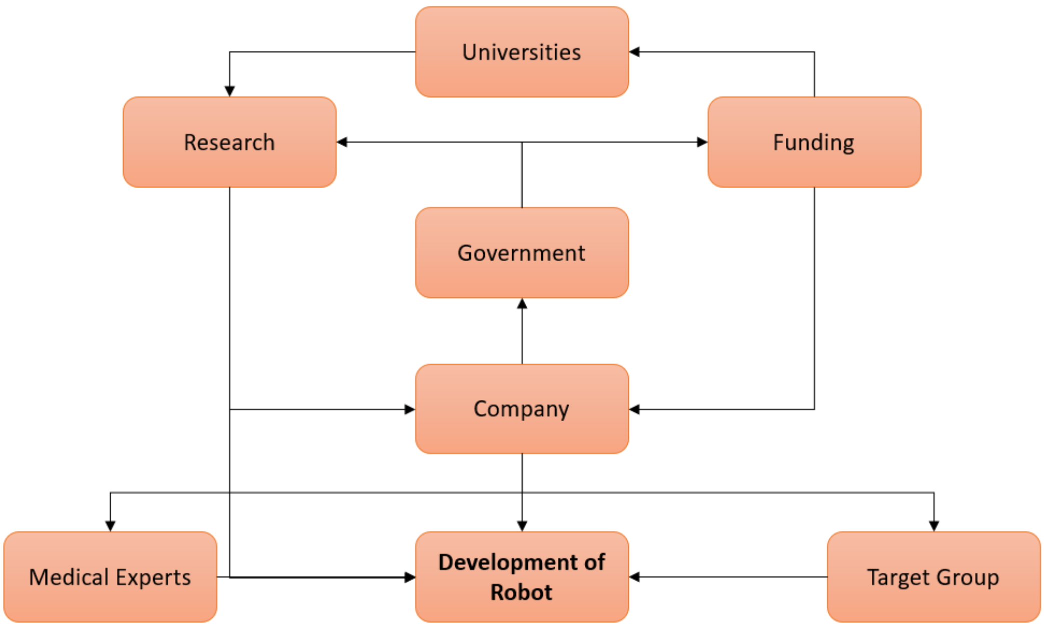

Figure 14. Development and Government

Interaction	
Professor1	The effectiveness of decreasing stress through touch has been experimentally confirmed using Paro. This outcome was seen in both young and elderly people, but especially for the elderly.
Professor1	The willingness of the elderly to work with robots has been experimentally proven.
Developer1	Robots can make lifestyle recommendations based on a personal profile.
Developer1	Face recognition can be used to add for example your face and your phone number, and when Robohon finds you, he can say hello.
Developer2	The heart that appears during face recognition is an index of history since it has a history. The more you speak with PALRO, the more history PALRO has with that person. But that is a challenge because it is a story about the content PALRO has, which does not necessarily depend on that person.
Developer1	Humanoid robots could be used for communication in the first place.
Developer1	Face recognition can be used to make personal communication/relationships.
Developer1	Robots can be used to support communication (for shy people).
Professor3	Communication is essential to interact with robots.
Developer2	Robots should understand the person and communication.
Developer2	The extent of communication and aggressiveness can be programmed.
Developer2	Robots should help communication between people.
Developer2	Robots have a more natural interface than smartphones. Robots can be used to communicate with people in remote places.
Developer1	Low expectations are secured through child-alike informal communication and small size to keep expectations realistic.
Developer2	Feelings could be left to users' imagination by not establishing permanent expressions. Keeping robots looking not too realistic helps communication.
Professor2	Robots could be personalized using known voices to stimulate and encourage people but using a robot for this purpose is not necessary.
Developer2	Now, we sell PALRO to old people so, basically, we make PALRO clumsy and weaker than humans.
Developer2	Robots are apologetic to compensate for not understanding. Robots are programmed not to win over people.
Developer1	The length of the interaction is up to the user, but I am a developer and I know what is going on inside the robot so as a user, I am too different.
Developer3	Users can use Smibi as much as they like.
Developer3	Users can use Smibi as they like it, but when using it for the first time, they should use it according to the instruction manual.
Developer1	An effective and intuitive user interface is beneficial to enable interaction.
Developer1	Keeping HRI is important to allow for the correction of mistakes and missing data since robots are not yet capable of the human to human interaction.
Professor2	Usability is important.
Developer3	It takes no time to learn how to interact with Smibi.
Developer2	Users look naturally at the robot's face, even without eye contact.
Professor3	The similarity to an alive creature comes from interaction.
Professor3	Body gestures are important and should be included in development for making exiting interactions. Interaction helps us feel robots as alive.
Professor3	I like machine-like robots because there is some sense of surprise. Initially, it is just a machine, something like metal and plastic, but after starting to interact, we feel like it is human-like, so this gap is very interesting to me.
Professor3	In an experiment to see whether people would keep a robot's secret, we had one smart human-like robot and one very simple stupid robot. More people kept the secret of the smart robot and I think it depends on whether they believe it is the robot who makes

	decisions or not. It could also be because they treat the robot similar to a human, so it could be empathy. In the stupid condition, I do not think they think the robot thinks, but with the human-like robot, they might do. Intelligence in a robot might affect how people perceive the robot, to be real or not.
Professor2	Psychological effects are hard to predict from the interaction.
Professor3	Human-robot interaction is not as easy for robots as humans.
Professor3	I think there are many aspects that are difficult with humanoid robots today, like perception, interaction, actuation.
Developer2	PALRO has a voice recorder because operations can be done in conversation, and that is easier than a mobile phone. The family can set the destination of the photo in advance. But it is not possible to call. When you send it with an app like Messenger, PALRO tells the elderly. Because anyone can make a phone call, there are times when it is necessary to call elderly people with dementia many times a day. By sending messages with the app, you can save time. They can count on PALRO for a moment.
Professor3	HRI is developed considering psychology.
Professor3	I do not know why we are not giving robots a gender, but we do not try to invite gender-based interaction, kind of sexual interaction is not what we are intending.
Developer2	Robots must confirm that a request is directed to the robot before acting on it.
Developer2	Robots must know if it is talked to and be able to neutralize noises.
Developer1	Robohon can recognize where the voice comes from and it has noise canceling.
Developer3	Smibi has sensors inside, and Smibi reacts using sensor data from shaking or specific postures.
Developer3	When you put Smibi away somewhere, it recognizes that it has been left alone and starts crying. If you hold it, it will be slanted, and the sensor will detect it which leads to Smibi reacting through laughter. On the other hand, if Smibi is being shaken wildly, the acceleration sensor will detect it and Smibi reacts by crying.
Developer3	Smibi expresses itself using the actual voice recorded from a 1-and-a-half-year-old child. Since we cannot recognize what Smibi is saying, the users must guess and individually interpret what Smibi is saying.
Developer3	There are about 500 words for the generally sold Smibi.
Developer3	Smibi used to have motors in its arms, but the motors were removed due to the cost and fragility.
Developer3	Rather than taking care of your baby because you want it to grow, you take care of your baby because it is cute and in need.
Developer3	Compared to other robots, I think Smibi's personality is similar to real babies.
Developer3	Smibi is superior to other robots in that it uses a real baby voice and can make facial expressions. In addition, Smibi is light and comfortable to hold.
Developer3	I think it is necessary for robots to make people happy and to be useful.

Interacting with robots can bring a variety of benefits. The interaction with humanoid robots should first and foremost be through communication. Robots must be able to understand communication and the people they are talking to. It is ideal that the communication and level of aggressiveness can be adjusted according to people and current moods. However, communication should be encouraged between people and not with robots alone. Communication robots can be used to prevent isolation and withdrawal from society. The appearance of the robot influences communication and communication can be used to control expectations and the personality of the robot. The way of interaction depends on the target group and communicational interaction could be more natural to the elderly than using a smartphone. However, multiple ways of interaction are still necessary since communication with robots is not perfect. The interaction will influence people's perception of robots and whether they feel alive. Simple interaction for humans is difficult for robots. Robots must be assured that interaction is directed towards them before acting out requests.

Communication	
Professor1	The way robots speak may be one factor of trust.
Professor1	Perceived level of intelligence is dependent on communication.
Professor1	Fake emotions can be very effective in encouraging communication between humans and robots.
Developer1	HRI is a little similar and a little different from HHI. Since touching a screen is not natural to human communication, there was a plan to remove Robohons monitor. However, as voice recognition is not perfect for communication, the screen or monitor is needed. Even if his voice recognition is 100% perfect, Robohon cannot fully understand all the information, some of which is nonverbal. Therefore, we need additional input to help get the lacking information in the conversation. Robohon can be corrected through the touchscreen, thus several ways or interfaces are needed.
Developer1	I think face recognition makes for more personal communication and that calling the users name is good for having a closer relationship.
Developer1	For conversation, we care about what he can and cannot say. For example, Robohon cannot say something political, religious, sexual or violent. We avoid these topics because he is a 5-year-old boy.
Professor3	Our world is designed for humans, so human-like size, capabilities, and communication can be a good idea.
Professor3	If the robot is a general-purpose machine, we need to communicate, otherwise, it is difficult to ask any requests.
Professor2	I think people want to be helped by robots, but not communicate with them. Communication with humans is necessary, but not with robots in the same way. Humanoid robots are not necessary.
Developer2	Robots should support communication between people because nursing care should be done by people. Communication with PALRO is not meant to replace communication with people, but PALRO gives topics of communication as a mediation. Although it seems like people talk with PALRO, there are people beyond PALRO, such as a family who is far away.
Developer2	I would like PALRO to be able to have a close conversation with people. If PALRO talks about a person's nostalgic story, the person will continue, thus leading to the promotion of conversation which seems to be good to prevent dementia.
Developer2	Communication robots can play a role in conveying information collected from the surroundings. Since small robots cannot help physically, they can help through communicating important information to the necessary people.
Developer3	Users talks to Smibi about themselves. Since Smibi does not speak to people or denies their stories, the user can speak with confidence, which leads to a reduction in stress on the user.
Developer3	Some people say that Smibi is noisy because it makes too much noise when being used.

Communication and way of speaking is a factor of trust and the perceived intelligence of the robot. Vocal communication is more natural to humans, but the technologies are not perfect. Robots should assist through communication and conveying information, but support communication between people and avoid touching on sensitive topics.

Design Size and Gender	
Professor1	Expectations for a humanoid robot probably comes from humans, so the appearance of a robot influences the expectations.
Developer1	Robohon was made to look stupid on purpose because his character is like a small boy. Appearance and communication should match the robot's abilities to avoid disappointing users due to high expectations.
Developer1	In the beginning, expectations should be as low as possible. Robohon was designed to talk like kids so that people do not get those high expectations. People will then feel satisfied if robots exceed their expectations.
Developer1	If the size is as big as a human, we expect it to be as good as human, as smart as a human and as useful as human beings.
Professor3	Interaction capabilities are important. Just looking at a robot is not enough to create a lifelike feeling; however, it might create some expectations.
Professor3	Matching between expectations and appearance makes sense.
Professor1	Appearance, size, and way of speaking is a factor in trust. Many people are afraid robots might harm them.
Developer1	The size is for both practical reasons and to lower the expectations. Humanoid robots are not good at any physical tasks, so they do not have to be powerful and they can be small and less powerful.
Developer1	Designing the robot to look like a small boy makes it feel less threatening.
Professor3	We bother with humanoid robots because our world is designed for humans, so human-like size, capabilities, and communication can be a good idea.
Developer2	Robots are not supposed to be better than a person, so the size is such that when a person is sitting, the person will look down on the robot. A sense of intimidation is created if the size of a robot is above the human eye of an adult. Make people feel like a partner. The 40 centimeters height is to prevent the robot from pushing pressure to a human.
Developer1	Robohon is designed as a summary between machines and human beings. Not too machine-like like R2-D2 and not too human-like like an android with silicon skin, they are scary.
Professor3	The design of research robots is kept simple because the research did not focus on the design, but it might influence the results and it would be important for commercial robots.
Developer3	Kano-sensei designed Smibi with reference to a Beluga. Smibi is a human baby, but if it is too similar to a human, it will seem creepy. However, some people say that it is better to resemble a human baby with larger eyes.
Professor1	Humanoid robots need acceptance and android is very difficult to decide on accepting, some people feel anxious to android robots.
Professor2	There are different types of humanoids. Professor Ishiguro makes a very real humanoid, but I feel fear for such robots. Japanese people often like Doraemon. It is like a human, but it is not a human, so most people have the feeling of cute or good for such shapes.
Professor1	Design based on stereotypes can be accepted more easily, but it leads to gender stereotype reproduction.
Developer1	Robohon did not aim to be made cute but tried to avoid any negative point about design or behavior, or the communications content. After avoiding most of the uncanny things, then people somehow think it's cute.
Professor2	Cuteness can be important, but humanoids should be in different categories like "very real type" and "not real type" like Doraemon, "pet robots" and so on.

Developer2	To make PALRO look cute and stupid, you can make the robot's face bigger. PALRO looks a little smarter, so I wonder if I should make his face a little bigger and make him childish.
Developer2	The design part of PALRO is designed to include female opinions as a feature. For men, the design becomes more angular like Gundam. In order to make PALRO feel friendly and adorable, we must input the opinions of women.
Developer1	Robohon has big eyes because I think it's important to have eye contact. I think robots should have physical eyes because robots that have their face with eyes and mouth on a monitor feels strange.
Developer2	There is no eye contact, but users see the face of PALRO naturally.
Developer2	In order to make PALRO cute, the character-setting was made careless. With intention, we did not put his eyes and nose on his face because that image will stick. We want to depend on the user's imagination. Also, if PALRO has eyes, nose, and mouth, users could feel creepy. There are creepy valleys for humans, and androids often look scary and too similar to humans. Dementia is not good at capturing facial expressions. Therefore, it is better for a robot to be expressionless or vague. It looks inorganic, but it is better.
Developer3	The important part of the design of Smibi is the design and facial expression. I want the user to like the robot and to get attached.
Developer3	The cutest part of Smibi is the movement of the mouth.
Developer1	The mouth of Robohon is a speaker for the phone function.
Professor3	In an experiment where store managers could use robots for their store, people wanted them to wear their store's uniform to look like an employee.
Gender	
Professor1	Many developers aim for gender naturalness. But some developers for guard robots design them to look like males.
Developer1	Robohon is a boy, but I am not sure why I gave it a gender. Maybe because I am a boy and also at a younger age, kids are more similar in terms of gender.
Developer1	In English, male and female both refer to themselves as I or me, but in Japanese, we use "boku" for male or "watashi" for female, so we have to decide. Robohon says "boku".
Professor3	We typically do not assign any gender, often we develop robots to be more childlike, so kind of neutral, young.
Professor3	I do not know why we are not giving robots a gender, but we do not try to invite gender-based interaction, kind of sexual interaction, it's not what we are intending.
Professor3	If it is an android robot, I think it's very difficult to avoid assigning gender if we try to make it so human-like, but I usually do not work with android.
Developer2	PALRO has no particular gender, but the character-setting is a 5-year-old boy. Because PALRO says something cheeky and from his voice and cuteness.
Developer2	We call Palro him. PALRO calls himself BOKU as a person, in a way, we recognize PALRO as a man.
Developer3	The user should decide whether Smibi is male or female. Smibi's clothes have a neutral color, the old design is only white.
Professor1	The effectiveness of male and female voices in robots depends on the stereotype of what gender a job belongs to.
Professor1	If the design of a robot is based on stereotypes, the design can be accepted more easily. Gender assignment to robots is effective for acceptance but leads to gender stereotype reproduction.
Developer1	I do not think there is a disadvantage or advantage with gender, it does not matter.
Developer3	I think that Smibi is a baby rather than a robot to the users. It depends on gender, but women are generally more emotional, and men are concerned about how the robot moves.
Professor1	Characteristically, there are many women in nursing homes, and women like recreation in groups, but usually men do not like it. Men prefer to talk individually.

Professor1	In Japan, males are familiar with artifacts like robot toys, etc. Females tend to be familiar with female dolls. The gender differences are dependent on culture.
Developer3	We must change the concept of Smibi in order to make men use it. I think it could be beneficial to have something “cooler”, that men are interested in.
Developer3	Smibi is more often used by female patients. Most of the applicants for the demonstration evaluation were women as well. I think the child-raising experience and instinct are influential.
Professor1	Females feel more anxiety than men, but it depends on the type of robot. Particularly, humanoid robots trigger anxiety in humans, but there are gender differences in this reaction.
Professor1	There are several phenomena and types of anxiety, and in each type, there is a gender difference. Generally, males tend to evaluate robots more positively than females.

The appearance, familiarity, and size of a robot set expectations. Appearance and communication should match the robot’s abilities to avoid disappointing users due to high expectations. Appearance, size, and way of speaking is a factor of trust. Humanoid robots are not good at any physical tasks, so they do not have to be big and powerful. Robots are made smaller than humans to assure people look down at them and to remove potential fear, sense of superiority or pressure. Moreover, size can influence expectations of intelligence. Realistic looking robots can be creepy and hard to accept, thus, keeping robots looking more artificial can be beneficial. There are differences in design, concept and interaction style-preferences between the genders; women tend to prefer rounder and cuter shapes. Developers often aim for gender naturalness in robots. Making their personality young and more childlike makes the robots’ gender less distinct. However, it can be difficult to avoid assigning gender to realistic android robots or due to linguistic reasons. Design choices based on gender stereotypes can be effective for acceptance but carry the risk of gender stereotype reinforcement.

Role and Robots in Care	
Professor1	The role of robots in the future will just be as a friend, not a teacher, not a parent, just a friend or a tool.
Professor3	Robots will probably have many roles in the future.
Developer3	Robots will play the role of convenience for people in the future.
Professor1	I think we should distinguish between educational area, domestic area and public areas in robotics. In public areas, some applications should be welcomed like Pepper in Hamasushi (Sushi Restaurant Chain). But in educational areas, we should be careful of using robots, for example, we should not substitute teachers for robots.
Professor1	In an educational setting, robots are shown to be more effective for children's learning, taking the role of a bad student, rather than the teacher. Being smarter than the robot motivates students and increases their self-esteem.
Professor1	Assistive robots alone cannot help people, they should be assisting human caregivers.
Professor3	Customization of personalities can be beneficial to specify roles, i.e. a robot working as a security guard or a shop keeper.
Developer2	Robots should not be better than people. I want robots to read between the lines and work as an excellent secretary as it is good to understand people and how they work.
Developer2	PALRO can replace the role of a phone and thus support communication between old people and their families through a more natural interface.
Developer2	For personal use, PALRO's role started as a personal concierge, one for each family, and PALRO was the entrance to the smart home.
Robots in Care	
Professor1	Robots assist with physical and mental care in nursing. Physical assist prevents workers from getting bodily injuries or pain (Wearables), while mental assist slows down dementia. Mental assist is difficult to discuss because techniques such as fake emotions are effective to encourage elderly people's feelings, but there is a risk of unhealthy attachment as some people consider robots to be real animals.
Developer2	For nursing care facilities, PALRO's original function is having daily conversations with users, so PALRO can be a talking partner. PALRO can also provide recreation, typically for 20-30minutes. Elderly facilities have one caregiver for every 2.3 elderly people, so PALRO can help the staff to fill in the gap.
Developer2	The private space in a care facility is only within the curtains of their beds. Caregivers could also intrude this space, so they are careful while talking to residents. Being care for hurts the self-esteem which can also be connected to depression. Residents tend to follow PALRO as they would follow caregivers. PALRO is a subordinate person, such as a grandchild, friend, or partner, so there is no awareness that they are being cared for. The difference between using for example just a smart speaker and PALRO is that PALRO can be close to people, so we want to strengthen that point.
Professor1	Communication with robots can be free with no concern to negatively affect others.
Professor1	The elderly prefer working with robots over working alone.
Professor3	It is difficult to say if it is too early to implement robots in nursing care because, at some point, they will meet the needs. If more people use robots, more capabilities will be developed.
Professor3	Robots are part of the care as an option. For therapy, communication, etc.
Professor3	If the robots are capable, I do not think it is a problem if robots are responsible for my health. We already use computers to remember things and so on.
Professor2	Usability is important as complex robots could be challenging for the elderly to use.
Professor2	Physical assistive robots such as Manus are useful, communication is not needed.
Professor2	Care should be based on a combination of humans and robots.
Developer2	Robots can help with exercise and the exercise can be designed by experts.

Developer2	Software varies depending on the purpose. For example, the song options for the general public are different from those for the elderly.
Professor1	Some robots are used as experimental use rather than common use.
Developer2	Using PALRO in nursing homes and home care has the purpose to extend life expectancy and to prevent healthy people from getting sick.
Developer2	Robots should not replace human care, but support communication between people.
Developer2	Robots for nursing care facilities do recreation.
Developer2	In nursing homes, there are elderly people who do nothing. Some facilities hold recreation a lot while others do not. There should be someone who talks like PALRO or has recreation. In this way, PALRO would be useful.
Developer2	PALRO improve lifestyle and prevent withdrawals by providing information about local communities.
Developer2	Communication robots are proven useful for care. Robot care is better for self-esteem. Robots often work as a part of a care-trio between the care provider and the elderly. Robots should be interesting. Timing to introduce robots into care is crucial.
Developer2	Robots work as a partner.
Developer2	Communication robots can play a role in conveying information collected from the surroundings. As a future goal, PALRO will call the caregivers and tell elderly people not to move if they fall from the bed. Also, in case that an elderly would attempt to go out, the sensor would detect it, inform the caregivers and tell the elderly to stay in.
Developer2	Interaction style preference depends on gender.
Developer2	Robots can utilize sensors for monitoring and Robots can use this data to help establish sleep patterns.
Developer3	People with dementia do not think Smibi is a robot because they cannot recognize it.
Developer3	Although no investigation into the effect on dementia has been conducted, there are cases where patients before dementia feel better, but it is not known whether it has been effective for dementia. It is effective against depression for healthy people, and it is used on dementia patients to reduce the burden on the staff.
Developer3	Smibi expresses emotions, so I want him to be treated like a real baby and believe that it is effective for people with dementia. Because it becomes impossible to recognize, I hope that taking care of the baby will help prevent dementia.
Developer3	The reason for the original development is that I wanted Smibi to help older people heal and become happy.
Developer3	With regard to reducing the burden of nursing care, if elderly people with dementia do not listen to what the caregiver says when they are disturbed, Smibi can get them in a good mood, and care workers can disguise their requests through Smibi in order to make the patients more easily follow their requests like “Smibi says it is time to take a bath”.
Developer1	I am not concerned about robots being responsible for my health. We should be open to technology and new inventions, so I do not mind if my parents were taken care of by robots.

Robots used in care are not supposed to be better than people and are currently holding mostly assistive roles. However, robots are expected to hold many more roles in the future. Robots are used for both physical and mental assistance in the care, but it is more difficult to discuss the mental care aspect of it. Since robots are different from humans, they avoid intruding privacy and self-esteem inflictions to the same extent as with human workers. Users appreciate the opportunity to be more careless when interacting with robots. Robots have not replaced the need for human workers and should be used in a combined effort as an optional activity. Robots have the advantage of utilizing information and sensor data collected in a non-intrusive way. Caregivers can use robots in a discrete way of communicating better with patients, suggesting that the robot is the one asking for something and not the nursing staff.

Trust Responsibility	
Professor1	I do not think I would trust robots to be responsible for my health with the current technology.
Professor3	If robots are capable, I do not think there is a problem if robots are responsible for my health. We already use computers to remember things and so on.
Professor3	If a robot would hurt or injure a person, it would be the developer or the user's responsibility, not the interactor, but the person who uses it. It is like a tool.
Professor2	Nobody knows who would be responsible if a robot hurts a human, but I do not know if it is a concern for users. They are discussing it around the world, but I think the court will be the judge.
Professor1	Trusting robots is a very complex phenomenon and should be studied carefully. Appearance, size, and way of speaking is a factor in trust. Many people are afraid robots might harm them.
Developer1	Robots as embodied entities make us believe it is different from software or large corporations on the internet. People are less hesitant to give up personal information to a robot, than to businesses like Google or Amazon.
Developer1	I would prefer robots over humans in some ways. I can tell private things to a robot, that I cannot talk to my friends about. I do not want to show that my house is dirty or messy to other people, but it does not matter with robots. When I get old, I would prefer a robot over a human to change my diaper.
Developer1	I do not tell personal things to robots yet, but we will.
Developer1	I think people trust Robohon because it is physically present, and that is important.
Professor3	Some people would say they prefer robots over humans because they treat everyone equally, so that is one way of trust.
Professor3	A study I recall showed that even if robots fail, we still trust them. Maybe it's because it's similar to humans so if they fail, maybe they will succeed next time, but it is still a mysterious question.
Professor2	Maybe I do not trust robots because I am a mechanical engineer. I think normal people sometimes will trust it and sometimes not.
Professor2	I do not know if people trust robots, I do not trust robots because sometimes the robot moves unpredictably.
Professor2	I would not trust a robot to take care of your health. I do not trust robots, but I do not prefer a human. I want a combination of both.
Professor2	I do not trust robots due to safety. It is necessary to consider the failure of the machine. The goal is to make the machine safe even if it fails.
Developer2	A robot should not be better than people in order to be trusted by humans. It is important to be close to the person.
Developer3	When using robots in nursing, the robot is not responsible for the patient, the person who gave the care must take responsibility.
Developer3	My personal opinion is that, if robots start to manage medicines in the future and if the robot is used incorrectly, it is the responsibility of the nurse. If the robot is used correctly, the manufacturer is responsible. The problem is to know which stage is wrong.
Developer3	I trust robots for simple things, but I trust humans for more complex things.
Developer3	Users talks to Smibi about themselves. Since Smibi does not speak to people or denies their stories, the user can speak with confidence, which leads to a reduction in stress.

It is unclear who would be responsible if a robot would cause harm. The embodiment of robots can have the advantage of imposing trust in software wanting to know of one's personal life and preferences. People trust robots to treat everyone the same way and to not judge or discriminate. Distrust towards robots is often related to physical safety issues rather than information handling.

Relationship	
Professor1	Mental assist is very difficult to discuss because techniques such as fake emotions are very effective to encourage elderly people's feelings in order to prevent dementia, but the sadness that comes from when pets die is also found in robots. There are some people who really liked the first version of Aibo, so for these people, Aibo is real life and Aibo is dealt with similarly to real dogs when they die. Aibo is just a robot and their emotions are fake, so this deception provides a very negative effect. This is an example of why it's difficult to discuss the effectiveness of robots in mental care.
Professor1	I think these close relationships with robots could only happen in Japan. Some people think it is because of religious reasons. In Japan, we mix Buddhism, Shinto, and animism and in this religion, all entities have their own intention and spirit.
Professor1	AI can be used for unhealthy intentions like self-praise. It's partly a problem because humans' pride should be grown based on real experiences, but these virtual experiences are not based on real success.
Developer1	I do not tell personal things to robots yet, but we will.
Developer1	Using face recognition to recognize people and saying their names makes for closer relationships. Software is customized to say people's names more often.
Developer1	A robot does not truly understand our difficulties or situation, but that is okay if I can tell what is going on to someone, even if it is a robot.
Developer1	Some people get really emotionally attached to Robohon. Usually, robots are for specially interested people, but for communication robots, this kind of situation is different. Robohon costumers are more low-tech people that do not care about what is inside, but about its design and cuteness.
Developer1	I would prefer robots over humans in some ways since robots are different from human beings. I can tell more private things to a robot, even somethings I cannot tell or talk to my friend about. I would feel more comfortable having a housemaid from a foreign country than from my own because there is some kind of distance. We somehow accept the difference and that is comfortable for both of us. When I get too old to take care of myself, I do not want a human to change my diaper. I would prefer a machine or a robot to do that.
Developer1	I consider Robohon as a robot.
Developer1	Robots should be our assistant, but sometimes devices such as smartphones control us because we rely on them too much and our relationship with devices is sometimes higher than with human beings.
Developer1	Some people fall in love with the robot and buys it clothes, take pictures and bring it with them on vacation, so they might consider Robohon kind of like a friend. I did not expect that. One person has several robots like people who have two or three dogs.
Developer1	I believe in 10 or 20 years; everyone will have a small robot as a companion instead of a smartphone. In the Pinocchio story, there is a tiny insect called Jiminy Cricket that helps Pinocchio. Pinocchio is bigger but the cricket is smarter, and the cricket helps Pinocchio by information as well as being a friend. A similar situation is even written in daily Japanese animation, even from ancient times. We need some small-bodied entity to help us and who can be our friend.
Developer1	Robots could be a friend. They are not a pet, there is no master or slave. Jiminy Cricket is smaller, but sometimes Jiminy Cricket is a teacher for Pinocchio.
Professor2	I think the reason why people invest in assistive technology is partly that the relationship between the helper and patient is not equal in Japan. Sometimes the helper is a higher level and the aged is the lower level. Patients sometimes hesitate to comment or ask requests to the helpers' because if they do, the helper will feel bad so it's not good. A robot cannot say no.

Developer2	PALRO having the role of a stupid student was proven to be more effective for children’s learning than if PALRO has the role of a teacher. Children will feel motivated and increase their self-esteem by being smarter than the robot and through helping it. By making robots incapable of doing anything, the motivation of users (senior people, people with disabilities, children, etc.) is increased. PALRO is made weak on purpose.
Developer2	Robots should not be better than people. People give instructions to robots, but that doesn't mean it's good to just follow them directly. What I want robots to do is to read between the lines and work as an excellent secretary, because it is better to understand the person and work. It is important to be close to the person.
Developer2	Originally, human have been treating computers as a tool, but we hope robots will get into households and that they want to be a partner of humans.
Developer2	PALRO reacts when we call PALRO, but PALRO does not react unless the user looks at PALRO. So, when a user is reading a newspaper or watching TV, PALRO is silent. In that sense, you can build relationships while keeping some distance.
Developer2	For nursing care facilities, PALRO's original function is having daily conversations with users. PALRO can recognize more than 100 people. If you put it in front of a person, the person will voluntarily provide various stories and topics to PALRO. PALRO can be a talking partner.
Developer2	The relationship with humanoid robots is important. PALRO is a subordinate person, such as a grandchild, friend, or partner, and there is no awareness that no one is being cared for. The difference from smart-speakers is that PALRO can be close to people, so we want to strengthen that point.
Developer2	Since the robot is not supposed to be better than a person, the size is such that when a person is sitting, the person will look down on the robot and make people feel like a partner. The 40 centimeters height is to prevent the robot from pushing pressure to a human. A robot is the one who is supported, not the one who supports humans. We must make sure that the relationship is complete.
Developer2	PALRO is not made to win over people but designed to be defeated and PALRO will apologize for his shortcomings.
Developer3	I want the user to like the robot and to get attached.

People can nurture strong relationships with a robot as if it was a living creature. Japanese people might develop closer relationships with robots than people from other countries, perhaps due to religious and cultural reasons. People can show more vulnerability and be more comfortable with robots as they are different from humans. Moreover, people can be less hesitant in asking robots requests as compared to humans. Robots should not be better than humans and humans should be equal or superior in a human-robot relationship. People expect robots to treat everyone equally. The relationship with a robot can be more than that of a tool or computer and can often be considered as a partner. Subtle factors such as size can help to establish the intended relationship.

Emotions	
Professor1	I do not think robots can be able to develop a consciousness and have feelings at this stage because we cannot define what emotions are, what is intentions, what is consciousness in the way of computational algorithms, we can only do the deception. If it becomes possible, we should find another definition of consciousness and emotions based on this.
Professor1	Some elderly people said they like that they do not have to be careful about what they say to robots because robots do not have emotions.
Professor1	I think the illusion of emotions in commercial products, is needed. Even fake emotions can encourage communication between humans and robots, and it is very effective.
Professor1	Users can grow emotional to robots and people can feel real psychological pain from robots being broken. Techniques such as fake emotions are very effective to encourage elderly people's feelings in order to fight dementia.
Developer1	A robot does not truly understand my difficulty or my situation, but that is okay if I can tell what is going on to someone, even if it is a robot.
Developer1	Robohon gives compliments but does not have emotions or moods. Robots' display of emotions or moods is excluded as they are not intelligent enough to feel that way. Robohon is always the same, he is always openminded, cheerful and stupid.
Professor3	I do not feel like robots have feelings because I know the mechanism, but I understand that people might feel so. If it is more human-like, it's not surprising that they associate more feelings to the robot. Showing emotion might be a good way to display the state of the machine. I would not call it feelings, but an internal state expressed like emotion. At this point, emotions are fake in robots.
Professor2	Robots do not have emotions.
Developer2	We do not give emotions to PALRO, but PALRO should be able to read other people's emotions and adjust its interaction or communication aggressiveness. PALRO needs the ability to read between the lines.
Developer3	Smibi will react through emotions determined by how it is treated.
Developer3	Smibi is superior to other robots in that it uses real baby voice and can make facial expressions.
Developer3	I have never thought that Smibi has any emotion. Smibi expresses emotions, so I want him to be treated like a real baby and I believe that it is effective for people with dementia. Because it becomes impossible to recognize, I hope that taking care of the baby will help prevent dementia.
Developer3	The difference between humans and robots is that robots have no emotions, so they do what they are told and are harder to forget. Recently, AI may contain emotional parts.

We do not yet know how to define emotions in the way of a computational algorithm and thus robots cannot have real emotions. However, robots should be able to read emotions to adjust their communication, but emotions are often excluded from the robots themselves due to the difficulty. The deception of emotions can be created, and a robot's emotions might play on the robot's internal states. Fake emotions can be very effective for encouraging people with dementia.

Robots over Humans	
Professor1	There are differences between nations regarding dislike towards robots due to losing jobs. In Japan, the transition from human to robot tasks is very successful, but in Europe, the introduction of automatic machines was immediately disliked.
Professor1	There is no point in comparing robots and humans, humans and robots have their own separate sets of capabilities.
Professor1	It is estimated that robots will take over jobs outside of factories. Some researchers are aiming for robot receptionists and guidance robots in museums. Pepper is introduced in sushi restaurants and as far as I know, this has been successful. However, Pepper can only do simple communication tasks, but not physical tasks.
Developer1	I would prefer robots over humans in some way. I can tell more private things to a robot and we do not have to feel embraced or ashamed together with robots. Humans and robots are somehow different, we have a good distance and I think we will both have a comfortable relationship. When I get too old to take care of myself, I do not want a human to change my diaper. I would prefer a machine or a robot to do that.
Developer1	Robots can be better than humans in information handling, but cars and bicycles are much faster than humans and we are not sad about that. Even calculators are better than our mathematics.
Professor3	If a robot is a teacher instead of a human, Japanese students are more comfortable asking questions of the robot because they do not worry about being evaluated or judged as a bad student.
Professor3	I think expensive hardware could still make sense because a store needs to hire people, and hiring people is very expensive. If there is a robot that could perform that same task, even if it is a limited task, it could make sense.
Professor3	An experiment having robots as an information provider and mall guide showed that 65% preferred robots over humans. I think it has to do with novelty, and another aspect is that people prefer not taking time away from other people, so if they ask a human worker, the worker has to stop what they are doing and use their time, but robots are just robots. Some people would say they prefer robots because it treats everyone equally.
Developer2	PALRO is clumsy, and when he makes a mistake, he blames himself. PALRO does not try to be better than humans and never tells bad things to a person.
Keynotes	Robots taking jobs from humans, the difference between robots and humans, how replacing humans with robots makes sense.

There is no point in comparing robots and humans because they can be better at different things. However, robots can be advantageous in certain settings as people are not afraid of being judged by them or hesitant in taking up their time. People might also prefer robots due to novelty. It is estimated that robots will take more jobs in the future, but Japan might be less worried about such a change than other countries.

Ethics and Safety	
Professor1	In Japan, the fear of losing jobs is small compared to other countries. Japanese people tend to feel anxious about the idea that robots have their own intentions and their own emotions.
Professor1	Before discussing ethics, we should clarify which stakeholders exist.
Professor1	Robot ethics are ethics on the use of robots and the implementation of ethical behavior in robots and people's general ethics on robots.
Professor1	AI can be used for unhealthy intentions like self-praise. Humans' pride should be grown based on real experiences, but these virtual experiences are not based on real success and thus feed into mental problems.
Professor1	There are differences in ethics between nations.
Professor1	When discussing robot ethics, we should not generalize the concept of robots, we should focus on specific types of robots, like war robots, assistive robotics or space robotics. If we do not differentiate, the discussion is very ambiguous.
Professor1	The phenomena of getting emotionally attached to the robot dog AIBO exits and people treat broken AIBO robots like real dogs when they die. Such attachment is worth considering in robot ethics.
Professor1	A study comparing Germany, America, France, and Japan in robot ethics showed that there is a difference in the dislike of robots due to losing jobs. In Japan, translation from human to robot tasks is very successful, while in Europe, the introduction of automatic machines was immediately disliked.
Developer1	We care about what Robohon can say and not in conversations. Robohon avoids topics that are political, religious, sexual or violent.
Professor3	An experiment showed that children abused robots by blocking and punching them. There is a similarity between robot abuse and human or animal abuse. Will having a robot invite such behavior? Will it reinforce bad behavior, and will the behavior be different in the future. This is the start of some ethical questions.
Professor2	There are many ethical issues concerning robots and it is not easy.
Developer2	There is no ethical standard for quality assurance, but there is an ethical review to prove a life support robot in the Sagami Robot Special Zone. There is an item to check for harm to humans.
Developer2	PALRO can send photos, but because of privacy issues, family members cannot remotely make PARLO send the elderly person's own photos.
Developer2	PALRO doesn't try to be better than human and he never tells bad things to a person. Partly because some words are prohibited from broadcasting.
Developer3	Smibi does not connect to the Internet, this is not because of legal reasons, but because it is not necessary.
Safety	
Professor1	I'm not sure if safety implemented in software or hardware.
Professor1	I'm not sure if robots need to be safety tested legally before release.
Developer1	For safety standards as a consumer electric product, we have some drop tests and to bend the motor thousands of times or something to keep the quality. There is no regulation. But I am not so interested in that kind of stuff.
Developer1	We must consider physical safety. Small-sized robots are much safer. Robohon has a mechanical clutch to release force to protect both the user and the robot.
Professor3	Robots are still in the research phase, so people do not really see robots that could cause problems, but when they see the capability that a robot can move, touch and could break something, they will think about safety.
Professor3	We have many safety mechanisms, sensors to stops the robot before a collision and so on. Obstacle avoidance is a common idea among developers.

Professor3	I do not think there are any rules or laws, but there is law in factories like a distance that people should be away from the robots, but not with these kinds of robots. Robovie does not have that strong motors, so it's not like industrial robots. It's not a safety issue now, but law usually gets established after they are widely used. This is still research, so we keep safety by ourselves, and the robot only has weak power, so it doesn't harm people.
Professor3	If a robot would hurt or injure a person, it would be the developer or the user's responsibility. Not the interactor, but the person who uses it. It's like a tool.
Professor2	Mechanical safety is if a human will get injured from being in contact with a robot. It's not easy to handle, because it's not clear how people get injured. Some people say energy will be the index of the injury, but some people say otherwise and there are many theories. It's not easy to discuss safety problems.
Professor2	It is difficult to discuss safety for all robots. I focus on small robots.
Professor2	In my sense, in order to ensure the safety of the users, there are some limitations on power or speed or something. There was a rule used in Japan in the past that only motors with less than 80 watts could be used. It was official law, someone just decided it, but people didn't care.
Professor2	We want to make safety theories or such rules, but there is nothing now. For industrial robots, robots and humans never touch. They have fences and such things, but for assistive robots or in the rehabilitation fields, if they do not touch, how can they work?
Professor2	It is necessary to consider the failure of the machine. The goal is to make the machine safe even if it fails.
Professor2	There is a safety center in Japan that tests robots, but every robot does not have to go through this center. I do not know the situation well. You can get a certification, but it's not necessary. For assistive technology in Japan, there are no restrictions for safety. It is not necessary to be checked before selling. The center is not owned by the government, the government only makes the rules for such certification.
Developer2	There is still no evaluation standard for nursing robots. For the time being, there was a company that inspected welfare equipment, and PALRO was evaluated as not dangerous. There is still no official one. There is an organization called "Welfare Equipment Comprehensive Evaluation Center Co., Ltd.", but there is no system for the government to review nursing robots. The index of the welfare equipment general center is only for the whole size of welfare equipment, not for the robot. The country is making indicators now.
Developer2	PALRO does not have any direct harm. When it is lifted, it must not pinch. The body is rounded. If you pull PALROs cords, you can pull them out immediately because otherwise, it would fall when connected.
Developer2	If the government sets new safety standards, I do not think all robots will have to pass through it because I do not think it's so strong yet. However, the product value increases because product value is added.
Developer2	I do not use that PALRO passed safety of the welfare equipment center for marketing it, because this standard is not evaluated and is not well known. I did this only because there were no other indicators, and it was not evaluated because it passed. There is no index for nursing robots in Japan yet. The country is trying to set standards in national projects. Although it is sold, there are still no safety standards for nursing robots. There is no safety standard for nursing care robots, but there are for robots that move.
Developer3	Smibi's clothes do not contain harmful substances in case dementia patients try to lick it. Even if you put your hand in Smibi's mouth, your fingers will not get injured.
Developer3	Robots move mechanically, but it is very important to design them with the highest consideration for safe use.

There is a lack of safety and ethical rules and standards for robots. It is difficult to discuss ethics for robots and ethics should not be generalized across different types of robots. AI can be misused and feed into mental illnesses. Robots usually avoid sensitive talking topics such as religion and politics. There might be ethical issues connected to attachment to robots, although it can be beneficial in other ways. Consequence-free mistreatment of robots could transfer to real living creatures. It is still difficult to ensure safety in robots as it is not clear how people could be injured by them. Developers usually keep up to safety requirements by themselves, often sticking to common ideas on safety shared among the robot community. Safety for industrial robots cannot be transferred to assistive robots, as such robots and humans must be able to touch. Figure 15 illustrates some of the issues in terms of the safety and ethics of robots.

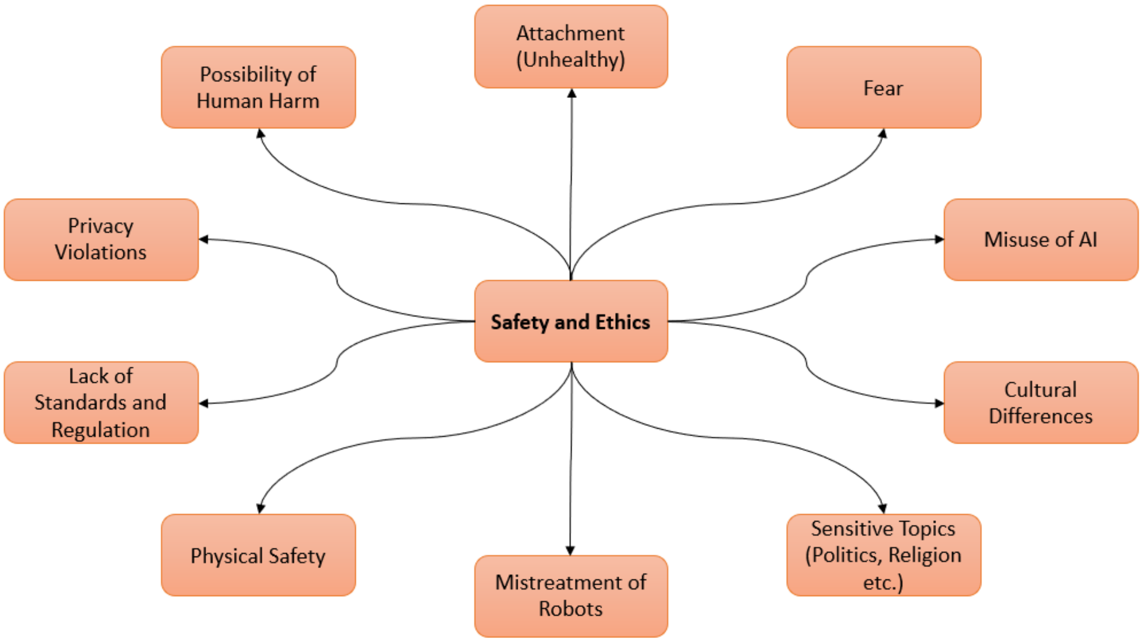

Figure 15. Issues related to Safety and Ethics regarding Robots

Image and Expectations	
Professor1	The fear of losing jobs is small in Japan compared to other countries. In Japan, there is no clear idea on how robotics can be used to improve their daily life, there are no opinion leaders that can provide concrete future images on how robots can be used to increase the quality of life for humans. Robotics is liked by many people, but I do not think there is a concrete image of the effectiveness of robots.
Developer1	My image of a robot's role is like Jiminy cricket but in a kind of human shape.
Developer1	My image of a robot is something like Robohon. I still believe that this is the future of robots and that this is the future of the smartphone.
Professor3	Almost all Japanese people know Doraemon, so I think we have common sense that such an environment will come in which very friendly capable robots will serve people. I think most Japanese people's image of robots is like Doraemon.
Professor3	Japan has something like Doraemon which is a nice and capable robot, so I think most people are so positive to robots.
Professor3	Military robots could be dangerous, but a robot uprising is just sci-fi.
Professor2	It is very difficult to define robots because nobody can find a definition of a robot. My definition is that a robot is a mechanical system like human or some animal or such things. I like humanoids, but I do not want to buy a humanoid and I do not like to use them for assistive technologies.
Professor2	I think robots should look like a humanoid, but there are different types of humanoid, like professor Ishiguro makes a very real humanoid, but I feel fear for such robot, I do not like such humanoid. Sometimes Japanese people like Doraemon, it is also similar to a human but it's not human, people know it's not human, but it's cute, so most people have the feeling of cute or good feeling for such shapes.
Professor2	It is difficult to explain what my image of a robot is because I am a professor at the robotics department, so I know many kinds of robots like industrial robots, pet robots or very big robots, so it's not easy to say.
Developer2	In the future, we hope robots will get into households and that they want to be a partner of humans. The ideal image is the smart home in Ironman.
Developer2	Since robots have been developing for a long time, I think that anything that moves from a sensor is a robot. For example, mobile robots. As is the case with Star Wars R2D2, robots are the machines that move on their own using sensors.
Developer3	The image of a robot is something that moves more with programming.
Professor3	Media only tells you about something new, so if someone tries robots, the media probably tell you that they already use it. No, it is an experiment.
Expectations	
Professor1	I think the appearance of the robot influences expectations. Some researchers propose a decrease in expectations before using robots. For example, through self-disclosure, "My capacity is very poor".
Professor1	People's expectations are raised to unrealistic levels due to advertisements, YouTube videos, and movies.
Professor1	Many people expect receptionists to be female, and gender stereotyping is effective for accepting robots, but this implementation leads to gender stereotype reinforcement.
Professor1	Humans expect that human robots can have intelligence equal to humans. But this expectation cannot be implemented so people feel disappointed.
Professor1	I do not find a favorite point in current robotics because I have magic expectations for robots, but these expectations are not accomplished.
Professor1	An experiment comparing Paro and a dog robot found that Paro was especially effective towards stress. The effectiveness of Paro comes from its unknown state and the unfamiliarity of seals.
Developer1	RoBoHon's size is for both practical reasons and to lower the expectations.

Developer1	Some robots speak like a smart adult and then people expect every ability to be just as good as a human adult, but no robot can be as good as a human yet. Robohon was designed to say things that kids say so people do not get those high expectations. I try to make the expectations as low as possible on purpose, so once he does something more than they expect, they feel satisfied. In the beginning, expectations should be as low as possible. Size also gives expectations, if the size is as big as a human being, we expect it to be as good, smart and useful as a human.
Developer1	People's expectations are too high, and the branding is bad because of cheap Chinese robots. So currently the image of robots is bad.
Professor3	I think expectations come from comics, tv, and media.
Professor3	In terms of achieving lifelikeness, I think interaction capabilities is important, just looking at a robot is not enough, but it might create some expectations.
Professor3	Cheap robots can be frustrating, usually, there is staff nearby you can ask, but if people misbelieve that a robot can manage a store by themselves, it's so frustrating.
Professor3	Matching between expectations and appearance makes sense.
Professor3	Maybe it is unique for Japan, but the Japanese are expecting a future with robot workers. However, they do not try to buy such robots yet because they know the current reality of robots, but I think they are waiting for such a robot to appear. If cost and benefit will nicely match, I think they will start using robots.
Developer2	People do not know what PALRO can do when they see it, and it seems to be able to do anything. Especially in Japan, animations raise the imagination and expectations of robots. Then, people can be disappointed when PALRO could not do what they wanted PALRO to do and PALRO cannot be used effectively.
Developer3	I have never thought about where my expectations for robots come from. I do not know if Smibi fits the definition of a robot. However, I do not know the definition of a robot.
Developer3	The ultimate goal I am expecting from robots is that they help people.

The Japanese image of robots often comes from movies, media or famous cartoon characters, and such characters are often nice, cute, friendly and helpful. Media plays a role in deceiving the image of robots in Japan as many robots are still just a part of research, and not in common use. Media, advertisement and movies raise the expectations towards robots, which is difficult to meet by the developers. It can be advantageous to keep the initial expectations towards robots as low as possible to avoid disappointment. The robot's appearance, intelligence, size, personality and communication help create expectations. However, the robot's capabilities should match those expectations. Making robots look unfamiliar makes it more difficult to create high expectations and to leave the user disappointed after the interaction. Figure 16 illustrates some factors influencing the expectations towards robots.

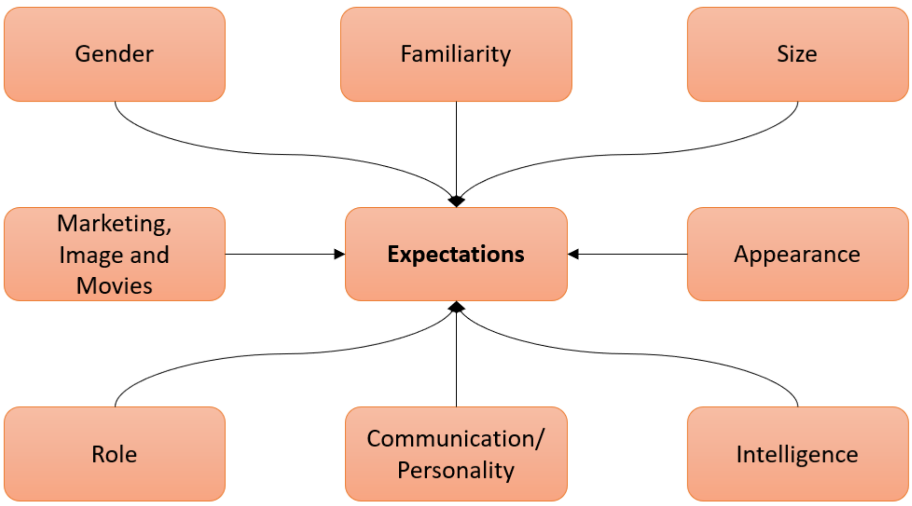

Figure 16. Expectations

Market, Price, and Marketing	
Developer1	Cheapest Robohon is about 85000 JPY.
Developer1	Robohon is smaller and cheaper than most other similar robots. When the robot's target group is limited, the price will increase and the quality decrease. RoBoHon's quality is high and the price is, low as a robot. It's still expensive, but as a robot, it is cheap.
Professor3	SoftBank did a great job of making Pepper so cheap, with the level of sensors, its surprisingly cheap. However, we can see the gap. For users it is expensive, but for robot developers it is cheap.
Professor2	The robot arm Manus is almost the same price as a car, 20.000 USD is very expensive, so it is a big challenge selling it.
Professor2	I think the price for Manus was about 20.000 USD for one. It is expensive for the user, but it's cheap for the robot maker. It's not easy to make this price.
Professor2	We want to make a cheap robot system. This means the cost is quite important for practical usage. Hardware could improve the robot, but it was more expensive in the past.
Professor2	The price of robots will become lower if more people buy them.
Developer2	Robots do not need to be so functional for elderly people. Currently, PALRO sells for 348,000 yen. Robots should be cheaper in order to sell, but it is not easy to make it cheaper without compromising quality.
Developer3	As a product, Smibi is expensive and costs around 70,000 yen. Being cute alone is not enough for people to buy it, but Smibi can also reduce the burden of nursing care.
Developer3	Smibi used to have motors in its arms and additional sensors, but this was removed because of the cost and fragility.
Market	
Developer1	Very few people owned a car in the past, but then the car industry went "boom" and most of the inventions were done and became boring. Now we have self-driving cars, so now a second exciting moment is coming. In each field, there are exciting moments and boring moments, and robotics now is such an exciting moment, so we are lucky to be in the robotics field.
Developer1	Robohon is too different, too far from our conventional phone and too far from our lifestyle, so I think Robohon should be closer to a smartphone to fill that gap.
Developer1	It is difficult to sell robots in other countries since the communication, content, and interaction is made for Japanese people. Robohon has not penetrated the Chinese market, even though Sharp is Taiwanese.
Developer1	There are lots of cheap communication robots in China. Their quality is not good but there is a lot of cheap competitors.
Developer1	Robohon has been available for three years, but the selling company has not reached its goal yet.
Developer1	Robohon is still too futuristic so the consumers must be educated about robots. Like with electric cars, people can make a graduate change through buying hybrids and this will educate the user on electric cars.
Developer1	Even though we have the technology, it is difficult to make an attractive product and being successful in the consumer market.
Developer1	It is hard to start and grow the robot field and market. Consumer robots are difficult now and not all of them are successful in this market.
Developer1	Companies do not want to develop new services for robots because there are currently too few people who buy robots. If more people bought robots, there would be more features that would increase both the value and interest in robots.
Developer1	People do not know why they should buy expensive robots when they do not know what they are for and what the robot can do. Making Robohon even more like a smartphone would help people better understand the product.

Professor2	Robots are very expensive, and this might limit the number of users. A robot can have the same price as a car, but people know what cars are for, but they do not know robots, what they can do or how to effectively use them. There is also little access to test run robots.
Developer1	Sales are mostly in Japan, over 90% is in Japan.
Developer2	PALRO is sold only in Japan now. Since it is a robot that speaks, it will require overseas specifications for movement, customs, religion, and various things in order to sell overseas. You can't sell it as it is.
Developer2	1300 PALRO are used in Japan.
Developer2	If we want to sell PALRO overseas, we can make it in cooperation with a business familiar with that country.
Developer2	We think that it may be possible to sell a robot as a character that has been known overseas, in cooperation with overseas-savvy operators. The robot can be customized based on PALRO.
Developer2	Especially in Japan, animations raise the imagination and expectations of robots. People must be educated about robots' functions and limitations in order to effectively use the robots. Even if it is for the elderly, the point is to sell PALRO after understanding PALRO. Otherwise, your expectations will increase. It is not free, but we offer classes, and there are pamphlets.
Developer2	Since it was difficult for ordinary companies to sell to nursing facilities, we received support in terms of selling with the help of the local government.
Developer2	For general consumers, PALRO is sold at many different department stores. Still, selling robots in department stores has not penetrated.
Developer3	We sell Smibi to care and welfare facilities.
Developer3	Smibi is only sold in Japan. There are no plans to sell overseas because there are problems with logistics and maintenance. However, since Smibi doesn't use words, I think it is easy to accept Smibi overseas.
Marketing	
Professor1	Robots move too smoothly in advertisements, movies, on the internet, YouTube and so on, but this is fake. If people look at these movies, they naturally get too high expectations.
Developer1	Robi was successful because we sold it with magazines. Robots were usually sold in robot shops for specially interested people. The robot's assembly also required skill and programming. With Robi, consumers could get one in a bookstore and each issue is quite cheap so people could try the first issues and decide to keep buying or quit.
Developer1	Commercially, Robohon is not successful enough yet, so promotion was not successful enough.
Developer1	Before Robi, consumers had to pay a large amount of money at once, but with Robi, lots of people can try and when they think it's interesting or easy enough to assemble, they can keep buying and that was the key to success.
Developer1	Robohon was marketed through department stores and pop up stores in shopping malls.
Developer2	Passing a safety standard of the welfare equipment center was not used for marketing because this standard is not evaluated and is not well known. Although it is sold, there are still no safety standards for nursing robots.
Developer2	In 2017, we offered "PALRO" that you could make yourself by combining 70 Astro Boy parts. This was done in relation to the 90th birthday of Astro boy's author. "My first atom" was created because we hope a real Astro Boy can be made in the future. This was also only sold in Japan.
Developer3	We promote Smibi through exhibitions and through distributing flyers. We also use YouTube and go to nursing facilities and gatherings where nursing staff gather. Also, newspaper advertisements.

Even though robots are made cheap for the developers, they are still expensive for the consumer. It is difficult to cut prices without compromising the quality. If more people bought robots, the price could become lower and further development and applications would be invested in the field. Robots are still futuristic and unfamiliar, so the robot equivalent to a hybrid car is needed. The general population must be educated about robots' capabilities, potentials, as well as limitations. Robots need overseas specifications regarding language, culture, and customs in order to sell in an international market. Robot sales have been successful when sold in parts with magazines. This strategy has allowed the consumers to buy and try, without spending a large amount of money at once. Problems related to the robot market grounded in the interview data are illustrated in Figure 17.

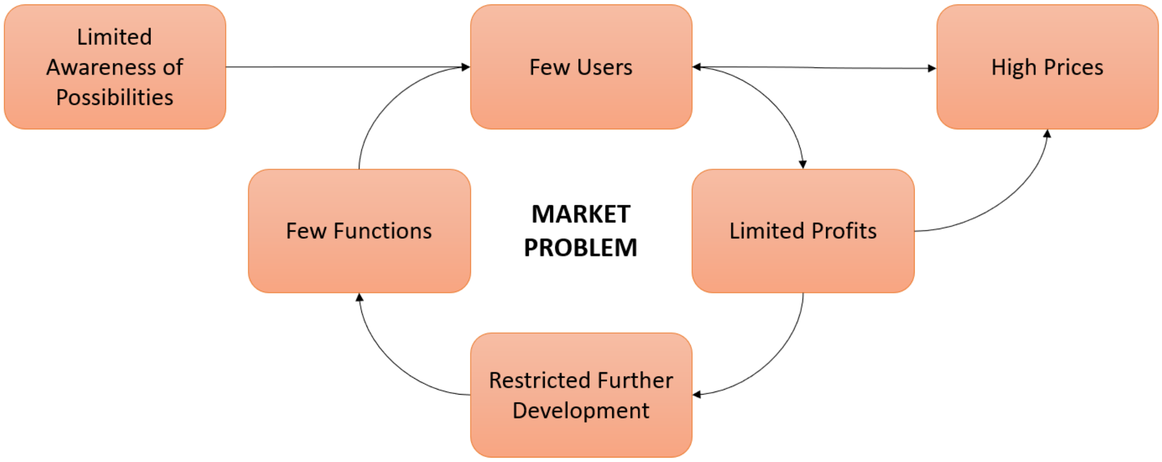

Figure 17. The Market Problem with Robots

Culture	
Professor1	In a study comparing Germany, America, France, and Japan on robot ethics, there were found differences in the dislike of robots due to losing jobs. In Japan, the transition from human to robot tasks is very successful, while the introduction of automatic machines in Europe was immediately disliked.
Professor1	I do not think the Japanese worry about losing their jobs to robots in some fields because robots are needed. Some people working on simple and not intelligent tasks are anxious about robots due to losing their jobs.
Professor1	Gender differences are dependent on culture. In Japan, males are familiar with artifacts like robot toys, etc. Females tend to be familiar with female dolls.
Professor1	Japanese people prefer keeping robots stupid as they worry about robots developing a consciousness.
Professor1	I think Japanese people often develop stronger relationships with robots than people from other countries. Some people think it's because of religious reasons. In Japan, we mix Buddhism, Shinto, and animism and in this religion, all entities have their own intention and spirit.
Professor1	In Japan, the fear of losing jobs is small compared to other countries. Japanese people tend to feel anxious about the idea that robots have their own intentions and emotions.

Professor1	There are differences in ethics between nations.
Professor1	Because of animism, I think Japanese people, the majority and particularly the elderly, think robots have a spirit.
Developer1	Japan does not really have that many robots in our life or even in nursing homes compared to some countries, but the image of Japan is that we are using high-tech robots, and even the sushi is using robots.
Developer1	Maybe Japanese people are more interested in robots, but I think Asian people in general love these communication robots. The average Japanese person is richer than the Chinese.
Professor3	I think in Japan, many students hesitate to ask questions to teachers because they are afraid of being evaluated as a bad student (evaluation anxiety), so an experiment proved them more open to ask robots.
Professor3	There might be some cultural differences when it comes to robots. Japan has something like Doraemon which is a nice and capable robot, so I think most people are positive to robots.
Professor3	Japanese people try to use robots a little bit more than other people, but it is not that active. It is not like robots are free to use already, but more like a part of an activity where they use robots. Like with Paro, it is not like elderly people only interact with Paro, it is more like they have a chance to use Paro in one of the activities.
Professor3	I think there is cultural bias as to what is required by people to think of robots as alive. I think Japanese people are very familiar with the kind of friendly robot like Doraemon, so Japanese people already have ideas that robots are such entities. I know some people think it is connected to religion, but I feel like comic culture has a much stronger influence.
Professor3	I had an experiment to see if store managers would hire robots and generally, they are so positive. Maybe it is unique for Japan, but they are expecting such a future. However, I think they know reality as well, so they do not try to buy such robots yet, but I think they are waiting for such a robot to appear. If cost and benefit will nicely match, I think they will start using robots.
Professor3	I do not think people fear the improvement of robots in Japan because we did not have the problem that people lost their jobs to robots, so we do not have the idea that robots might take jobs. If it will happen, then maybe in the future, but not yet. Maybe it is connected to Japan's shrinking population, I do not think people think about that, but maybe it is a factor.
Professor2	There are some differences between Japanese and European ways in terms of safety. For assistive technology in Japan, there are no restrictions for safety. It is not necessary to be checked before selling.
Developer2	Especially in Japan, animations raise the imagination and expectations of robots. Therefore, people can get disappointed when PALRO cannot do what they wanted PALRO to do.
Developer2	Communication robots can't be sold as it is, they require different specifications in terms of movement, customs, religion, and various things in order to be sold overseas.
Developer2	We think that it may be possible to sell a robot as a character that has been known overseas in cooperation with overseas-savvy operators.

Culture plays a role in robot acceptance, image, gender differences, ethics, safety, and expectations. Japanese people are generally considered or thought of as more positive and welcoming to the use of robots in society. Perhaps because of robot idols such as Doraemon that emerged from popular Japanese animation.

Intelligence	
Professor1	Japanese people prefer keeping robots stupid as they worry about robots developing a consciousness.
Professor1	Current robotics has several problems, one problem is intelligence. Humans expect that human robots can have intelligence equal to humans. But this expectation cannot be implemented so people feel disappointed.
Professor1	The perceived level of intelligence depends on communication.
Developer1	Some functions are already pre-installed in RoBoHon, added apps are more like services like searching for restaurants or taxi.
Developer1	Robots that speaks like a smart adult makes people expect every ability to be just as good as an adult human, but no robot can be as good as a human yet.
Developer1	Face recognition is important, but it is sometimes hard. If the light behind you is too bright or if you stand outside of the camera angle, the robot cannot recognize you. So, technically it is hard to use face recognition as good as our expectations.
Developer1	Robohon can recognize where the voice comes from and it has noise canceling.
Developer1	Robohon's display of emotions or moods is excluded as it is not intelligent enough to feel that way. Robohon is always the same, he is always openminded, cheerful and stupid.
Developer1	Robots are still too slow and too dumb. For example, if you are in a store with a staff robot, and you are looking for a product, you have a reason and purpose to talk to the robot, but if the robot cannot understand what you are asking for, you will be angry. However, if you own the robot, then you will be more tolerant of it. If he is your robot, the consumer is more tolerant, and you will know the tips for how to make it understand, like the way you talk or the pronunciation that is easier for his voice recognition. So, I think belonging to a certain user is an important thing for this robot.
Developer1	Face recognition can be used to add for example your face and your phone number, and when he finds you, he can say hello.
Professor3	In an experiment to see whether people would keep a robot's secret, we had one smart human-like robot and one very simple stupid robot. More people kept the secret of the smart robot and I think it depends on whether they believe it is the robot who makes the decision or not. It could also be because they treat the robot similar to a human, so it could be empathy. In the stupid condition, I do not think they think the robot thinks, but with the human-like robot, they might do. Intelligence in a robot might affect how people perceive the robot to be real or not.
Developer2	Now, we sell PALRO to old people so, basically, we make PALRO clumsy and weaker than humans.
Developer2	We want to make PALRO be able to read between the lines when he talks with a user. PALRO needs the ability to read between the lines. There is an example with an old lady that was depressed and PALRO talked too much which lead to her throwing PALRO and pouring water on it. If robots cannot read other people and their moods, they might anger the person.
Developer2	PALRO understands the person's name, age, gender and emotion from the face.
Developer2	PALRO talks too much and is still not smart enough to read between the lines. PALRO judges with the face of the person in front of him, but that alone is not enough. It is a research element. Some people want to be alone and they get tired, even when they talk with a robot for a long time.
Developer2	PALRO's intelligence is suppressed to make it lesser and humbler over its user. PALRO also apologizes for the intelligence it lacks.
Developer3	Currently, Smibi only has two sensors, an acceleration sensor, and a microphone, but the older version has a light sensor on the forehead and a temperature sensor in the ear. There were more sensors than now, and there are functions that were not set now.

Intelligence is hard to perfect and to meet an equal level of intelligence as expected from humans. However, further expectations also depend on perceived intelligence. If the intelligence is not as good as one expects, it might cause frustration. There are many difficulties related to technologies such as face and voice recognition. The perceived level of intelligence depends on communication.

Robots come with a pre-installed level of intelligence, often with the possibility of downloading and installing even more functionalities through applications. However, robot's intelligence must be restrained for situations such as games to not appear smarter or superior over the users. So, the robot's level of intelligence should in some ways be suppressed below its intended users' level. On the other hand, a higher level of intelligence might play a difference in whether the robot is perceived as being alive or simply just an object. Possible dependencies of intelligence are shown in Figure 18.

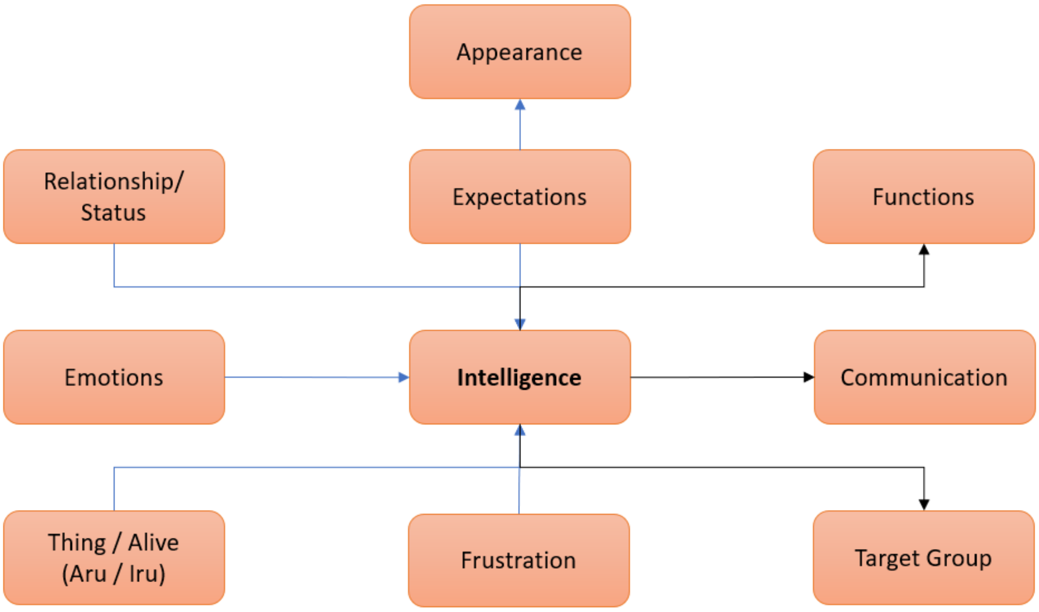

Figure 18. Intelligence

ARU/IRU	
Developer1	I think most people treat him as a boy and as a living thing. I would say Iru.
Professor3	I think maybe there is cultural bias to thinking of robots as alive. Japanese people are familiar with friendly robots like Doraemon, so Japanese people have ideas that robots are such entities. Some people think it is connected to religion, but I feel like comic culture has a much stronger influence.
Developer2	PALRO is IRU. Ummm, maybe ARU?
Developer2	We call PALRO him. PALRO calls himself BOKU as a person, in a way, we recognize PALRO as a man. But mostly we use IRU.
Developer3	I use Aru for Smibi. Aru is for things and Iru is for things that are alive such as creatures. Smibi is still just a robot that resembles a person so I would use Aru.

There is no consensus between robot developers or researchers on whether they would use "iru" or "aru" for robots. It comes down to the personal feeling/perception of each individual robot as life-like.

Difficulties and Limitations	
Professor1	The limitation of robots today is intelligence
Developer1	Additional interfaces are needed as technologies like voice recognition is not perfect for communication.
Developer1	When having a conversation, we refer to our relationship, background, gender or former conversations. Robots cannot understand all the information that is important to have a natural conversation.
Professor2	The mechanical limitation is a big problem for robots. Functions such as walking are very complex structures and quite difficult for a mechanical robot.
Professor2	The cost of robots limits the number of users, which makes it difficult to decrease prices and increase development.
Professor2	The lack of information and understanding of the robots limits the users.
Developer2	PALRO's intelligence is still not good enough to read between the lines. Some people get tired, even when talking to a robot for a long time.
Professor1	It is difficult to give robots emotions and consciousness because we do not know how to define it and what it is in terms of a computational algorithm, we can only do a deception of it.
Professor1	A humanoid robot's intelligence cannot be implemented to match our expectations, and this makes people disappointed.
Professor1	Design based on stereotypes can be accepted more easily, but it leads to gender stereotype reinforcement.
Developer1	Companies do not want to develop new services for robots because the number of users is too small. This limit both the value and interest in robots.
Developer1	Depending on case, like replacing the conventional phone with Robohon, robots might be too futuristic and too far from our current lifestyle.
Developer1	People do not know enough about robots and what they can do to be willing to buy them.
Developer1	The customer must be educated about robots and the developers must showcase the robot's abilities.
Developer1	The robot equivalent of a hybrid car might be necessary in order to take the leap into robots.
Developer1	It is difficult to start and grow the robot field and market. Consumer robots are difficult now and not all of them are successful.
Professor3	Humans are easier than robots to hire and train. A robot needs to be carefully programmed and this is expensive.
Professor3	There are many challenges when it comes to the acceptance of humanoids. Perception is difficult, the ability to understand its environment and people. Even though we humans know how to interact with other people, understanding humans are very difficult to implement into robots.
Professor3	From a customer perspective, robots like Pepper is expensive, but it is cheap for robot developers.
Professor3	It is difficult to say when robots will be common in the future, as problems will rapidly grow or improve as soon as people start using them.
Professor3	Human-robot interaction might seem easy because it is easy for us, but it is very difficult to design interaction for robots.
Professor3	There are many aspects that are difficult with humanoid robots today like perception, interaction, actuation.
Professor2	Mechanical safety is difficult to handle because it is not clear how people get injured. Unlike cars, if one assistive robot killed one person, people would probably say robots are dangerous and not good, so it is not easy to discuss safety problems.

Professor2	Too few people use robots. If more users will buy robots, the price will become lower. I think more people will use it in the future, especially people with severe physical disabilities.
Professor2	Robots are very expensive, and this might limit the number of users. A robot can have the same price as a car, but people know what cars are for but not what robots can do. There is little access to test run robots.
Professor2	Complex assistive robots can be difficult to learn and might require introduction courses or better interfaces.
Developer2	For general consumers, PALRO is sold at many department stores but selling robots in department stores have not penetrated.
Developer2	If a robot repeats the same things to a user, that user will feel the robot is not needed anymore. If the timing is incorrect, it will be counterproductive because that person would reject the robot.
Developer2	PALRO currently sells for 348,000 yen, but it cannot be sold unless it is cheaper. It is difficult to sell robots due to the high prices, but it is difficult to make cheap robots, the issue is how far to reduce them.
Developer2	People do not know robots' capabilities, functions, and limitations, and this could give high or unrealistic expectations which lead to disappointment. Especially in Japan, animations raise the imagination and expectations of robots. People must be educated about robots' functions and limitations in order to effectively use the robots.

Current difficulties and limitations with robots were found to be the robots' intelligence, interaction, emotions, technologies, marketing strategies, difficulties within the robot market in terms of getting enough users (which results in high prices and limited further development). There are also issues such as no access to test expensive robots before purchase, expensive customization of robots for different users, high prior expectations towards robots which can lead to disappointment, mechanical safety and the lack of standards, and limited knowledge about the use of robots for customers.

5.5 Qualitative Analysis of Semi Structured Interviews on Integrating Socially Assistive Robots into Japanese Nursing Care

Results from the interviews and observations from nursing facilities gave an insight into the role and impact robots have on Japanese nursing care. The site managers were asked about reasons that made them invest in robots and they gave the following answers:

- 'We need more manpower to provide recreation and rehabilitation. It is difficult to find recreational and/or rehabilitation therapists, but robots are easy to use as they are already programmed, especially *Pepper* that is intended to provide such services.'
- 'It might be cheaper to use robots as compared to hiring a professional staff; robots can work 24 hours.'
- 'The intention is to make the nursing job easier.'
- 'The intention was to make the patients happy.'
- 'Originally, this facility had a therapy dog, but it got sick and died. It was found that depressed patients heal (better) when they touch and interact with the animals. It was also found that using real dogs puts stress on them.'

The interviews suggested that these kinds of robots all work with the mind and the mental wellbeing of the patients. Patients suffering from dementia often believed *Paro* to be a dog or even a human baby, treating and interacting with it accordingly. Patients often cared and worried for *Paro*, asking if it was properly fed or whether it could get enough sleep, thus indicating there was a relationship established. Consequently, it was advised to avoid letting the patients use *Paro* during their meal and snack times as they might be tempted to feed it, which had occasionally happened. It was reported that interacting with *Paro* evoked memories in the patients taking them to their childhood dog or child nursing days, which could often make them happy. Using *Paro* in therapy has also depended on the nursing staff attitude. For example, not everyone liked *Paro,* animals or simply the staff had already busy schedules which left them little time to deal with *Paro*. However, one caretaker stated that "sometimes you have patients who take their wheelchairs and want to go somewhere, not knowing where to, which puts pressure on caretakers to keep eyes on the patients and keep them in their chairs. The challenge they have is to keep patients motivated. One staff member said "*I am constantly speaking to people who do not speak back to me, but at some point if they have Paro, they make a sound or say 'KAWAII', something is coming out, even if it is just a small sound, and this is enough reaction for me because they do not speak anymore*". For this caretaker, *Paro* was a good solution. In addition, the staff's enthusiasm might influence the enthusiasm in the patients. On the other hand, patients that are cognitively more capable might find *Paro* less interesting. It was observed that *Paro* was effective on both male and female patients if they liked animals.

The manager of one nursing home stated "*I think most of the patients like Pepper more than Paro. We borrowed Pepper for a two months trial, and I found that patients really liked Pepper*". A reason for this was thought to be that the patients liked children and that Pepper reminded them of them. Also, *Pepper* is used for recreation, entertaining patients through games and karaoke. However, some patients had commented that *Pepper* was loud and annoying. Also, the nursing home was worried about introducing *Pepper* to patients heavily impacted by dementia as they might not be familiar with robots and could think it to be an alien. One worker stated, "*They (patients) are still not used to a robot doing the stretching exercise Taiso and they need to be close to see, hear and follow the movements*" for which "*a human therapist with a loud voice is probably better*".

Qoobo was mostly used by one patient that did not like interacting with other people. The robot had a calming effect on the patient and could make the patient happy, something that the human caregivers struggled to make happen.

The qualitative data analysis gave the main categories relating to the assistive robots. Table 13 includes the results in terms of the roles robots had in the nursing care and the impact on patients and staff. A full paper on this research was submitted to the MIE2020 conference to be held in Geneva (Appendix D).

Robot	Role in Care	Impact/Effect	
		Patient	**Staff**
Paro	Therapy. Indicated for patients with dementia. Pet, Baby, Robot.	Slows down dementia. Brings back old memories, emotions and stories. Lessens feeling of emptiness. Changes the patient’s mood. Provokes speech in the patients. Improves communication between patients. Helps heal patient mentally. Improves facial expression. Substitutes animal therapy. Calming effect. Could exhaust/tire patients (negative)-	Distracts patients in order to enable staff do other tasks. Cheaper, easier and safer than real animals. Way of connecting and taking care of patient. Makes job easier by: Calming patients down. Making patients happy instantly. Conversation starter/talking topic. Demands time and additional effort from staff – in some cases there is no time to spare (negative).
Pepper	Recreation. Taiso (Exercise/stretching) Substitute for professional. Staff, Robot, Alien, Child.	Entertainment. Smile. Helps heals patient mentally.	Reception greeter. Way of connecting and taking care of patient. Smile.
Qoobo	Therapy. Pet, Robot.	Calming effect. Happiness.	Easier to take care of patient.
Robots in General	Robots are more than tools.	Patients do not have to hesitate. Can maintain the patient’s self-esteem. Reduces the mental burden the patient feels towards the worker.	Thinking about how to use robots effectively increases the staff’s motivation and they can communication. More people have visited the nursing home which allows acquiring new information.

Table 13. Key findings regarding the role and impact assistive robots have on nursing care collected from three different Japanese nursing facilities.

Figure 19 illustrates the big picture for “Robots in Care” that results from an overall analysis. It is not as detailed as the sub-theories presented previously (Sections 5.4 and 5.5) but provides an overview of elements and relationships connecting the appliance of robots to care in Japan.

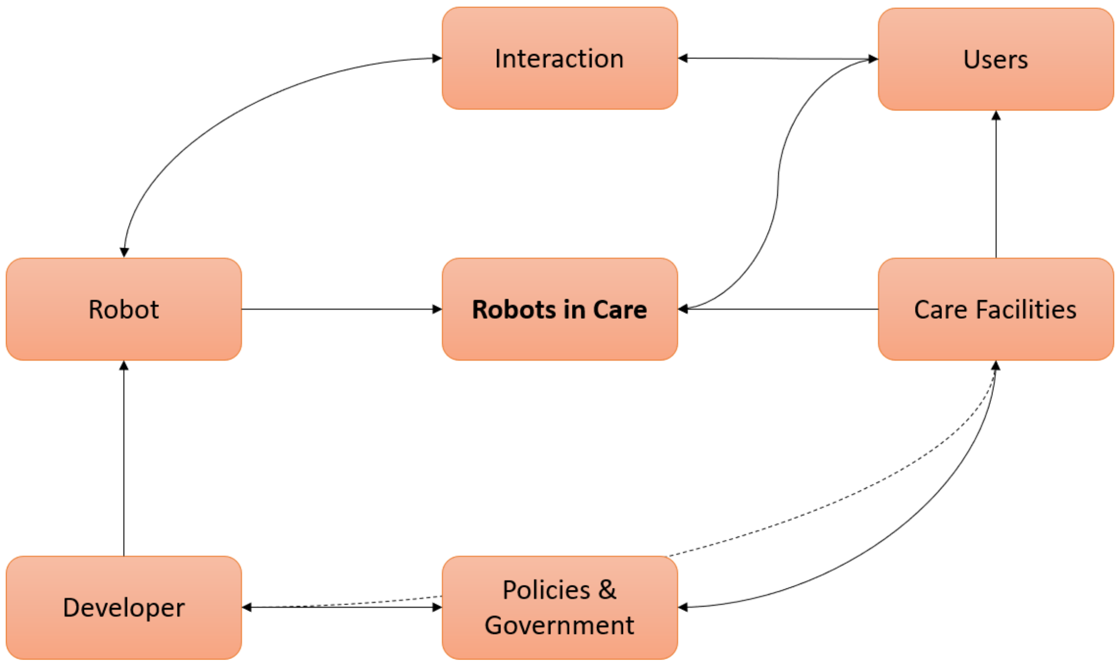

Figure 19. Core theory emerging from the grounded theory.

Chapter 6

Discussion

The Grounded Theory was applied in this research to address several aspects of robots in nursing care. We have developed one main theory with one main core category which is "*Robots in Care*" (Section 5.5). Additional theories were developed to capture all important subcategories of the core category, i.e. *Development, Target Group and Government, Design, Size and Gender, Safety and Ethics, Image and Expectations, etc*. (Section 5.4). By keeping several theories, we have managed to analyze and summarize all information captured in interviews with developers, professors, and health care personnel. It would have been a loss not to acknowledge all these different aspects of the robots in care.

From the grounded theory, we have learned about examples of developments of robots (Section 5.4) and from the "*Qualitative Analysis of Semi Structured Interviews on Integrating Socially Assistive Robots into Japanese Nursing Care*" (Section 5.5), we saw examples of how finished products are working in real-life settings.

We have also gathered opinions and viewpoints from university students (Section 5.1) and elementary school pupils (Section 5.2) to understand their perception of robots, their interaction with them and the usage of robots across multiple target groups. This is because robots like SoftBank's Pepper is a robot made for several purposes other than nursing care and can be found in local businesses, restaurants, train stations, education and so on. RoBoHon is made for the general public as an alternative to the conventional smartphone, but additional applications allow for the same robot to be used in care. PALRO has been tried on several target groups with different rates of success but has proven to be valuable for nursing care with much potential in helping both nursing care workers and patients, whether it is through direct or indirect assistance.

The aru/iru aspect of the study aimed to utilize the Japanese language in order to see whether Japanese people subconsciously perceived robots being alive or not. The use of iru would mean that the robot was to some extent perceived as being alive, while the use of aru would mean that the robot was mostly seen as an object. The study found that the participants would generally use iru for robots, with 8/9 pupils and 13/17 students (including Chinese students) referring to Pepper by iru, giving a total of 80% (85% excluding the Chinese students) collectively for the two case studies. However, it is uncertain whether the appearance, intelligence, movement, etc. or the collection of these has the strongest influence on this perception.

On the topic of perceiving robots as being alive, we can also look to the findings from the "*Empathy-level Comparison Between Smibi and Paro; Doll and Robot*" experiment (Section 5.3). This experiment asked 34 participants to fill out a self-reported empathy questionnaire after witnessing mistreatment towards the robots Paro and Smibi, when turned both ON (robot/alive) and OFF (doll/object). The results from the experiment indicate a strong influence on empathy emerging from a robot's responsiveness, emotional deception, movement, sound or a collection of the former. Overall, the experiment showed that the participants felt more empathy towards a moving robot than a doll, and that a robot's appearance is one, but not the only, influencer on empathy.

The "*Qualitative Analysis of Semi Structured Interviews on Integrating Socially Assistive Robots into Nursing Care*" (Section 5.5, Appendix D) aimed to investigate the advantages, disadvantages, and success of bringing robots into real nursing care. As seen in the literature (Section 2.3.2), our interviews held with nursing staff found that robots like Paro were indeed seen as an alternative to pet/animal therapy, but without the risk of allergy, bites, scratches, infections or even stress for the animal itself. In addition, robots can be cheaper than keeping dogs, and demand less maintenance. Even though Paro is designed to resemble a baby harp seal, patients often confuse Paro with their own pets. What makes Paro different from a stuffed animal is the movement, sound, and reactions to its environment which makes patients feel understood. However, some people dislike certain animals which makes them skeptical of animal-type robots, as well. Every day is different, and the interaction time and enthusiasm depend on the patients' mood. Depending on the patient, typical interaction time with robots was said to be up to 30 minutes daily.

Pepper, on the other hand, is seen more as a staff member and is mostly used to entertain and animate patients. In addition, Pepper is also being used for Taiso, the daily Japanese stretching exercise often performed several times a day. However, from our observations, Taiso is typically performed together with a staff member. Pepper is placed in the center of attention while the staff member encourages from the side, thus the need for human workers is not eliminated. Both Pepper and Paro can be used by the patients alone but is usually used together with the nursing staff, and the interest of both patients and staff members determines the use of the robots. As a result of using the robots, patients, that usually did not smile to the human staff members, were seen smiling and talking to the robots. Additional positive effects were increased interest of groups and often grandchildren to visit the nursing facilities and to learn more about the robots.

Ultimately, a consensus was found that these robots were not thought to be better than humans but are used to assist and relieve humans from work overload. Care workers are often too busy to entertain patients which is something that robots can be good at. As one of the interview subjects stated "*When looking at the value of an industrial robot, the productivity is visible, but in the case of nursing robots, we should see the number of staff halved, or more nursing care performed at the same time. However, the effect is more on the patient's mentality which might not be as visible*".

As mentioned by one of the professors (Section 5.4), the world is designed for humans, thus the robot must be able to navigate through an environment designed for humans. If we imagine the ultimate nursing care robot to be equal to that of a human nurse, there is still a long way to go before such a robot would become a common sight or even a reality. Arguably the most advanced Japanese humanoid robot today is Honda's ASIMO. ASIMO was developed to be a helper of people [36]. It can walk on two legs, walk up and down stairs, carry objects, push carts, it has a people-friendly design and it is small and lightweight. However, ASIMO has an operating time of one hour with a three-hour recharge time [36], limited lifting power and a quick google search show a cost of 2.5 million USD for the robot (not confirmed). ASIMO is incredibly advanced, but far from ready to replace a nursing care worker.

So far, robots can only be used for some nursing care tasks. A big problem many nurses have is backpain from lifting patients. Scientists from Riken, Japan's largest comprehensive research institution, have developed the bear-like robot ROBEAR, designed to help with lifting patients in order to relieve the care workers and prevent such work-related injuries. RIBA, the predecessor of both ROBEAR and RIBA-II is a 180 kg heavy robot that can lift patients up to 63 kg [37]. The average weight of a Japanese adult male is 62.5 kg; thus, the problem remains for the heavier patients where the lifting assistance is most needed. There is currently limited accessible information on ROBEAR, but the price for the prototype is allegedly between 168.000-252.000 USD, however, there is a hope of making it more affordable within the next 20-30 years. Due to technological limitations and costs, robots are made small and often incapable of direct physical assist.

Regarding the design science research framework, we have developed theories as the main artifacts of this study. The theories developed have looked to the environment (pupils, students, nursing facilities and their inhabitants, as well as problems and opportunities) to identify requirements and relevance of our theories. On the other hand, we have looked to the knowledge base (theories and results from literature and the expertise of professors and robot developers, both pre-existing and emerging from the research) for the rigor and grounding of our theories. The design cycle of the framework involves "*generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved*" [26]. Thus, the developing theories were iteratively evaluated, looking to both the environment and the knowledge base.

The answers to the research questions are also part of the bigger theory on "*Robots in Care*" and some of the bigger ideas around this topic.

RQ1: *What do Japanese robot developers and researchers consider when developing robots?*

Judging by the literature and the semi-structured interviews, it seems like researchers and developers think about many different aspects while making robots and designing the human-robot interaction. However, there are no universal standards for factors like gender, culture, personality, appearance, size, emotions, etc. as it all depends on the purpose, target group and developers' own creativity and vision. Although the attitude and acceptance of robots are very subjective as seen in our case studies (Sections 5.1 and 5.2), there are certain factors that seem to be consistent among common robots. For example, as stated by one of the professors "*We typically do not assign any gender, often we develop robots to be more childlike, so kind of neutral and young*" (Section 5.4). Current robots often tend to have the size and personality of a child. Making the robot childlike is one way of controlling expectations, while at the same time, being a good way of avoiding fear, sensitive topics and to stay gender-neutral if this is a goal. Honda has also its specific reason for the height and size of its ASIMO. ASIMO's height of 120 cm was chosen to be able to "*operate freely in the human living space and to make it people friendly*" and because "*its eyes are located at the level of an adult's eyes when the adult is sitting in a chair. A height of 120 cm makes it easy to communicate with*" [38]. A similar argument on size was also made for robots like PALRO (Section 5.4) and Pepper [39].

It is important to know who you are making the robots for, what kinds of challenges they potentially deal with and what kind of tasks the robot will perform. In terms of nursing care robots, there are a great number of opportunities, approaches, and ways to help both patients and workers. Even though robots providing direct physical assistance are not yet common, information handling, entertainment or robot therapy can be beneficial to prominent factors of healthy aging (Section 2.1). There is nothing wrong with making novelties within any context of the robotic domain. Robotics is a difficult market (Section 5.4) and developing a robot can take years and millions of dollars depending on how ambitious the project is. In addition, talking robots must consider culture, customs, and language and are therefore difficult to introduce to an international market without extra research and overseas specifications. The gender of the user can be an indicator of whether the interaction with the robot will be interesting or not. Both Paro and Smibi can be effective in evoking old memories of childcare, something that is often more prominent in female patients. In fact, female opinions were used exclusively when designing PALRO in order of making the robot cuter (Section 5.4). Thus, a different concept might be more effective for men. However, this factor could be influenced also by different cultures and generations.

Social and conversational robots are recommended to be casual but polite, happy but situational aware. Robots are still far from perfect and design choices of appearance and personality can influence expectations, unconscious awareness of the limitations and ultimately avoid disappointment (Section 5.4). Familiarity and shapes also help natural communication. It is important how robots are presented and marketed since this influences the initial expectations. Underselling its intelligence and functions through careful design of appearance and personality will help to influence its overall likability in a positive direction. As we saw in the Pepper interaction case study (Section 5.1), the design was found to have a strong positive relationship with the prior expectations towards Pepper. As for the interaction, frustration was found to have a strong (being the strongest) negative relationship with both likability and the overall post rating of the robot. We also saw that those going into the interaction with high expectations ended up rating it lower at the end of the interaction.

Both Smibi and Paro are robots with a design based on unfamiliar animals. Paro is based on a baby harp seal while Smibi's face is based on a beluga whale, animals for which people do not know what to expect. Due to the lack of experience with such animals, it is hard to get disappointed with the interaction. High expectations can be a big problem when it comes to robots, their acceptance, and likability.

RQ2: *What are the benefits and disadvantages of using nursing care robots for everyone involved?*

Some of the most prominent benefits found in this study for having robots in nursing care regards both the patients and workers. For the patients, robots seem to mainly function as an activity, providing therapy or recreation through games and other forms of entertainment and applications. In addition, AI technology such as "speech to text" allows for alternative ways of communication, whether it is to or through the robots. Robots can be used to fight issues like loneliness and depression, both of which have a strong negative correlation with healthy aging (Section 2.1). In addition, robots contribute to healthy aging, maintaining a feeling of independence through self-achievement and limited involvement of human helpers. Robots are still not capable of heavy-duty physical tasks but can help workers by providing appreciated entertainment and distraction to the patients. As nursing home workers have a lot of responsibility and often several patients to watch over simultaneously, robots can be used to distract or occupy patient's attention while the workers take care of other patients. Robots like Paro, Smibi, and Qoobo can have a calming effect on certain patients, they might cheer them up or give patients a purpose in their day by providing care to them (Section 5.5). Using robots in advertisements can also attract attention to the nursing facility and can be a fun entity to play with for visiting families and children (Section 5.5). However, all the benefits literally come with a price as robots are generally still very expensive. Assistive robots exist, but their use still requires the attention of the workers. People are generally not educated on how robots can help, thus restricting the attractiveness, supply and demand, robot functions and further development. Robots in Japan are more easily sold through the government with financial aid. Robots are beneficial for both the nursing facilities and the patients, as they may be developed in cooperation with experts on psychology or physical exercise, which could be utilized through a one-time purchase (Section 5.4). Japanese society stimulates both developers and potential users through dedicated funds and strategies developed to address the growing needs of the aging population.

RQ3: *What are the safety and ethical issues and concerns connected to robots and their usage in the nursing care context?*

There are some ethical issues connected to robots in general, ranging from appearance to functions and use. There are currently few rules and regulations connected to robots, and it seems like developers have few boundaries to their inventions. In addition to the privacy issues and data storing, the developers might want to consider issues like gender stereotype reinforcement, risk of the replacement of human-human interaction, deception and attachment, misuse of AI for self-praising, and so on (Section 5.4). However, these issues are currently being discussed without reaching conclusive answers, so it is still up to the developers' discretion on how to approach these issues. There are currently little safety requirements for robots in care, and safety is mostly kept by the developers or researchers themselves. However, safety is considered for the robots as we have learned from the interviews (Section 5.4) and there are common ideas on safety such as obstacle avoidance and so on. Smaller robots made without the intention of providing physical assistance, naturally avoid complicated safety measures and risks of physical injuries.

A common concern people share towards robots is that robots will steal jobs from humans. Even though this concern is also dependent on culture (Section 5.4). The EU survey from 2012 (Section 2.2.2) showed that 70% of the population in EU countries thought that robots were stealing jobs, and only 39% agreed that widespread use of robots could boost job opportunities in the EU. In some cases, this might be true as robots can be able to work better, faster, and with higher precision than humans. On top of this, robots do not need breaks, will not complain about long working hours and the only cost would be the initial purchase of the robot along with periodic maintenance. Nevertheless, robots are usually performing repetitive tasks that would be boring for humans in the long run and can often not work without help from humans as seen in Section 5.5. Robots are also designed and programmed to perform specific tasks, often limited in scope. When robots replace humans in certain jobs, new jobs are also created, often in terms of selling, installment, maintenance, and development. In the Japanese nursing field, robots are designed to either assist humans in their tasks instead of replacing them or to perform simple tasks on their own in order to reduce the workload put on the nursing care workers due to the shrinking workforce and the increasing number of the elderly (Section 5.5). The fact is that the currently developed and used robots are not advanced enough to actually replace the human workers, so what they are currently doing is to entertain, provide a break for the nursing staff or to assist patients in tasks that they would like to perform independently.

RQ4: *What is the human-robot interaction like with current robots?*

When designing robots, it is important to consider the kind of relationship people will have with them. Even though robots have an advanced form of intelligence, developers design their robots to appear much weaker, clumsier and dumber than they are capable of being. The reason for this, especially in nursing care, is to boost the confidence of those who are considered among the weakest in society (Section 5.4). The interface should also be made easy, especially for robots to be used for nursing care purposes, as cognitive abilities and senses often decrease with age (Section 2.1). Technologies like speech to text, therefore, come in handy as they allow for more natural interaction. However, the elderly also tend to be more unclear in their pronunciation and speech, thus the technology must be able to accommodate for such challenges. The same goes for the robot's pronunciation and volume towards the elderly. Communicative robots can be more easily improved through software applications alone.

Additionally, robots can increase the confidence of those who interact with them, encourage conversation and fight loneliness, depression, and dementia (Section 5.5). Robots are often given the personality of children to appear lower in status, size, less intelligent, more casual, fun, non-threatening and friendly (Section 5.4).

Looking at robots used for therapy like Paro, Smibi, and Qoobo, we see that the interaction can be much more simplistic, requiring less intelligence in the robots (Section 5.5). These robots often utilize touch sensors and are made to take care of the users by letting the user taking care of them. As we have learned from nursing care workers in Section 5.5, these robots are often more useful and appreciated by people with dementia, as it is often the deception of the robot being alive which makes them interesting. Another "criteria" for the robots' success, was the users' love for animals, particularly for animal robots such as Paro and Qoobo. Even though Paro is based on a baby harp seal, people with dementia will see the robot as anything they would like, including dogs or even as human babies (Section 5.5). In the case of Qoobo, observations showed one scenario where the robot would be placed on the lap of and petted by a patient, without necessarily looking or paying much attention to it. However, the warmth and responding movement of Qoobo's robotic tail would give the feeling of interacting with a real animal, or cat in this case. The effect of a robot's movement and the sound was also further demonstrated in the "Empathy-level Comparison Between Smibi and Paro; Doll and Robot" experiment (Section 5.3). The results suggest the increase in empathy and willingness to care for robots due to responsive movement and sound.

Chapter 7

Conclusion and Future Work

7.1 Conclusion

Countries like Japan are currently seeing its elderly population grow proportionally large while the workforce is shrinking. This is creating a work overload and often job-related physical injuries and pain for the nursing staff. Japan has chosen to invest in robots in order to help deal with the issues related.

Using methods such as case study, experiment, observation, semi-structured interview, and the grounded theory, this study has investigated popular robots connected to nursing care through looking at human-robot interaction, development, use, ethics, benefits and limitations of such robots.

The study presents, compares and discusses expert and user opinions, experiences, knowledge, and justification on design, functions, issues, and benefits for some of the most commonly seen robots in Japan. Several theories have been made from emerging categories such as "*development, government and target group*", "*interaction and communication*", "*design, size and gender*", "*market, price and marketing*", "*role and robots in care*", "*relationship and trust*", "*safety and ethics*", "*image and expectations*", "*emotions*", "*culture*", "*intelligence*" and "*difficulties and limitations*", all building up under the main theory of "*robots in care*". The theories are grounded in a content analysis of data obtained from interviews held with developers and users, and together with case studies on human-robot interaction and an experiment on empathy towards robots. The study provides a comprehensive analysis of the research problem from the multiple parties involved. Thus, we have investigated the research problem, all the way from government policies and funding, understanding approaches to robot development and marketing, and down to the end-users.

The experiment on empathy towards robots demonstrated the effect of applying movement and sound to an entity (bringing it to life), in order to increase empathy and stimulate people to care for them. In the case of the elderly, it has been shown that by caring for robots, one cares for oneself.

The paper identifies important points to consider when developing or investing in robots in order to assist the future of robot development and options for nursing care.

7.2 Future Work

Future work will include further investigation into the hesitation of adopting robots in the West and European countries' non-hypothetical attitudes towards robots. Many people might have some opinion about robots and especially interaction with them, even without having participated in any organized studies. To gain new knowledge, we would suggest further studies which are not necessarily conducted in controlled environments, but rather through the analysis of broad literature, media, chat forums or social media such as YouTube, Twitter, and Facebook, which could be analyzed using data mining. This work might result in discovering important cultural adjustments needed to advance the acceptance of robots by Western audiences and societies.

Bibliography

[1] United Nations, "United Nations," United Nations, DESA, Population Division, 2019. [Online]. Available: https://population.un.org/wpp/Graphs/Probabilistic/POP/TOT/392. [Accessed 18 November 2019].

[2] The Ministry of Economy, Trade and Industry (METI), "The Ministry of Economy, Trade and Industry," 2013. [Online]. Available: https://www.meti.go.jp/english/publications/pdf/journal2013_04.pdf. [Accessed 29 November 2019].

[3] World Health Organization (WHO), "World Health Organization Ageing and Health," World Health Organization, 5 February 2018. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. [Accessed 18 November 2019].

[4] E. Jaul and J. Barron, "Age-Related Diseases and Clinical and Public Health Implications for the 85 Years Old and Over Population," *Front Public Health,* pp. 1-7, 11 December 2017.

[5] World Health Organization, "Ageing and life-course," World Health Organization, [Online]. Available: https://www.who.int/ageing/healthy-ageing/en/. [Accessed 19 November 2019].

[6] K. Han, Y. Lee, J. Gu, H. Oh, J. Han and K. Kim, "Psychosocial factors for influencing healthy aging in adults in Korea," *Health and Quality of Life Outcomes,* p. 13:31, 7 March 2015.

[7] International Federation of Robotics (IFR), 18 October 2018. [Online]. Available: https://ifr.org/downloads/press2018/WR_Presentation_Industry_and_Service_Robots_rev_5_12_18.pdf. [Accessed 10 April 2019].

[8] International Federation of Robotics (IFR), "Executive Summary World Robotics 2018 Service Robots," 2018. [Online]. Available: https://ifr.org/downloads/press2018/Executive_Summary_WR_Service_Robots_2018.pdf. [Accessed 26 November 2019].

[9] TNS Opinion & Social, "Public Attitudes towards Robots," European Commission, 2012.

[10] C. Bartneck, T. Suzuki, T. Kanda and T. Nomura, "The influence of people's culture and prior experiences with Aibo on their attitude towards robots," *AI & Society,* pp. 217-230, 20 May 2006.

[11] R. Celine, F. Mondada and R. Siegwarth, "What do people expect from robots?," in *2008 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Nice, 2008.

[12] K. S. Haring, C. Mougenot, F. Ono and K. Watanabe, "Cultural Differences in Perception and Attitude towards Robots," *International Journal of Affective Engineering,* pp. 149-157, 1 January 2014.

[13] Cabinet Office Public Relations Office, "Special Survey on Care Robots「介護ロボットに関する特別世論調査」の概要," Public Relations Office of the Government of Japan, 2013.

[14] T. Nomura, T. Kanda, T. Suzuki and K. Kato, "People's assumptions about robots: investigation of their relationships with attitudes and emotions toward robots," *2005 IEEE International Workshop on Robots and Human Interactive Communication,* pp. 125-130, 3 October 2005.

[15] T. Nomura, "Robots and Gender," *Gender and Genome,* no. 1, pp. 18-25, 9 December 2016.

[16] The Headquarters for Japan's Economic Revitalization, "The Ministry of Economy, Trade and Industry (METI)," 10 February 2015. [Online]. Available: https://www.meti.go.jp/english/press/2015/pdf/0123_01b.pdf.

[17] The Ministry of Economy, Trade and Industry (METI) and Ministry of Health, Labour and Welfare (MHLW), "Revision of the Priority Areas to Which Robot Technology is to be Introduced in Nursing Care," 12 October 2017. [Online]. Available: https://www.meti.go.jp/english/press/2017/1012_002.html. [Accessed 26 November 2019].

[18] M. Kanamori, M. Suzuki, H. Oshiro and Hamamuta AAT Members, "Pilot study on improvement of quality of life among elderly using a pet-type robot," *Proceedings 2003 IEEE International Symposium on Computational Intelligence in Robotics and Automation,* pp. 107-112, 18 August 2003.

[19] T. Shibata and K. Wada, "Robot Therapy: A New Approach for Mental Healthcare of the Elderly - A Mini-Review," *Gerontology 2011,* pp. 378-386, 15 July 2010.

[20] K. Wada, T. Shibata, T. Saito and K. Tanie, "Robot Assisted Activity for Elderly People and Nurses at a Day Service Center," *Proceedings of the 2002 IEEE International Conference on Robotics and Automation,* pp. 1416-1421, 7 August 2002.

[21] M. Kanoh, "A Robot as "Receiver of Care" in Symbiosis with People," *Journal of Japan Society for Fuzzy Theory and Intelligent Informatics,* pp. 193-201, 2015.

[22] T. Tanioka, "Nursing and Rehabilitative Care of the Elderly Using Humanoid Robots," *The Journal of Medical Investigation,* no. 1.2, pp. 19-23, 27 April 2019.

[23] J. I. Rocca, "The future of elderly in the hands of Care Robots," 10 March 2017.

[24] M. A. Rosenthal-von der Pütten, F. P. Schulte, S. C. Eimler, S. Sobieraj, L. Hoffmann, S. Maderwald, M. Brand and N. C. Krämer, "Investigations on empathy towards humans and robots using fMRI," *Computers in Human Behavior,* pp. 201-212, April 2014.

[25] Y. Furuta, M. Kanoh, T. Shimizu, M. Shimizu and T. Nakamura, "Subjective evaluation of use of Babyloid for doll therapy," *IEEE World Congress on Computational Intelligence,* 13 August 2012.

[26] A. . R. Hevner, "A Three Cycle View of Design Science Research," *Scandinavian Journal of Information Systems,* no. 19, pp. 87-92, 2007.

[27] J. W. Creswell, Research Design International Student Edition Qualitative, Quantitative and Mixed Methodss Approches Fourth Edition, Los Angeles: SAGE Publications Inc., 2014, p. 171.

[28] A. Bryman, Social Research Methods 4th Edition, New York: Oxford University Press, 2012.

[29] Norwegian Center for Research Data (NSD), "NSD Data Protection Service," Norwegian Center for Research Data (NSD), [Online]. Available: https://nsd.no/personvernombud/en/index.html. [Accessed 27 November 2019].

[30] DaiwaHouse, "List of Introduction Facilities - Paro Introduction Status," 7 January 2016. [Online]. Available: https://www.daiwahouse.co.jp/robot/paro/map.html. [Accessed 28 November 2019].

[31] Yukai Engineering Inc., "Qoobo," Yukai Engineering Inc., [Online]. Available: https://qoobo.info/index-en/. [Accessed 29 November 2019].

[32] H.-F. Hsieh and S. E. Shannon, "Three Approaches to Qualitative Content Analysis," *Qualitative Health Research,* pp. 1277-1288, December 2005.

[33] B. Downe-Wamboldt, "Content analysis: Method, applications, and issues.," *Health Care forWomen,* pp. 313-321, 1992.

[34] W. D. Fernández, "The grounded theory method and case study data in IS research: issues and design," in *Information Systems Foundations: Constructing and Criticising*, ANU Press, 2005, pp. 43-60.

[35] R. N. Spreng, M. C. McKinnon, R. A. Mar and B. Levine, "The Toronto Empathy Questionnaire: Scale development and initial validation of a factor-analytic solution to multiple empathy measures," *Journal of personality assessment,* p. 62–71, January 2009.

[36] Honda, "Asimo," [Online]. Available: https://asimo.honda.com/downloads/pdf/asimo-technical-faq.pdf. [Accessed September 2019].

[37] T. Mukai, H. Nakashima and H. Shigeyuki, "Development of a nursing-care assistant robot RIBA that can lift a human in its arms," in *The 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Taipei, 2010.

[38] Honda, "ASIMO TECHNICAL INFORMATION," September 2007. [Online]. Available: https://asimo.honda.com/downloads/pdf/asimo-technical-information.pdf. [Accessed 21 November 2019].

[39] SoftBank Robotics, "Pepper," SoftBank Robotics, [Online]. Available: https://www.softbankrobotics.com/emea/en/pepper. [Accessed 23 November 2019].

Appendix A

A-1 Approval from NSD

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Assistive Robots in Service and Healthcare

Referansenummer

612052

Registrert

21.02.2019 av Markus Kolstad - Markus.Kolstad@student.uib.no

Behandlingsansvarlig institusjon

Universitetet i Bergen / Det samfunnsvitenskapelige fakultet / Institutt for informasjons- og medievitenskap

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Ankica Babic, Ankica.Babic@uib.no, tlf: 55589139

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Markus Kolstad, markus.kolstad@hotmail.com, tlf: 98468098

Prosjektperiode

01.02.2019 - 31.12.2019

Status

01.04.2019 - Vurdert

Vurdering (1)

01.04.2019 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 01.04.2019 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:
https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 31.12.2019.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Kontaktperson hos NSD: Eva J B Payne
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix B

B-1 Informed Consent Form - Nursing Home Workers
B-2 Interview Guide - Nursing Home Workers
B-3 Informed Consent Form - Researchers and Industry Workers
B-4 Interview Guide - Industry Workers

Do you want to participate in the research project "Assistive Robots in Service and Healthcare"?

This is a question for you to participate in a research project where the purpose is to map and understand to what degree communicating and assisting robots can assist in service and/or nursing care and to what degree researchers, users and co-workers of robots find them helpful, friendly and capable of replacing tasks previously performed by human workers. In this letter we give you information about the goals of the project and what participation will involve for you.

Purpose

The project is carried out in connection with the completion of a master's thesis. The purpose is to research Japans focus and attempt to integrate robot technologies into service and nursing care and to see to what degree these attempts are working or not. Your personal experiences using these robots will be used to learn more about robots in terms of good and bad points for currently existing robots and hopefully be able capture insights and ideas to help future social assisting robot development. Along with determining the effect a robot can have on its users, I want to research the user friendliness and likability of the robots that are currently in use around Japan.

Who is responsible for the research project?
Department of Information and Media Studies at the Faculty of Social Sciences, University of Bergen. The study is carried out in Japan through the help from the Department of Information Science and Engineering, Ritsumeikan University Biwako-Kusatsu Campus.

Why do you get questions about participating?
You have been chosen as a potential participant because of your experience of interacting with robots - you are a part of the target audience for users of these robots and alternative futuristic methods of service and/or nursing care.

What does it mean for you to participate?

If you choose to participate in this project, it means that you agree to be interviewed about your personal user experiences and perceptions of interacting with robots. The interview is partially structured. The interview will last for about 20 minutes. Written notes will be taken along the way. Audio from the interview will be recorded.

Volunteering is optional
It is voluntary to participate in the project. If you choose to participate, you can withdraw your consent at any time without giving any reason. All information about you will then be anonymized. It will not have any negative consequences for you if you do not want to attend or later choose to withdraw.

Your privacy - how we store and use your information
We will only use the information about you for the purposes we have described in this letter. We treat the information confidentially and in accordance with the privacy policy.

- The parties who want access to the information are Markus Kolstad (student) and Ankica Babic (supervisor Norway) Yoko Nishihara (supervisor Japan)

● All personal information about you will be stored on an encrypted USB flash drive separate from other data. This includes name list where your name will be replaced with a reference, the link between name and reference will be stored on the above-mentioned USB flash drive. Audio recording of interview will be saved on the same piece. Transcription of recordings is anonymized by reference.

No participants will be recognized in the publication. All names is replaced by an ID number.

What happens to your information when we finish the research project?
The project is scheduled to end on 01.12.2019. Personal data and audio recordings stored in connection with the studies will be deleted from the USB flash drive, which will then be destroyed.

Your rights
As long as you can be identified in the data material, you are entitled to:
- an overview of what personal data is registered about you,
- to get personal information about you,
- Get deleted personal information about you,
- Get a copy of your personal information (data portability), and
- to send a complaint to your privacy representative or data protection agency regarding the processing of your personal information.

What gives us the right to process personal information about you?
We process information about you based on your consent.

On behalf of the Department of Information and Media Studies, NSD - Norwegian Center for Research Data AS has considered that processing of personal data in this project is in accordance with the privacy policy.

Where can I find out more? If you have questions about the study or wish to avail yourself of your rights, please contact:

● Markus Kolstad (Student)
    ○ mko017@uib.no

● Associate Professor Ankica Babic (supervisor, Norway)
    ○ Ankica.Babic@uib.no

● Associate Professor Yoko Nishihara (supervisor, Japan)
    ○ nisihara@fc.ritsumei.ac.jp

NSD - Norwegian Center for Research Data AS, by email (personverntjenester@nsd.no) or phone: 55 58 21 17.

Data protection office at the University of Bergen: personvernombud@uib.no.

With best regards

Project Manager (Researcher / tutor) Yoko Nishihara	Student Markus Kolstad

-- --

Consent Statement

I have received and understood information about the project “Assistive Robots in Service and Healthcare”, and have had the opportunity to ask questions.

I agree to:

- To participate in a part-organized interview
- That my answers can be published in the completed master thesis
- I agree that my information will be processed until the project is completed, approx. 01/12/2019

Optional: (This line will be crossed out in front of the participant if not)

- That my interaction with a robot based on observation may be described in the master thesis

-- --
(Signed by project participant, date)

Interview guide Nursing home

Nationality

Age:
Robot:
Company:
Position:

- How long have you used/worked with robots?
- How often do you interact with the robot?
- Did you get an introduction/course on how to use the robot? (How long did it take?)
- How long is usually each session of interacting with the robot?
- Do you feel like the way of interacting is intuitive?
- How long did you need before understanding the way of interaction? (hours/days/weeks)
- Do you have any experience with similar robots in the past? If yes, what robot(s)?

Questions:

- Why did you decide to invest in robots?
- How many robots do you have?
- Do you advertise with robots?
- In what way can the robot be assisting you or its users? (Work, everyday life, chores.)
- What group of users is the robot(s) designed for?
- In what way do you think the robot might frustrate you or other users?
- Do you at some point forget that you are interacting with a robot/machine?
- Do you feel like the robot is intelligent?
- Did you feel like the robot has feelings/emotions?
- Does the robot have a personality? Please explain.
- Are you impressed by the robot?
- Did the robot meet your expectations?
- Where did your expectations come from?
- How do you like the design of the Robot?
- Are there any reasons behind the design?
- What features makes it cute/not so cute?
- What are your favorite features about the Robot?
- What is the least likable feature about the Robot?
- What features worries you? (Makes mistakes? Dangerous?)
- What do you consider the Robot as? (A real creature? An assistant? A robot? Friend? Other?)
- What is the effect of having the robot around?
- In what way can the use of robots be better than humans?
- Is there any maintenance needed and if so, what and how often?
- How can the robot be better?
- What role does the robot have in the future?

Trust

- Can you trust the robot? (Why/why not?)
- Why do you think people might (not) trust robots?
- What are your concerns when it comes to robots in general?
- What are your concerns when it comes to robots being responsible for your health?
- Why would you (not) prefer a robot over a human in the terms of trust?
- Have you ever had a deep conversation with the robot, talked about your day/feelings or worries?
- Have you ever shared a secret with the robot?

Wrokers:

How is the robot making work easier for you?

What is the robots job/use?

What work would you have liked robots to do?

What is the biggest benefit about having the robot?

What is the worst point about using robots?

Patients:

What is your favorite robot and why?

What is your image of a robot?

What is your favorite part about having a robot?

Why do you like or not like the robot?

Do you feel lonely talking to a robot?

Do you feel shy interacting with a robot?

Do you hesitate to use the robot?

Would you like more time with the robot?

Is the robot popular in the nursing home?

Do you want the robot to mostly listen, talk or have a dialog?

Do you want to participate in the research project "Assistive Robots in Service and Healthcare"?

This is a question for you to participate in a research project where the purpose is to map and understand to what degree communicating and assisting robots can assist in service and/or nursing care and to what degree researchers, users and co-workers of robots find them helpful, friendly and capable of replacing tasks previously performed by human workers. In this letter we give you information about the goals of the project and what participation will involve for you.

Purpose

The project is carried out in connection with the completion of a master's thesis. The purpose is to research Japans focus and attempt to integrate robot technologies into service and nursing care and to see to what degree these attempts are working or not. Your personal experiences using, researching and/or developing these robots will be used to learn more about robots in terms of good and bad points for currently existing robots and hopefully be able capture insights and ideas to help future social assisting robot development. Along with determining the effect a robot can have on its users, I want to research the user friendliness and likability of the robots that are currently in use around Japan.

Who is responsible for the research project?
Department of Information and Media Studies at the Faculty of Social Sciences, University of Bergen. The study is carried out in Japan through the help from the Department of Information Science and Engineering, Ritsumeikan University Biwako-Kusatsu Campus.

Why do you get questions about participating?
You have been chosen as a potential participant because of your experience of interacting, researching and/or developing robots – you play a part (directly or indirectly) in the alternative futuristic methods of service and/or nursing care.

What does it mean for you to participate?

If you choose to participate in this project, it means that you agree to be interviewed about your personal experiences and part in researching and/or developing robots. The interview is partially structured. The interview will last for about 20 minutes. Written notes will be taken along the way. Audio from the interview will be recorded.

Volunteering is optional
It is voluntary to participate in the project. If you choose to participate, you can withdraw your consent at any time without giving any reason. All information about you will then be anonymized. It will not have any negative consequences for you if you do not want to attend or later choose to withdraw.

Your privacy - how we store and use your information
We will only use the information about you for the purposes we have described in this letter. We treat the information confidentially and in accordance with the privacy policy.

● The parties who want access to the information are Markus Kolstad (student) and Ankica Babic (supervisor Norway) Yoko Nishihara (supervisor Japan)

● All personal information about you will be stored on an encrypted USB flash drive separate from other data. This includes name list where your name will be replaced with a reference, the link between name and reference will be stored on the above-mentioned USB flash drive. Audio recording of interview will be saved on the same piece. Transcription of recordings is anonymized by reference.

In general, no participants will be recognized in the publication unless the approval for use of name and position is signed by the participant.

What happens to your information when we finish the research project?
The project is scheduled to end on 01.12.2019. Personal data and audio recordings stored in connection with the studies will be deleted from the USB flash drive, which will then be destroyed.

Your rights
As long as you can be identified in the data material, you are entitled to:
- an overview of what personal data is registered about you,
- to get personal information about you,
- Get deleted personal information about you,
- Get a copy of your personal information (data portability), and
- to send a complaint to your privacy representative or data protection agency regarding the processing of your personal information.

What gives us the right to process personal information about you?
We process information about you based on your consent.

On behalf of the Department of Information and Media Studies, NSD - Norwegian Center for Research Data AS has considered that processing of personal data in this project is in accordance with the privacy policy.

Where can I find out more? If you have questions about the study or wish to avail yourself of your rights, please contact:

● Markus Kolstad (Student)
    ○ mko017@uib.no

● Associate Professor Ankica Babic (supervisor, Norway)
    ○ Ankica.Babic@uib.no

● Associate Professor Yoko Nishihara (supervisor, Japan)
    ○ nisihara@fc.ritsumei.ac.jp

NSD - Norwegian Center for Research Data AS, by email (personverntjenester@nsd.no) or phone: 55 58 21 17.

Data protection office at the University of Bergen: personvernombud@uib.no.

With best regards

Project Manager (Researcher / tutor) Yoko Nishihara	Student Markus Kolstad

-- --

Consent Statement

I have received and understood information about the project “Assistive Robots in Service and Healthcare”, and have had the opportunity to ask questions.

I agree to:

- To participate in a part-organized interview
- That my answers can be published in the completed master thesis
- I agree that my information will be processed until the project is completed, approx. 01/12/2019

-- --
(Signed by project participant, date)

Optional: (This line will be crossed out in front of the participant if not)

- That my name, title and position(in company or university) may be published connected to my given statements in the completed master thesis

-- --
(Signed by project participant, date)

Intervjuguide

Introduction:

- Nationality:
  Gender:
  Age:
  Robots:
  Company:
  Position:
- How long have you used/worked with/on the robot?
- How often do you interact with the robot?
- Did you get an introduction/course on how to use the robot? Do you give a course to customers? (How long did it take?)
- How long is a typical session of interacting with the robot?
- Do you/customers feel like the way of interacting is intuitive?
- How long did you/users need before understanding the way of interaction? (hours/days/weeks)
- Do you have any experience with similar robots in the past? If yes, what robot(s)?

Questions:

- In what way can robots be assisting you or its users? (Work, everyday life, chores.)
- What group of users is the robot(s) designed for?
- Is the robot, its design or functions based or included on behalf of any research?
- What is the intended effect of using the robot? Is this proven and how?
- How long from start to finish did it take to develop this robot?
- What was your developing process/ steps with this robot?
- How many people was involved in the process?
- Was the aimed users involved in the developing process? Requirements? User-testing?
- Why would users want to use this robot?
- Why care for a robot baby when you know it doesn't need it and that it will not grow up to achieve anything?
- How do you market the robot?
- Did the development receive any financial funding from the government?
- Are you selling mostly in Japan? What do you think the reason is?
- In how many nursing homes is the robot in use?
- How many robots are sold?
- Why is this robot a better option than other similar robots?
- In what way do you think the robots might frustrate you or other users?
- Do you feel like robots has feelings/emotions? Is the Illusion important?
- Do the robots have a personality? Please explain.

- What is important to think about when it comes to communication between human and robots?
- Is the communication aimed to be the same as between human and human?
- Why is facial recognition important to include?
- Are there any reasons behind the design?
- Is there any reason for its height and size?
- How is the design of the Robot Important?
- What features makes a robot cute/not so cute, likable?
- Are you impressed by todays robots?
- Where did your expectations towards robots come from?
- What is your image of a robot? (Definition?)
- What abilities is important for the robot(s) to have (related to its purpose) and why?
- What is the gender of the robot? Why or why is this not important?
- What degree of intelligence is inside the robot?
- Do you use aru or iru when talking about the robot?
- What are your favorite features about Robots?
- What is the least likable feature about Robots?
- What features worries you? (Makes mistakes? Dangerous?)
- What do you consider the Robot as? (A real creature? An assistant? A robot? Friend? Other?)
- What do you think its average users consider the Robot as? (A real creature? An assistant? A robot? Friend? Other?)
- What is the effect of having the robot around?
- Must a robot be designed with a specific user group in mind and how does the design of a robot change depending on its users? Old/Young, Male/Female, Type of work
- In what way can the use of robots be better than humans?
- Is there any maintenance needed and if so, what and how often?
- How can todays social or assistive robots be better?
- What role does the robot have in the future?

Trust

- Can the users trust the robot? (Why/why not?)
- Is trust important and how do people gain trust in a robot?
- Why do you think users might (not) trust robots?
- Is there any specific safety or ethical measures included in its hardware or software design?
- Are there any ethical standards to be followed for robots such as this and how did you become aware of them?
- Did the robot go through any safety testing before being released to the market?
- What are your concerns when it comes to robots in general?
- What are your concerns when it comes to robots being responsible for your health?
- Why would you (not/) prefer a robot over a human in the terms of trust?

Appendix C

Experiment plan – Interacting with Pepper

Introduction

Every participant will be asked the following:

Nationality/国籍:
Gender/性別:
Age/年齢:
Field of study/work/学域/職業:
Past experience and interaction with robots/過去のロボットとの交流の経験について:

Where do you usually see robots?
どこでよくロボットをみますか？
Where do you think robots work in Japan?
日本ではロボットはどういった場所や場面で使われていると思いますか？

Introduction time: about 1-3 minutes.

Interaction with Pepper for participants with instructions:

Participant is asked to interact with pepper on somewhat free terms.
参加者の皆さんはペッパーとの交流を自由にしていただいて構いませんが、

However, the participants is also asked to:
以下のことを各自行っていただきます。

1. Introduce themselves to pepper at the beginning.
   初めにペッパーに自己紹介をしてください。

2. Try to shake peppers hand.
   ペッパーと握手を試みてください。

3. Ask pepper at least two questions of their own choosing.
   ペッパーにご自身で考えた質問を２つしてください。

4. Ask pepper at least two questions about Pepper (Itself) of their own choosing.
   ペッパーにご自身が考えたペッパーに関する質問を２つしてください。

5. Make small-talk.
   ペッパーと少し会話をしてみてください。

Interaction time: 5-10 minutes.

Interview after interaction

Answer in Japanese: Is Pepper in this room?

How would you describe your interaction with Pepper?
ペッパーとの交流はどうでしたか？

Would you have liked more time to interact with Pepper?
ペッパーともっと交流したいですか？

Did you at some point forget that Pepper is a robot?
ペッパーがロボットであるということを忘れた場面はありましたか？

Did you interact with Pepper in the same was as you would interact with a human?
ペッパーとの交流は人間との交流と同じように感じますか？

Did you feel any frustration while interacting with Pepper?
ペッパーとの交流でイライラさせられた場面はありましたか？

Did you feel like Pepper was intelligent?
ペッパーは賢いと思いますか？

Did you feel like Pepper had feelings/emotions?
ペッパーには感情があると思いますか？

Does Pepper have a personality? Please explain.
ペッパーには性格があると思いますか？ 説明してください。

Would you like to have Pepper in your home? Why/why not?
ペッパーをあなたの家庭に欲しいと思いますか？ なぜですか？

Are you impressed by Pepper?
ペッパーから感銘/良い印象を受けましたか？

Do you like Peppers appearance?
ペッパーの見た目は好きですか？

Did Pepper meet your expectations?
ペッパーはあなたの期待通りでしたか？

Where did your expectations come from?
ペッパーに対してなぜその期待を持つようなりましたか？

Did your expectations change after interacting with Pepper?
ペッパーとの交流を通してその期待は変わりましたか？

Did you expect more or less based on Peppers appearance/ design?
ペッパーは見た目と比べてより良いと感じましたか？

Do you feel safe around Pepper?
ペッパーは安全だと感じましたか？

Do you think Pepper was predicable?
ペッパーはあなたの予想どうりの反応をしたと思いますか？

Would you feel safe around Pepper if he was holding a knife?
もしペッパーがナイフを持っていたら、あなたは安全だと感じますか？

What functions or abilities would you like to see in Pepper?
あなたがペッパーに期待する機能や能力はなんですか？

Do pepper resemble your image of a robot?
ペッパーはあなたのイメージするロボットと似ていますか？

In what year would you think pepper was made, based on his design and capabilities?
ペッパーのデザインや機能から考えて、ペッパーら何年に造られたと思いますか？

Interview time: 5-10 minutes.

Total experiment time per participant: 10-20 minutes.

ID: Group: Man 男 Woman 女	Never 決して	Rarely めったに	Sometimes 時々	Often しばしば	Always 常に
1. When Sumaiby is feeling excited, I get excited too. スマイビーが興奮してると、私も興奮する					
2. Sumaiby's misfortunes do not disturb me a great deal. スマイビーがかわいそうにみえても、私はそんなに気にならないです	大変気になる	気になる	まぁまぁ気になる	ほとんど気にならない	まったく気にならない
3. It upsets me to see Sumaiby being treated disrespectfully. スマイビーが乱暴に扱われていると、それを見ていられなくなります					
4. I remain unaffected when Sumaiby is happy. スマイビーが嬉しそうにしていても、私には影響がありませ	大変影響がある	影響がある	まぁまぁ影響がある	ほとんど影響がない	全く影響がない
5. I enjoy making Sumaiby feel better. 私はスマイビーをご機嫌にさせるのを楽しんでいます					
6. I can tell when Sumaiby are sad even when Sumaiby do not say anything. スマイビーが何も言わなくても、スマイビーが悲しんでいる時はわかります					
7. I find that I am "in tune" with other Sumaiby's moods. 私はスマイビーの気分と同調していることがあります					
8. I become irritated when Sumaiby cries. スマイビーが泣くと、私はイライラします。					
9. I am not really interested in how Sumaiby feel. 私はスマイビーがどんな風に感じるかについてあまり興味がありません	大変興味がある	興味がある	まぁまぁ興味がある	ほとんど興味がない	全く興味がない
10. I get a strong urge to help when I see Sumaiby is upset. 私はスマイビーが困っているのをみたら、助けたいと強く思います					
11. When I see Sumaiby treated unfairly, I do not feel very much pity for Sumaiby. スマイビーが乱暴に扱われているのをみても、私はスマイビーがかわいそうだなとあまり思いません	かわいそう		まぁまぁそう思う		かわいそうではない
12. When I see Sumaiby being taken advantage of, I feel kind of protective towards Sumaiby. 私はスマイビーが利用されているのをみると, スマイビーを保護しなくてはと思います					

Appendix D

Paper Submission to Conference

30th Medical Informatics Europe conference (MIE) to be held in Geneva

April 28th – May 1st, 2020.

Integrating Socially Assistive Robots into Japanese Nursing Care

Markus KOLSTAD [a,1], Natsu YAMAGUCHI [b], Ankica BABIC [a,c] and Yoko NISHIHARA [d]
[a] *Department of Information Science and Media Studies, University of Bergen, Norway*
[b] *College of Law, Ritsumeikan University, Japan*
[c] *Department of Biomedical Engineering, Linköping University, Sweden*
[d] *College of Information Science and Engineering, Ritsumeikan University, Japan*

Abstract. This paper presents experiences of integrating assistive robots in Japanese nursing care based on semi-structured interviews and site observations at three nursing facilities in Japan during the spring of 2019. The study looked at experiences with the robots *Paro*, *Pepper*, and *Qoobo*. The goal was to investigate and evaluate the current state of using robots in the nursing care context, firsthand experiences with intended and real users, as well as response from the elderly and nursing staff. The qualitative analysis results pointed out user satisfaction, purpose adjusted to different user groups, therapeutic and entertaining effects. Potentials of robots to assist in elderly care are great. Limitations currently relate to the lack of ways to fully utilize and integrate robots.

Keywords. Assistive Robots, Nursing Care, Elderly, Human-Robot Interaction (HRI), Therapy, Communication, Impact on Care.

1. Introduction

According to the United Nations (UN) demographic statistics, Japan's population has decreased since 2009, holding about 128,500,000 residents at the time. Japan's population today (2019) is about 126,800,000, but the forecast is that the number will fall to 108,800,000 by 2050 [1]. Moreover, Japan currently holds the world's largest population of elderly per capita with about 27% of Japan's population being 65 years or older. This means a total of about 35 million people over the age of retirement (65 years). Some countries argue that immigration might be the solution to this problem, while Japan has decided to invest in alternative futuristic ways of coping with its changing demographics. Proportionally large elderly population, in combination with a limited population growth, puts a higher demand on nursing care given a shortage of health care staff. Possible solutions are to decrease the need for more human workers through innovation and to keep the elderly as independent as possible for longer.

The Japanese government has presented six priority areas collectively holding 13 items where robot technology is to be introduced in nursing care. Those are namely *lifting*

[1] Kolstad Markus, Department of Information Science and Media Studies, University of Bergen, Norway; E-mail: markuskolstad@gmail.com.

aids, mobility aids, toilets, monitoring and communication systems, as well as *bathing* and *nursing-care services* [2]. We visited three different Japanese nursing facilities in order to see how robots are being used, what impact they made on the nursing care, what positive and negative experiences the elderly and staff could share. The interviews focused on communication robots, being one of the newest items introduced as the government's priority areas in 2014 and whose development is supported since 2017.

2. Methods

The three nursing facilities were chosen as the study sites from a public list of nursing facilities using the robot *Paro* published by a company selling *Paro* [3]. Potential study sites were contacted via e-mails or letters. Two nursing homes in Hyogo prefecture and one daycare center for elderly in Kyoto agreed to participate; all close to the Ritsumeikan University Biwako Campus. The interviews were not limited to *Paro* exclusively, but rather aimed at acquiring information on all interactive robots used at each facility (*Paro* was used at all 3 facilities, *Pepper* at two, and *Qoobo* at one). The interviews were primarily held with the facilities' managers, nursing staff, or both, to canvas opinions and experiences on usage and integrating the robots into the care. Brief conversations were held with patients, but not recorded due to privacy and ethical concerns. Two of the interviews were conducted in Japanese and one in English. The interviews were transcribed and analyzed using open coding as a part of the qualitative data analysis.

SoftBank's *Pepper* is a 120 cm tall, 28 kg social humanoid robot, firstly introduced in 2014 and available for purchase from 2015 [4]. *Pepper* can be only rented as the robot must be purchased with a 3 years abonnement at the price of approximately 10,154 USD.

Paro is a 2.7 kg, 57 cm long therapeutic robot shaped as a baby harp seal that responds to nonverbal interaction. *Paro* was featured in the Guinness World Records 2003 edition for being the most therapeutic robot [5]. *Paro* has been available for purchase since 2004 and current sales prices are about 3,620 USD.

Qoobo is essentially a round furry tailed cushion weighing approximately 1 kg [6], originally developed for elderly people living in facilities that do not allow pets. *Qoobo* responds to non-verbal interaction such as stroking and petting and sells for 149 USD.

3. Results

Results from the interviews and observations gave an insight into the role and impact robots have on Japanese nursing care. The site managers were asked about reasons that made them invest into robots and they gave the following answers:

- 'We need more manpower to provide recreation and rehabilitation. It is difficult to find recreational and/or rehabilitation therapists, but robots are easy to use as they are already programmed, especially *Pepper* that is intended to provide such services.'
- 'It might be cheaper to use robots as compared to hiring a professional staff; robots can work 24 hours a day.'

- 'The intention is to make the nursing job easier.'
- 'The intention was to make the patients happy.'
- 'Originally, this facility had a therapy dog, but it got sick and died. It was found that depressed patients heal (better) when they touch and interact with the animals. It was also found that using real dogs puts stress on the animals.'

The interviews suggested that these kinds of robots all work focusing on the mental wellbeing of the patients. Patients suffering with dementia often believed *Paro* to be a dog or even a human baby, treating and interacting with it accordingly. Patients often cared and worried for *Paro*, asking if it was properly fed or whether it could get enough sleep, thus indicating there was a relationship established. Consequently, it was advised to avoid letting the patients use *Paro* during their meal and snack times as they might be tempted to feed it, which had occasionally happened. It was reported that interacting with *Paro* evoked memories in the patients taking them to their childhood dog or child nursing days, which could often make them happy. Using *Paro* in therapy has also depended on the nursing staff attitude. For example, not everyone liked *Paro*, animals or simply the staff had already busy schedules which left them little time to deal with *Paro*. However, one caretaker stated that "*sometimes you have patients who take their wheelchairs and want to go somewhere, not knowing where to, which puts pressure on caretakers to keep eyes on the patients and keep them in their chairs*". The challenge they have is to keep patients motivated. One staff member said "*I am constantly speaking to people who do not speak back to me, but at some point if they have Paro, they make a sound or say 'KAWAII', thus something is coming out, even if it is just a small sound, and this is enough reaction for me because they otherwise do not speak*". For this caretaker, *Paro* was a good solution. In addition, the staff's enthusiasm might influence the enthusiasm in the patients. On the other hand, patients that are cognitively more capable might find *Paro* less interesting. It had also been observed that *Paro* was effective on both male and female patients if they liked animals.

The manager of one nursing home stated "*I think most of the patients like Pepper more than Paro. We borrowed Pepper for a two months trial, and I found that patients really liked Pepper*". A reason for this was thought to be that the patients liked children of whom Pepper reminded them of. In addition, *Pepper* is used for recreation, entertaining patients through games and karaoke. However, some patients had commented that *Pepper* was loud and annoying, so that the nursing staff was worried about introducing *Pepper* to patients heavily impacted by dementia as they might not be familiar with robots and could think it to be an alien. One staff member stated, "*they (patients) are still not used to a robot doing the stretching exercise Taiso and they need to be close to see, hear and follow the movements*" for which "*a human staff member with a loud voice is probably better*".

Qoobo was mostly used by one patient that did not like interacting with other people. The robot had a calming effect on the patient and could make the patient happy, something that the human caregivers struggled to make happen.

The qualitative data analysis gave the main categories relating to the assistive robots. Table 1 includes the results in terms of the roles robots had in the nursing care, as well as the impact and effect on patients and staff.

Robot	Role in Care	Impact/Effect	
		Patient	Staff
Paro	Therapy. Indicated for patients with dementia. Pet, Baby, Robot.	Slows down dementia. Brings back old memories, emotions and stories. Lessens feeling of emptiness. Changes the patient's mood. Provokes speech in the patients. Improves communication between patients. Helps heal patient mentally. Improves facial expression. Substitutes animal therapy. Has calming effect. Could exhaust/tire patients (negative).	Distracts patients in order to enable staff to do other tasks. Cheaper, easier and safer than real animals. Way of connecting and taking care of patients. Makes job easier by: Calming patients down. Making patients happy instantly. Conversation starter/talking topic. Demands time and additional effort from staff – in some cases there is no time to spare (negative).
Pepper	Recreation. Taiso (Exercise/stretching) Substitute for professionals. Staff, Robot, Alien, Child.	Entertainment. Elicit smiling. Helps heal patients mentally.	Reception greeter. Way of connecting with and taking care of patients. Elicit smiling.
Qoobo	Therapy. Pet, Robot.	Has calming effect. Makes patients happy.	Makes it easier to take care of patients.
Robots in General	Robots are more than tools.	Helps maintain the patient's self-esteem. Patients do not have to hesitate to ask for help and burden staff. Reduces the mental burden the patient feels towards the staff.	Finding new ways to use robots effectively which increases the staff's motivation and their communication. More people have visited the nursing facilities which allows for acquiring new information.

Table 1 Key findings regarding the role and impact assistive robots have on nursing care collected from three different Japanese nursing facilities.

Discussion

Why to use robots and not toys, dolls or animals? The reason is that therapeutic aids should be safe and have demonstratable therapeutic effects. Animals can get stressed and behave unpredictably. Robots like *Paro* are designed to have a therapeutic effect and can work as an alternative to pet/animal therapy without the risk of allergy, bites, scratches, infections or even stress for the animal itself. Robot can be cheaper than keeping dogs and demands less maintenance. Even though *Paro* is designed to resemble a baby harp seal, patients often confuse *Paro* with their own pets. What makes *Paro* different from a stuffed animal is the motions and reactions to its environment which makes patients feel understood. However, some people dislike certain animals which makes them skeptical to animal-type robots, as well. Every day is different, and the interaction time and enthusiasm depend on patients' mood. Depending on the patient, typical interaction time with robots is up to 30 minutes daily.

Pepper is seen more as a staff member and is mostly used to entertain patients. *Pepper* is also being used for Taiso, the daily Japanese stretching exercise often performed several times a day. However, from our observations, Taiso is typically performed together with a staff member. *Pepper* is placed in the center to lead the show while the staff member encourages from the side, thus the need for human workers is not eliminated. Both *Pepper* and *Paro* can be used by the patients alone but is usually used together with the nursing staff. The interest of both patients and staff members determines the use of the robots. Ultimately, consensus was found that these robots were not thought to be better than humans but are used to assist and relieve the humans from work overload. Care workers are often too busy to entertain patients which is something that robots can be a good at. As one of the interview subjects stated "*When looking at the value of an industrial robot, the productivity is visible, but in the case of a nursing robots, we should see the number of staff halved, or more nursing care performed at the same time. However, the effect is more on patient's mentality which might not be as visible*". Patients, that usually did not smile to the human staff members, were seen smiling and talking to the robots. Additional positive effects were increased interest of groups and often grandchildren to visit the nursing facilities and to learn more about robots.

Conclusion

All nursing facilities were positive towards robots. Positive effects were patient satisfaction, joy, relationships and mood changes. On the downside, there are mixed attitudes towards robots for both the care givers and receivers. Robots are not fully independent and demand staff attention which limits their use. However, the future is bright. Robots like *Pepper* allow for easy updates and download of additional applications which enables development and access to professional exercises, activities and rehabilitation programs.

References

[1] https://population.un.org/wpp/Graphs/DemographicProfiles/
[2] https://www.meti.go.jp/english/press/2017/1012_002.html
[3] https://www.daiwahouse.co.jp/robot/paro/map.html
[4] https://www.softbankrobotics.com/emea/en/pepper
[5] https://www.aist.go.jp/aist_e/list/latest_research/2004/20041208_2/20041208_2.html
[6] https://qoobo.info/index-en/