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An explorative study between Sweden and Japan

Master thesis in Interaction design and Technology

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Abstract

New technologies have enabled the development of robots for use in many different areas. In the recent decades, research has focused on how to facilitate interaction between humans and robots, thus a field of human robot interaction (HRI) has arisen. A novel area of research is human drone interaction (HDI) which investigates how interaction between humans and drones can be expanded into more areas of use. One area that is of interest is that of having drones as companions. While the field of drones as companions is novel, robots as companions have been researched to some extent and thus can give valuable input to further research in the HDI area. The aim of this project was to gain a clearer picture of how the user responds to having a drone as a companion and their attitude towards it. In addition to that the aim is also to create a good discussion on what developers of drone companions should consider in order to design an as good as possible companion in the future.

This thesis investigates and elaborates on how people respond to having a drone as a companion and if drones can be used as companions instead of using them as tools. One aim was also to find out what kind of cultural differences there might be between Swedish and Japanese participants in the study that could influence design implications for future drone companions. In order to understand the participants backgrounds and preferences, questionnaires were created to gather opinions about different perceived roles, size, appearance, interactions and which preferred tasks a drone companion could have, response were collected from 24 participants in Sweden and 24 participants from Japan. The data retrieved from the questionnaires was used as a basis for the forthcoming workshops, these were done to further enhance the knowledge about which characteristics a future drone companion should have and this was done in accordance to four specific themes that also were discussed during the workshop. The workshops in Sweden were done with a total of 10 participants whereas the workshop in Japan had 9 participants.

The outcome from the workshops yielded different ideas on how to design drone companions which in turn was used in the user studies. A user study was conducted in Sweden with 16 participants who interacted with two different virtual drone designs in a virtual reality environment. The sessions contained different tasks that the drone would perform as instructed by the participants. Furthermore a user study was conducted in Japan, the same methodology was applied in the study as done in Sweden, however with drone designs derived from the Japanese questionnaires and workshop. The Japanese user study had 16 participants. The results show that both Swedish and Japanese participants would like to have a drone companion in a home setting. The most prominent social role that was preferred both by Japanese and Swedish participants were an assistant. The most preferred task was that the companion would bring items to the user for both Japanese and Swedish participants. Although there were many similarities, some features were different, such as emotions seemed to be more preferred in Sweden. The study yielded some interesting design implications for future studies about drone companions.

Key words: Drone companion, HDI, Robotics, HRI, Culture differences, Sweden, Japan

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1
Introduction

Robots have existed for a long time and have also changed over time, both in terms of performance and look. In the beginning, robots where not as technically advanced as they are now and many of them were built using inexpensive material and waste (Robotics then and now, n.d). Robots started to get useful when the industry implemented them and then usually used robotic arms for assembly e.g. to build cars (SciShow, 2015[1]). In the 20th century the research of the functionality and the potential area of use started to increase and the focus were more on imitating human behaviour and manage work that was too dangerous (Robotics then and now, n.d) or too physically demanding for humans.

Over the past decade, research on robots has focused on understanding and designing interactions with human users, which resulted in the emergence of the Human-Robot Interaction (HRI) field. One of the field's goals is investigating how Social Robots can be used in our daily lives in areas such as entertainment, security and health. A robot companion is one form of a social robot that is personalised to the user's preferences and can perform tasks that are supposedly adapted to the user's behaviours (Dautenhahn, 2007).

There are many definitions to what is a companion. According to the Oxford Dictionary a companion is "*A person or animal with whom one spends a lot of time or with whom one travels*". In the area of robots a companion is usually referred as an artificial entity that spends time with the person, do activities together and maintain a relationship with the person (Young Kim et.al., 2016). Because of people's different needs/preferences of robots, there is not one robot that fits all people's needs but instead there are many different robots with different appearance and features (Dautenhahn, 2007).

With recent technical advancements, drones (e.g. quadcopters) have emerged as a new form of a robot which have attracted the attention of HRI researchers; thus resulting in a whole new research area on Human-Drone Interaction (HDI). More and more studies explore people's attitude and perception of robots (Dautenhahn et.al, 2005), but not many studies focus on drones. Drones can be used in many ways and are expected to have promising future which might estimate the usage of up to two drones per household (Young Kim et.al., 2016).

Very few studies address drones as a social entity such as a companion and that is what this thesis is about. Robot companions have advanced to be used in several domains, and researchers have investigated the field and the possible positive impact in these domains. Moreover, introducing drone companions might elaborate or support the findings of previous social robots research as we are dealing with a different form, i.e. a flying robot. Thus, to be able to understand this new emerging field, we plan to investigate not only what a social drone companion can do, but also focus on investigating its design, and explore possible domain areas that it can be used in.

[1] *A Brief History of Robotics*. (2015). [YouTube] SciShow. Available at: https://www.youtube.com/watch?v=uoC2ZGRI8a8 [Accessed 2017-02-20]

The aim of this project is to give a clear picture of how the user responds to having a drone as a companion and their attitude towards it. In addition, we aim to create a good discussion on what developers of drones needs to consider in order to design possible drone companions in the future.

1.1 Research questions

The research questions for this thesis are inspired by the questions Dautenhahn et. al. (2005) had used in their research about people's perceptions and desires for robot companions. Our research questions are somewhat modified to fit the domain of drone companions, thus the purpose of this thesis is to answer the following questions:

- *"How do people respond to having a drone as a companion?"*
    - *"Do users prefer a certain appearance of the drone?"*
    - *"Do users want the drone to possess anthropomorphistic features?"*
    - *"What kind of aspects of drone companion-interaction do people think are more or less acceptable?"*
- *"How can a drone be used as a companion instead of a tool?"*
    - *"What specific tasks do users want the drone to perform?"*
    - *"What features and tasks need to be added in order to make the drone a companion instead of a tool?"*
- *"What kind of cultural differences are there between Sweden and Japan when it comes to drone companions?"*

A drone as a companion is in this case a companion that keeps you company in your home or when you are outside. It can do different tasks to assist humans and behave socially in order to interact with the user (Dautenhahn, 2007).

1.2 Expected contributions

By using a user centered approach, the expected contribution from this study is to explore:

C1 To find possible domains where users can envision having a drone as a companion
C2 To determine important attributes that users would like to have in a drone companion
C3 Based on elicited domains, explore specific tasks for drone companions
C4 Offer a set of design implications that can help designing and developing drone companions

1.3 Delimitations

This study focuses on some functions that are expected to be essential when it comes to companionship in a drone, for example functions such as entertainment and assistance. If the aim of the thesis was to incorporate as many functions as possible into the drone and at the same time try to investigate the responses to all of the functions, it would go beyond the scoop of this thesis.

Based on result from a pre-study and related work (presented in the following section), the environment chosen for this study was a home setting where the drone could fly around freely. This is because of the scope would become too large if the study should include drone usage in all conceivable environments.

There are some technical limitations on the prototyped drone's appearance that is used in the VR study, such as the design of the drone's hands. These are due to the inexperience with 3D-modelling which made the design not fully corresponding to the wishes of the participants which were to have human shaped hands. This issue has been dealt with by utilizing simpler design, which is duplicated both in the prototyped drone used in the Swedish user study and as well the Japanese user study.

Lastly, the prototype is not a highly functional prototype that can be used by users outside this study. It works as a tool in the user study and helps collecting the data from the participants.

2
Background

This background section describes the research area and problem studied as well as some of the technologies related, such as drones and robots. The field of interaction between humans, drones and robots is also presented and which relation Human-Robot Interaction has to Human-Drone Interaction, and how autonomy may be used to support a way of interacting with these technologies. Furthermore related work is presented and divided in human-robot interaction and human-drone interaction.

2.1. Research area and problem

The research area of human-drone interaction is relatively new and the technologies that make this possible have evolved during the last few years. The history of drones however is connected much to military use, where the idea of Unmanned Aerial Vehicles (UAV) performing missions without the risk for casualties was a contributing factor to the development in that sector. With the emergence of small portable drones intended for civil use, i.e. toys, deliveries, medical use etc., the domains of use has expanded to many areas (Nesta.org.uk, n.d.[2]). A typical drone for the civilian sector is a so called Quadcopter, it is basically a small helicopter with four rotors placed in the corners of the machine to help keep balance. The propulsion comes typically from electric motors, and the adjustment of rotor angles controls the direction of travel of the drone (Luukkonen, 2011).

With the increasing popularity, the use of drones in a civil domain is an interesting area to investigate since they are becoming more common in use, the drones applications today spans from being used in sport arenas, public delivery service, entertainment and in photography related areas of use.

More autonomous operation of drones may be the next step in the evolution of the areas of use, however the interaction with humans will still be needed to instruct or communicate with the drone in some manner. A common way to communicate with drones is by remote control, and is often used in recreational applications where the main purpose is merely to control the flight, however the remote controls may be hard to use while the user conducts other activities, thus can an autonomous drone be a solution to this issue (Cauchard et. al., 2015). A way to interact with autonomous drones may be to use gestures with the purpose to make communication as intuitive as possible (Obaid et. al., 2016). There can also be some use of simple voice commands to control the drone (Cauchard et. al., 2015).

An adjacent field of technology is more traditional robots, these types of robots can come in many forms, e.g. a humanoid type. The interaction between humans and robots is an active field of research.

[2] Nesta.org.uk, *Drones: A history of flying robots*, Available at: http://www.nesta.org.uk/drones-history-flying-robots [Accessed 19 January 2017].

In HRI, autonomy which incorporate companionship has been previously researched and some features that a robot can have is the ability to act in unstructured environments, i.e. the robot can with the aid of sensors and programming be able to distinguish objects and humans, and associate gestures with visual objects (Haasch et. al., 2004).

Companionship is described as the ability to keep long-term relations. The ability to understand affective states or expressions of humans are vital for a robot companion, the need to elicit socially intelligent behaviour is important in order to be able to keep long-term relations with humans (Castellano et. al., 2009). A factor that helps evoke social interaction with a robot is that the interaction feels meaningful for the users. Also there is some evidence in research that there is a preference for people to interact with physical social actors rather than with virtual social actors (Jung & Lee, 2004).

A research challenge for this thesis is how people respond to a drone companionship, and if there is possibilities to use drones as a companion instead of tool. We would like to expand the research in this field by adding new dimensions to the interaction between humans and drones. We believe the potential for projecting some of the research made in HRI onto the human drone interaction and companionship is possible. We therefore think that we can contribute to the relatively new research within human-drone interaction by investigating how people respond and their attitude towards a drone as a companion, as there is not much research done in this subject so far, and we can see a gap between the research done in HRI and regarding companionship in HDI.

2.2. Related work

This section describes articles which are relevant to our research and the articles are divided in sub-categories according to their area of research. The articles describe HRI and HDI literature which consists of study methodology, Robot Companionship, relations, autonomy etc.

2.2.1 Human-Robot Interaction

Articles that are relevant to consider for our study are described below. HRI is a relevant field of research to our study since many of the aspects described in the different papers can be projected onto the research about HDI. Such aspects can be regarding methodology approaches where test settings are being designed, also how people's attitudes toward robots, communication and perception of behaviour influence the design of robots.

How a robot approaches a person can have a large impact on how people perceive the interaction with the robot. Dautenhahn et. al. (2006) have conducted two studies done on 38 participants in a non-laboratory setting and 15 participants in a controlled setting. The study investigated how users prefer a robot to approach them while in sitting position. The purpose was to find out a path planning system for robots. Feelings of comfort amongst the test subjects was measured, and the results show that the subjects did not like to be approached from the front, this could be felt uncomfortable or even threatening. The study showed that most subjects preferred that the robot approached them from either the right or left hand side. Predominantly from the right side. The robot in the study was mobile, and had a short reach gripper which picked up a tray with an object in it (Dautenhahn et. al., 2006). Many different aspects to consider are described in the paper, such as distances between humans and the robot, speed of which the robot moved and practicality of the different approach directions. The methodology of the study consisted of test settings which were set up for the practical testing, questionnaires both before and after the trials and a structured interview to assess the subject's view of the conducted study (Dautenhahn et. al., 2006). This gives

some insight in different aspects that can be relevant when considering how a future drone companion should behave in the near proximity of users. Also the described methodology can to some extent be interesting with a test setting which resembles a home situation, and the use of questionnaires to measure users comfort levels.

The perceptions and attitudes of people about having a robot as a companion in a home setting was the aim of another study conducted by Dautenhahn et. al. (2005). HRI trials were conducted with 28 participants and supplemental questionnaires were used to retrieve data from the participants. The results from the study showed that many of the participants did like the idea of having a robot as a companion, and saw the robot's potential as assistants or servants. However few participants would like to have a robot as a friend. Communication with the robot was preferred if it was conducted in a humanlike manner as possible. But regarding humanlike behaviour or appearance was deemed less important (Dautenhahn et. al., 2005). The authors conducted a series of questionnaires before and after a test session with a robot. With the participants of the study, test sessions were done in a simulated living room. The surveys showed that although many subjects liked the presence of information technology at home, there was lesser acceptance of having a robot as companion.

Many other interesting traits of a perceived robot at home are presented in the results, such as that the subjects would like the robot's behaviour to be predictable and that the robot companion should be highly controllable. Also in this study participants expressed that they did not like the robots to come to near (Dautenhahn et. al., 2005). A few interesting aspects of what Dautenhahn et. al. (2005) describes in their article are, that despite robots are considered being useful in home settings, people still seems reluctant to connect with a robot as a companion other than having use of them as assistants. Also in this study it was clear that users do not prefer the robots to come too near physically. It is also interesting to note that communication is preferred to be conducted in a humanlike manner, these are traits that may be considered when designing for a sociable drone.

Another aspect that is presented in an article is if a robot's personality should match a human being? That is the question that Woods et. al. (2007) wanted to have answers for. By setting up an experiment with 28 adult participants where the subjects was confronted with robots which had two different behaviour styles and implementation of questionnaires which asked for opinions regarding the behavioural traits (Woods et. al., 2007). The authors describe that personalities in social robots is an important domain of research for robot designers. However, there is mixed opinions whether how humanlike a robot should be. Woods et. al. (2007) also mentions that earlier research shows that people tend to give objects such as computers and robots personality attributes, which could help to understand what to expect in interacting with such technology. The study performed incorporated simulating a living room environment where the participants encountered different personality traits with the robot. Two tasks were performed, one which consisted of the robot moving in the room while the participant also moved in the same space, and one task where the robot was to bring an object to a table. Some of the results from the study showed that participants thought that they had stronger personality traits than the robots, and they did not think that there were similarities between their own and the robots personalities. Contributing factors that affected the results were age, gender and technological experience. Findings also stipulate that participants without a technical background did not think that either of the two behavioural traits of the robots could be described as having personalities. This finding, the authors describe as very important since it can have implications of how to design for human robot interaction (Woods et. al., 2007).

Woods et. al.´s (2007) article resembles the way that the Cogniron project's (2004) exploratory user study was carried out. In the report, *Evaluation of User Studies on Attribution of Intentionality* (2004), it is described that two robots were constructed with different behaviour styles, one with socially ignorant and the other with socially interactive behaviour. Also that the report describes how there are correlations between participants and the robot's personality traits.

Another similarity is how the use of questionnaires was present during the tests, and the test itself is carried out much similarly as Woods et. al. (2007) describes in their article, where the robots and participants do certain tasks comprising the retrieval of a pen, moving near the participants etc. The purpose with the findings in the report was to be able to elicit design guidelines for robot behaviour. A point that is made in the Woods et. al. (2007) study is that people tend to project human attributes to technology, and this is interesting to consider. The different behaviour styles and the perception of them are likewise appealing.

Ferrer et. al. (2013) describes in their article a model on how a robot companion in an urban setting can navigate its way through crowds and accompany a user. The Social Force Model (SFM) is applied to the robot's Human Awareness Navigation to help it be aware of the vital spaces and comfortableness needed when interacting in social environments. Three different forces are considered, person to person, person to obstacle and person to robot. People prediction is also mentioned as an important feature by the authors, this is the ability to forecast different trajectories that the robot can take at any moment as instructed by the user. The robot should be able to move naturally in human environments (Ferrer et. al., 2013). Behaviour of the robot should be in line with the other people's expectations like how a person would move on for example a sidewalk with other pedestrians. A method that the authors used to evaluate comfortableness was with the use of a Wii-remote, where the test subject pressed either '+' key if they wanted the robot to approach closer to them or '-' key if they wanted the robot to proceed directly to the destination. There is also an intimate distance which is 0 cm - 45 cm. Experiments in simulated environments were conducted to test the validity of the SFM, and some testing was performed in real environments with test subjects (Ferrer et. al, 2013). The article gives some insight in the importance of comfortability for users while interacting with robots, what social spaces are better suited in different situations. Another interesting topic is how to manoeuvre in crowded spaces and the technology of the navigation which makes this possible.

An article by Lee et. al. (2012) describes a comparative analysis of domestic robot designs made by participants of a study that took place in both South Korea and the United States. The research aimed to find out more about the cultural variability that may be present in the user's needs and expectations of different robots. The methodology that the authors implemented to gain knowledge of the area was to ask participants of the study to draw their own interpretations of how an ideal robot design in a domestic context would look. The results of the study was then categorized in four different themes, look and feel, interaction mode, social features and desired tasks. Questions that were of great interest for the authors to investigate in the study were if there is significant cultural differences that influence attitudes towards robots and what design implications can be identified. Some of the results indicate that there is differences in attitudes between countries, and some factors can be for example religious influences. Previous studies has showed that people in Japan, as an example, tend to believe that all living and non-living things have a soul, whereas it is not the case in western cultures where the distinction between living and non-living things is more accentuated. Other influences may also be causing the different perceptions of robots, such as how the media portrays them in different films etc. The study was conducted with 20 participants in the US and 20 participants in South Korea, and they were instructed to draw their own representations of robots for a home environment, the participants had access to a variety of different tools to help them generate ideas. The results from the study, after being categorized in the different themes, showed that Korean participants draw human-like robots that had attributes such as 'warm, friendly and tender' and preferably female gendered. The US participants however had created more abstract and futuristic envisions, and male gendered. Other differences were identified as well, such as that US participants wanted the robots to be more autonomous than the Korean participants, which wanted to have greater control. Some of the other interesting conclusions are that US participants tend to think that robots are defined by their functions, whereas Korean participants

think that the robots theme should be in line with similarity to family members such as 'mother like'. From this article there are many interesting aspects to consider to our study, such as methodology with categorization according to the four presented themes, and the cross-cultural conduct of the study since our study aims to compare preferences between Japanese and Swedish participants.

2.2.2. Human-Drone Interaction

HDI is a relatively novel area of research and much of the related studies done are quite recent. In the section below there are articles that describes how people perceive a drones personality traits, autonomy where the drones act by themselves or with little input from the user, also traits that involves user experience (UX) of the interaction between users and drones and control of the drones. An additional interesting related topic for our study is the communication with drones, where studies show that the drones can be addressed like the users would interact with a pet or even other humans.

In a recent article by Cauchard et. al. (2016) the description on how emotional traits can be attributed to the way a drone flies. The authors performed a user study to investigate if three different flight patterns which represents emotional and personality traits could be recognized by the participants. The personalization of drones is argued being favored since research in HRI has shown that acceptability of robots increases by adding these traits (Cauchard et. al., 2016). A concept of natural HDI is discussed, and ways to support this is by adding a dimension of emotional aspects which would also increase the possibility to create intelligent interaction and decision making. The authors conducted workshops to find out which personality traits would best be expressed by the drone. By using questionnaires they discovered how recognizable the emotions would be. The participants were asked to observe the drone performing five tasks for each personality, and thereafter try to match the drone's behaviour to a certain emotion. A conclusion the authors could make is that it is possible for persons to match how the drone behaves to a certain emotion (Cauchard et. al., 2016). Interesting findings from this article was for example the attribution of human feelings to a flying drone, and how the users perceived the different patterns of flying. This could give us a foundation in how to personalize a drone into being something perceived more than an object.

A case study is described by Christ et. al. (2016) which intended to investigate different levels of autonomy of drones and how it affects the user experience (UX). The case study was conducted as a student competition where the students built four drones with different level of autonomy under relatively high workload. The evaluation of the perceived UX was done by 24 semi structured interviews. UX is important to consider for future assistive technologies according to the authors. The level of automation can affect the perceived workload in a positive manner. Two types of autonomy was implemented in the drones, "full autonomy" which meant that the drone would make all decisions by itself, and "semi-autonomous" where the drone executes an alternative when the operator wishes so (Christ et. al., 2016). After conducting the case study, the interviews showed that the participants liked both systems, but still the semi-autonomous drone elicited the feeling of control which was appreciated. The reduction of workload was something the autonomous drone provided.

Environmental factors played a role in how the feeling of control was perceived. The study concludes with stating some design guidelines for autonomous drones, such as manoeuvring in a 3D space can be done easier if the number of allowed movements is restricted. Feedback from the systems is something that also is mentioned as important, because it influences the feeling of control aspect (Christ et. al., 2016). Some interesting aspects that this article points to, is that higher level of automation lowers the perceived workload, and this could for our concept mean that users do not

need to invoke all commands by themselves. However, there still needs to be some level of control to make the users feel confident in use. The UX aspects are also of interest for our study.

An article by Obaid et. al. (2016) describes a set of gesture controls for drones, and a study how to elicit the types of gestures which would be used. The study had 25 participants which performed gestural interactions with drones. In order to identify preferences of the users, a user centered approach was implemented to better understand the user's needs. A more intuitive way of gesture control would be the outcome if the users were involved in the development process, as today gesture control can be much of the likings of the developers and might therefore not conform to real user's preferences. One way to allow drones to follow human motion can be with the help of multimodal techniques, such as a Microsoft Kinect device. The identification of gestures can be elicited by studying other areas, such as users interacting with other technical devices i.e. tablets etc. (Obaid et al., 2016). The user study was conducted with a Wizard-of-Oz conductor, which controlled the drone with a remote control. A Wizard-of-Oz means that one person hides out of sight from the participant and controls the device (in this case a drone) when he or she is interacting with it. The participant stood in front of the drone and a camera recorded the session. A demonstration video was shown to the participant to show how a drone worked. When the test was done the participants were asked to rate the actions performed, in total twelve. The tests revealed that some gestures seemed to be more preferred than others, e.g. "Go down" is gestured with "two hands move down". The authors created gesture candidates for the twelve different actions that were performed (Obaid et al., 2016). Some aspects that can be of interest is for example the use of gestures, since it may be a way to communicate user needs to the drone, other than the use of verbal commands. Also the way in which the performing of the user study itself can be inspirational. Aspects of technology used can also be relevant to our study.

A Wizard-of-Oz elicitation study with 19 participants was conducted by Cauchard et. al. (2015) to find out gesturing techniques that would be as natural as possible when communicating with drones.
There are many advantages and areas of development of drone use according to Cauchard et. al (2015), for example as a personal trainer which gives feedback in real time. Autonomy of drones is vital in these cases since it would be hard to use a remote control while the user conducts other activities. The study conducted by the authors showed that participants felt extremely comfortable interacting with the drones. The use of metaphors were present, the participants referred to the drones as they would with pets or other humans, calling the drones by name etc. The user study was done as a test session with the use of task cards which the participants used in the interaction with the drone. Each task and action was then described by using a think aloud technique (Cauchard et. al., 2015). The results showed that participants mainly used gestures as means of communication, although the use of voice commands also occurred, initially many felt discomfort talking with drones but after feeling more confident in using the drones the use of voice commands increased. In gesture control, many participants used sweeping motions to indicate the direction which the drone should move. The authors got some insights in the communication which resembled how the participants would treat a pet or a person (Cauchard et. al., 2015).

As Obaid et. al. (2016) mention in their article, the use of gesture control of drones is a commonality with Cauchard et. al. (2015). Another interesting topic for our study is the animate being addressing, where the drone tended to be treated as a human or pet in how the participants communicated with the drone. The commands sometimes resembled the ones that would be given to eg. a dog.

Young et. al. (2016) describes that Drones as Companions can help people to overcome some psychological resistance against drones. As the drones become smaller and the prices drop, drones become more accessible to the public, and this may create anticipations on the areas of use of drones. Some aspects that however dampen this anticipation can involve security and privacy issues and these need to be resolved. The authors also describe that if the drones have certain degree of

autonomy and have some emotional traits the drones would likely be more accepted. The authors' research aimed to develop the understanding of perception of the drones and users desires of a companion device in a human centered approach. The study was conducted with 10 participants, both user experience factors and the suggestion of principles that aimed to help people to recognize drones as companions were investigated in the study. An unstructured in-depth interview was conducted where the participants were asked open-ended questions about their feelings of drones and then asked if they could draw their interpretations of a drone on a piece of paper. The participants also tested to operate the drone, and via a facilitator act as the drone was autonomous (Young et. al., 2016). The results from the study show that some of the participants would like the drone to run errands for them and playing games with the users. Other findings suggested that the drones should be able to shoot video and transmit them to the user's smartphone, transport items, navigating activity, surveillance etc. The participants did mention that they would like to see many different functions in the same drone. The findings also indicated that users tended to like the drone to have different roles depending on the situation, but most preferred was the role of a servant. Attribution of personality was also a topic which was presented, characteristics could be; partial predictability, limited controllability, adorability etc. (Young et. al., 2016). Some interesting findings from this article are that many of the participants have perceived drones as having many different roles depending on the situation, and also it is interesting that personality traits have been attributed to the drones.

In summary, previous research on human-drone interaction is heading in the direction of investigating social interaction with drones, thus we will in our thesis build on previous work in both HRI and HDI by investigating possible design attributes that are important for social drone companions which can help future design and development of social drones.

3

Theoretical Foundation

This section describes the theoretical framework for our study. Theory about subjects such as, user centered design, social robots and companions, the technology behind Drones and the theory of different evaluation tools for social robots such as Cogniron (Cogniron Project, 2004) questionnaires is also included.

3.1 User-centered design (UCD)

According to Preece et. al., (2011) a user centered design should involve real users and their goals as a foundation for the development process of a product, service, interactions etc. There are different levels of involvement, in some cases the users can be full-time committed to the process and at the other side of the spectrum the users might be involved by giving feedback through workshops or other means of communication at specific times. If there is a large group of users involved a compromised approach can be the best to suit where representatives from the user groups can be involved in workshops etc. Sometimes there can be issues that arises from adopting new technologies, to change people's habits or routines, and the change needs to be implemented gradually (Righi & James, 2007).

In the user centered approach the users and tasks are important aspects to consider, Preece et. al. (2011) describes that the user´s goals and tasks should be the driving force that underlines development, the technologies should support the user's goals, not the other way around where new technology is forced into an area of deployment.

The user´s behaviour and use context is also an interesting area to investigate, since it elicits how users actually perform tasks, it can highlight preferences and priorities, Righi & James (2007) also mentions that organizational behaviour might also be useful to give insight to the context. However, Preece et. al. (2011) mentions that a problem can arise where users bad habits are observed, and this needs to be taken into consideration.

The characteristics of the users are important as well, different human traits should be designed for, and thus limit the possibility of errors. It can be cognitive aspects such as memory, attention and perception. But it can also be physical characteristics such as mobility and strength. It is vital for the design decisions to be made with the user's work and environment context in mind (Preece et. al., 2011). In early phases of development there can be observations made also of how users react to material such as scenarios of use or even using instruction manuals. As the process is iterative, problems found in user testing should be attended and rectified, and new prototypes and simulations be made and the reactions from the user analyzed. The iterations can be repeated as many times as necessary (Preece et. al, 2011).

3.1.1 Research through design

In design there are no concrete truths or absolute solutions to problems. Hence, design does not produce rules that are to be seen as definitive. Design work build on enhancing previous designs or deal with new solutions to problems, as Gaver (2012) mentions in their article xxx, an aspect that usually is present while conducting design work, is the emergence of so called wicked problems. These types of problems do not usually have final solutions, but they are being dealt with in a constructive way to try to mitigate them as much as possible (Gaver, 2012).

Research through design is a way to embrace the potential of conceptual work throughout a design process which produces design examples. The way that designers compare and discuss other people's work, norms, success principles etc. is also to express conceptual statements. If other people adapt these concepts, they practically become theories (Gaver, 2012).

In our study, there might not be a clear and fully defined theoretical framework as there is not that much earlier related work done in this area of research. As such the approach needs to continuously adapt to new, and probable wicked problems that might arise while conducting the study. However, related work in adjacent fields of research may serve as guidelines or inspiration to how to conduct research in the field of HDI.

3.2 Social robots

There are different definitions to what is meant by a social robot. A social robot is a special kind of embodied interaction device which can make new kinds of interactions with people and engage new roles in society (Dautenhahn, 2014). A social robot can also according to Dautenhahn (2007) be socially evocative which means they depend on human's drive to anthropomorphize and utilize the his or her feelings toward the robot. They can also be socially situated where they are placed in a social context and can distinguish between other social agents and different objects. Social robots can also be sociable and socially intelligent which means that they engage with humans in order to satisfy their personal needs and show human-like social intelligence (Dautenhahn, 2007). Social robots do not need to be like human beings but they need to do their tasks well and incorporate human culture and provide enjoyable interaction experience (Dautenhahn, 2014). A social robot should perform its tasks in a way that does not distress or disturb the humans it encounters. The interactions needs to be comfortable and acceptable to the human (Sverre Syrdal et.al., 2007).

Below the concept *robot companion* will be presented which can be seen as a subcategory of social robots. By knowing what social robots are can help to understand what robot companions are and their potential area of use.

3.2.1 Robot companions

According to Dautenhahn (2007), a robot companion is a robot that makes itself useful and behaves socially together with people. A robot can for example assist humans in their homes or interact with people in a social adequate way. Haasch et. al. (2004) describe a robot companion as a special kind of service robot which is designed for personal use in homes.

To fulfil some of these statements, a robot companion needs to have social skills which is appealing to the human. Dautenhahn (2007) characterize these necessary skills into four characteristics; contact with humans, a robot's functionality, the role of a companion and social skills. A social robot needs to have a long termed contact with its humans and enable customisation of the robot's appearance and behaviour. A robot companion's functionality or skills, in addition to perform

ordinary household tasks, should be able to communicate and interact with humans in order to mediate tasks and preferences and to some extent provide companionship. It should also be able to adapt, learn and expand its skills. The role of a companion is to be as humanlike as possible when it comes to interaction capabilities. A robot companion's skills are important and without these it will not be accepted on a long term basis. This means that the robot's etiquette which is a set of heuristics and guidelines on how a robot should communicate and behave in the home are important in order to get the human's acceptance (Dautenhahn, 2007). By knowing what robot companions are will help to understand how this can be implemented in a drone.

3.3 Drones - Technology and Control

Drones come in many forms and sizes, a drone for civilian use can be described as a so called quadcopter. The electronics that control all aspects consists of a microcontroller and input from an accelerometer which gives coordinate positions. A receiver is also present to process incoming signals from the transmitter, which can be a remote control or other device that can send appropriate data to the receiver (Jeremia et. al, 2012).

As a power source the quadcopter is equipped with a battery for both the electronics and motors. To achieve balance so that the copter does fly in a controlled manner, it is important that the different components are distributed in an even way, the heavier components such as battery and receiver are usually located in the center body of the copter. The copter can, depending on the area of use, be equipped with cameras that transmit video or photographs (Jeremia et. al, 2012).

The quadcopters movements are controlled by the speed of the motors. If all rotors are spinning at the same speed, hovering should be achieved and the copter is situated in a standstill position. If the user wishes to move the drone in another direction, the instruction is transmitted to the receiver which tells the motors on the corresponding side to accelerate and thus produce more lift and move the drone in the desired direction (Jeremia et. al., 2012).

The technology that makes HDI possible is important to understand in order to be able to conduct prototyping and testing of drones. These technological components are the basics in order to have a functional and flying drone. If any extra equipment is added to the construction, the consideration of placement is utmost important since the balance of the quadcopter can be disrupted, hence making it fly unsteady or not be able to lift at all.

3.4 Anthropomorphism and robotics

Anthropomorphism is the attribution of human characteristics on non-human subjects. The term is mostly used in relation to animals, when attributed certain human characteristics (Colman, 2015).
If an entity is meant to be used merely as a tool, anthropomorphistic features may not be necessary to incorporate in a design. However, if the intention is to design artificial intelligence in social robots, human-like traits are important since the goal is a human-centric machine that elicits behaviour in a social setting. In this case there is a need for the behaviours to be clear, comprehensible and predictable (Duffy, 2003). Furthermore, using anthropomorphistic features in companion robots can affect how users perceive the usefulness of the robot and also that social interaction can increase by adding anthropomorphistic features (Goudey & Bonnin, 2016).

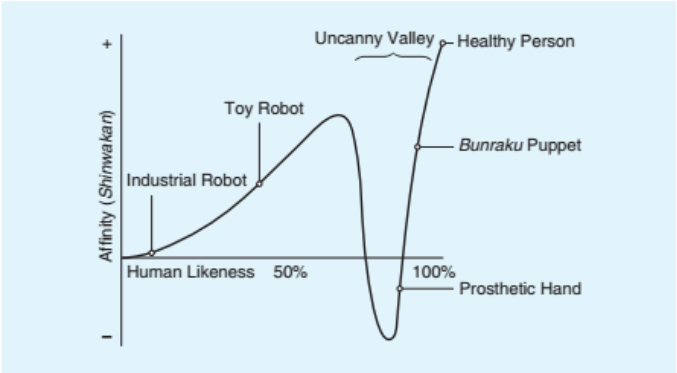
There are however differences between the features of an object which has human characteristics, such as visual resemblance, and that of the subjective process of anthropomorphization which is when a person attributes human characteristics to objects. It can present itself in different manners, a partial anthropomorphization can occur when some subjective human traits are present in an

object, it can typically be seen when people for example think that “computers think slowly” etc. (Goudey & Bonnin, 2016).

With the emergence of new intelligent technology, the anthropomorphizations of these objects become more prevalent when they are personalized. But a paradox is that many people seem to reject the notion of having humanoid robots that has too human like features, this phenomenon can be described as the uncanny valley (Goudey & Bonnin, 2016).

3.4.1 The Uncanny valley

Mori (2012) argues that when a robot’s appearance resembles a human more and more, the observer’s emotional response is positive until a certain point when the appearance causes revulsion, and even though this phenomenon appears, the acceptance of a robot still can become better if the robot elicits almost fully human traits. The uncanny valley means that an almost human-like robot can be seemed to be ‘strange’ and invokes feelings of uncanniness which can have a great effect on the interaction with robots.



(Figure 3.1: The Uncanny valley. Courtesy: Mori (2012))

3.5 Evaluating tools for social robots

There are many ways to evaluate social robots which could be conducted by questionnaires. Below two of the existing evaluation questionnaire will be presented. These questionnaires are used in several studies where they investigate people’s perceptions and attitudes against social robots.

3.5.1 Cogniron questionnaires

Cogniron questionnaires are well used questionnaires when it comes to analysing people’s attitudes and perceptions to social robots. By using a psychological approach through questionnaires in order to investigate people’s attitudes towards domestic robots could aid the design of social robots (Cogniron Project, 2004). One can explore which social skills are eligible for robots and how the robot should look and behave considering different roles of the robot and target groups. The questionnaires can also support the design of robot’s personality, empathy and cognition (Cogniron Project, 2004).

Cogniron Introductory Questionnaire

This questionnaire focuses on obtaining personal data from participants, such as age, gender and occupation. The participants also need to answer their level of technical knowledge with robots, the level of familiarity and prior experience which cover their previous experience with robots for example at work, in schools, as toys, in movies or books etc. These three are measured in a 5-point Likert scale (Cogniron Project, 2004; Dautenhahn et. al., 2005; Woods et. al, 2007).

Cogniron Final Questionnaire

This questionnaire is designed to obtain participant's thoughts about how a future robot should be like. It is divided in two different sections where the first section focuses on questions about what a robot companion is including how predictable, considerate, controllable the robot in the future should be and how human-like it should look, communicate and behave (Cogniron Project, 2004). These questions includes for example "*Do you like the idea of having a robot companion at home?*", "*What role do you think a future robot companion in the home should have?*" and "*Should the robot try to find out if you need help before it helps?*"(Dautenhahn et. al., 2005; Cogniron Project, 2004). The second section is answered after the session and focuses more on open-ended questions where the aim is to understand the participant's feelings about the robot interaction session, what was the most interesting/annoying during the session and whether appearance, speech or behaviour of the robot should be changed (Dautenhahn et. al., 2005).

4

Methodology

In this section the different methods and why they were chosen will be discussed and compared to other alternative methods. As shown in figure 4.1, the elicited requirements work as basis for forthcoming steps.

(**Figure 4.1:** Flowchart of methods used in thesis)

4.1 Requirement elicitation

There are many different ways to elicit requirements, and in order to elicit requirements it is necessary to decide data collection methods. The data collection methods can according to Engelbrektsson (2004) be divided into question-based or observation-based methods. When examining requirements for a drone companion, question-based methods are the most suitable because the study investigate something that is not out in the market yet and the aim is to find out what the user want in a drone companion and how it should look.

4.1.1 Pre-study

There are many ways and reasons to do pre-studies before you continue with the real study. A pre study can be seen as a miniature version of the project where it can be fewer participants are included or the scope is smaller. By using a pre-study you can discover different problems, procedural bugs and things that need to be added or removed (Woken, n.d.).

4.1.2 Questionnaires

Questionnaires are useful in this study because they help to understand the user and what the user actually wants. By sending out questionnaires to as many participants as possible, a lot of data can be collected and analysed in order to reach requirements to, in this case, a drone companion.

There are many ways to structure a questionnaire and some are more suitable than others for different kinds of purposes. If the aim is to have qualitative data, the questions should be open ended where the participant can write as much as he or she wants. This was suitable for the work

presented in this thesis because by understanding how the user thinks and feels about different aspects of a drone companion are valid in order to elicit requirements. If the aim is to have quantitative data the questions should be closed and only enable options for the user to choose. This approach is also appropriate for this study because it gives a clear statistical picture of different preferences that the participants may have.

Questionnaires are in this case more useful than for example interviews because of its quantitative and qualitative nature, the ability of collecting data and the ease of analysing the data.

4.1.3 Workshop

Workshops can be used in the divergence phase to elicit requirements. When conducting workshops, the user is a part of the development and can contribute with valuable information. In this case the workshop lets the user to be creative and provide low fidelity prototypes that can show how the drone companion should look and behave. The low fidelity prototypes can consist of mock ups that are made of cardboard or paper etc. Muller et. al. (1993) describes that an appropriate amount of participants for creating mock-ups could be six to eight persons and that the activity should be performed relatively early in the development cycle of a project. Brandt (2007) describes, mock ups work as mediating tools to support creative thinking and could inspire to new perspectives of usage.

An approach that can be used when involving users in the design process is Participatory Design (PD) where the users are actively cooperating with the designers (Preece et. al. ,2011 : Muller et. al., 1993). This is in line with the general user centered approach of our study where the intention is to obtain the user preferences and ideas of drone use by involving users as much as possible.

Workshops that incorporate participatory design instead of interviews or focus groups are more suitable in this study because by giving them hands on tasks which supports more creative thinking than ordinary interviews and focus groups. As a requirements eliciting activity, both workshops and focus groups can be useful since they can highlight problem areas with the help of stakeholder involvement, also they can be good on a social level where the designers meet the users. A sense of consensus about the design can be achieved through workshops, it is however important that the choice of participants and the structure of the workshop is done well, so that there is little risk of some few individuals dominating the discussion during a session. from the data collected, usually qualitative answers will be elicited (Preece et. al., 2011).

4.2 Prototype

There are many ways to prototype a drone companion and it can vary from low fidelity to high fidelity. If it is a low fidelity prototype, It can consist of paper or cardboard where the concept and appearance can be shown (Preece et. al., 2011). If it is a high fidelity prototype, a real drone can be used in order to evaluate different tasks and appearance.

The prototype does not need to be physical but it can also be virtual or recorded. By using a video recorded prototype, more difficult concepts and tasks that would be time consuming and demanding to do, could video prototype be a useful approach. A video prototype lets the participant see the drone companion and how it would look like when interacting with it.

A virtual prototype can let the user interact with a computer simulated drone companion in a simulated environment by using a Virtual Reality (VR) headset. With this prototype the user can interact with the drone in a more “hands on” way and try and see things that is not possible to do in

real life. The use of virtual reality for prototyping can be a valid way to test a concept, for example, a study which compares VR simulation with contemporary simulation (CS) in a Dental simulation context showed that results from the study indicated that there are no significant qualitative differences in test results. In fact, test subjects seemed to need less support when performing tasks in VR environment than in CS (Jasinevicius et. al., 2004).

4.3 Evaluation

Evaluation is an important activity in a design cycle, and the goal is to assess if a design meets up to users' needs and if the design is liked by the users. In an iterative process, formative evaluation is an activity that takes place during the whole design process in order to continuously check that the product or concept meet the expectations of the users (Preece et. al., 2011).

There are many ways to evaluate a product or concept, such as interviews, observations, questionnaires and user studies. To evaluate a prototype, observation can be a useful technique. The use of notes, audio, video recordings while conducting observations can help to create a story of the use of the product. When opinions and attitudes about a product are wanted, useful techniques to aid this activity can be the use of interviews and questionnaires. The structure of the material can be either unstructured open ended questions which gives the user more room for elaboration on their answers, or very structured questions where there might be a set selection of multiple answers. Interviews can also be very helpful, and a good way of getting a lot of information, however a drawback can be the amount of resources needed to conduct analysis of recordings. User studies can be used to evaluate a concept, prototype or even a developed technology in order to see how these are used, and modify or improve on basis of the findings of such a study (Preece et. al., 2011).

4.3.1 User study

A user study is a generic term that can include both field studies and experiments. A user study can be conducted in different ways, either as a way to get valuable insight in how potential users behave in a natural environment using a product or service, or it can be conducted in a laboratory environment where the setting is controlled. User studies has evolved from being carried out only as an evaluation tool, to be more integrated in the development process of a new product or service throughout the entire design process. A way to test a concept within a user study is by using prototypes, these can be simpler "mock-ups" to more functioning concepts. In a user study, cognitive aspects could be considered to understand how a potential user interacts with a product, these aspects can be how they perceive a device and how they form a mental model of how the product works. The cognitive aspects can become much useful when comparing two different designs and evaluate them against each other. An another way to conduct a user study in a meaningful manner is to introduce new concepts to the potential users and see what the reactions towards the concept would be, this in order to discover unmet needs of the users (Preece et. al., 2011).

In this study the intention is to find out what users perceive of two different designs, and this is done in a controlled setting as opposed to a natural environment. This is to ensure that the experiment has consistency where the variables of a natural setting are minimized, thus it is supposedly easier to rely on the data that is collected since it has been all collected under exactly the same conditions.

5
Planning

This section describes the overall planning of our study and consists of descriptions of the working process as well as different methodology that were planned to be used.

Initially there needed to be a literature study phase which was intended to expand the knowledge about the current research available in the area of HRI and HDI, as well as in adjacent areas of interest such as interaction design, human computer interaction (HCI) and other technology and robotics related areas of research that are relevant to our study.

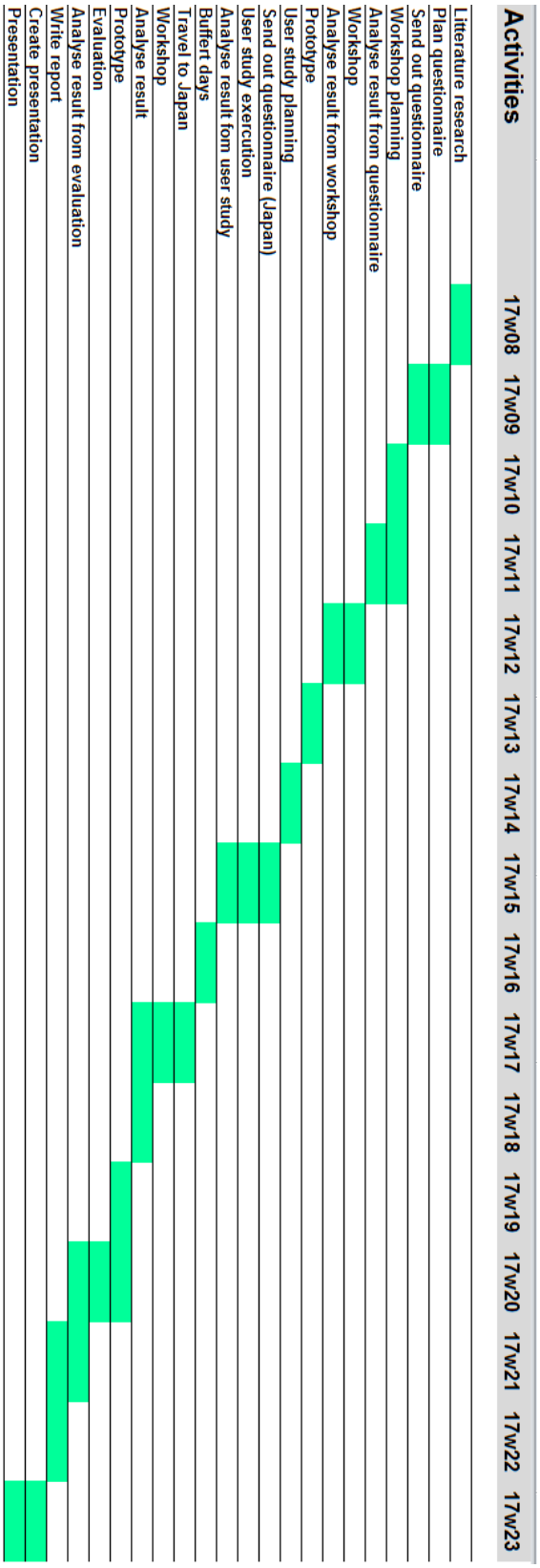
The planned methods to use were questionnaires and focus groups in order to elicit requirements, and then the plan was to create a prototype which could be a physical drone and use the Wizard-of-Oz technique in a user study were the drone companion is evaluated.

This study was planned to be divided in two parts, one part done in Sweden and one done in Japan. The initial plan was to do a complete study in Sweden and replicate the process in Japan in order to compare cultural differences in user's perceived opinions about drone companions.

The idea was to ask participants what they thought and felt about having a drone companion, then also what kind of tasks they wanted the drone to be able to perform. This was planned to be achieved through the use of questionnaires and workshops. When the requirements were elicited the idea was to put the appearance requirements on a physical drone and plan what kind of tasks the drone should do in the user study. The user study was supposed to be conducted by one facilitator, and one person that was located out of sight from the participants controlling the drone. The participant should then answer questions about the experience. From this, design guidelines were planned to be elicited and a basis for further discussions created.

This overall process was inspired by Dautenhahn's (2005) article "*What is a Robot Companion – Friend, Assistant or Butler?*", and the interaction design cycle, which is further elaborated in chapter 6.

Below a more detailed thesis plan will be presented to show the overall time plan of this master thesis.



(**Figure 5.1:** Gantt chart that shows the intended planning schedule)

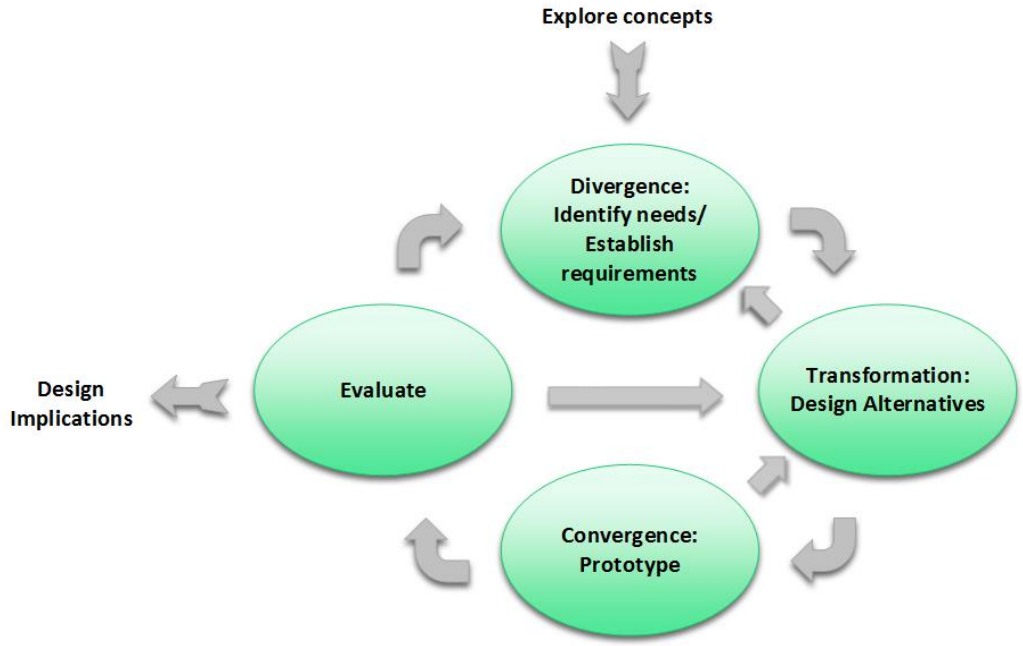
6

Execution

Our approach in this research is a user centered approach, which follows the interaction design cycle described in Figure 6.1 as our working process. The work starts with an explorative phase where different concepts of HRI and HDI are investigated through mainly literature research. The divergence phase defines and describes the problem area where the current status in the research field of human drone interaction is investigated, also by studying literature within the domain. Additional information that addresses attitudes and desires about HDI is investigated with questionnaires that are based in currently available research. Analysis of the questionnaires provided functions and other properties connected to a drone companion, which then gave some input to the small story that was presented in the workshops. This small story worked as a foundation which helped them to understand the drone companion. From the workshops several design concepts and appearances were found and worked as a foundation to the prototype.

In the transformation phase, methods that inspire to create new interesting ideas within the chosen context were used. A brainstorm session was used to find the most eminent functions and appearance people would like in a drone companion based on the data from the questionnaires and workshops.

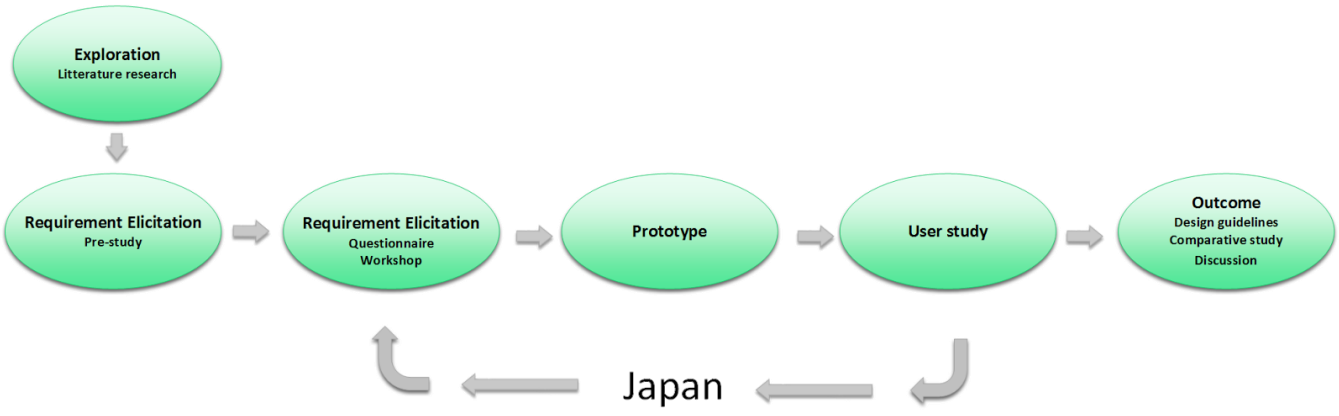
Lastly in the convergence phase the ideas were narrowed down into more manageable and feasible concepts. When this was done, a prototype was created in order to evaluate the user's responses and attitudes towards a drone as a companion. In this phase, users were involved in a controlled setting to conduct a user study and retrieve information and valuable data how they respond to two different drone companions. Finally, the outcome was analysed and discussed.



(**Figure 6.1**: Our sketch of the Interaction Design Cycle of our study)

In this section the overall execution of the thesis will be presented. The differences between the planned execution did not distinguish itself much from the final execution. A pre-study was added and the prototyping method was changed. Below a detailed description of the process is presented.

Because this is an explorative study between Sweden and Japan, parts of the design cycle were needed to be replicated in Japan in order to investigate cross-cultural aspects and differences in companion drone preferences. The requirement elicitation with both questionnaire and workshop, prototype phase and the user study was executed both in Sweden and Japan but the main planning of each step was conducted in Sweden. The Figure 6.2 will demonstrate the process. Below the different phases of the design cycle will be presented.



(**Figure 6.2:** Explanation of the working process)

6.1 Literature research

In order to understand the area of HRI, HDI and related supporting theory for this study, a wide variety of research articles, publications and other relevant literature concerning methodological, technological and theoretical aspects has been reviewed and presented in Chapter 2. The goal has been to achieve a solid theoretical foundation asserting as high level of validity as possible for our study.

Within the field of HRI there is much research regarding more traditional robotics and people's perceptions about having robots as companions, which is further elaborated in section 3.2 of Chapter 3 on Social robots. The literature research in the HRI area has yielded insights and served as inspiration to questionnaires and research methods used in our study. Some related research has also been done in the field of HDI, since it is a novel research area not much material has been found. Although the articles and publications that are presented in Chapter 2, Section 2.2 on HDI related work, has given insight in the ongoing research in the area.

6.2 Requirement elicitation

In the first phase of the interaction design cycle the elicitation of requirements and identifying the user's needs are fundamental tasks that need to be performed in order to be able to start designing concepts. By using different data collecting methods, the thoughts and ideas from the users were collected in order to elicit the requirements for a drone companion. Below the different methods used will be presented and why they are preferred over other options.

6.2.1 Pre-study

A pre-study was planned and executed in order to elicit in what type of environment participants would imagine the use of drone companions. Furthermore perceived roles of the drones were elicited. The pre-study was designed as a questionnaire study where also relevant questions regarding demographics of the participants were asked in order to create a foundation for an explorative study (Dautenhahn et. al., 2005). The study incorporated both open ended questions which could be motivated by the participants themselves and also multiple choice questions were used.

Participants
There were 14 individuals that participated in the pre-study. The ages ranged from 20-32 years old were the majority of the participants (71.4%) were around 20-23 years. All of the participants were born in Sweden and were studying at the University of Uppsala, Sweden. All participants signed consent forms before participating in the study.

6.2.2 Questionnaire

A more quantitative study of the intended user's demographics, perceptions of drone usage, some tasks that the drone would do, size, interactions and emotions of a drone companion was done in form of an online questionnaire. The composition of the questionnaire was derived from some of the answers gotten from the pre-study, as well as Dautenhahn et. al. (2005) Cogniron questionnaires. The first questionnaire was sent out only to people born in Sweden and the second one was translated to Japanese and sent out to people born in Japan. This is because it is an explorative study between Sweden and Japan and in order to be as reliable as possible, only native people can participate.

As the questionnaire was based on an online platform, the possibility to distribute it to many recipients was believed to be achieved and furthermore aiding the cross-cultural study between Sweden and Japan in the HDI area.

Participants
The questionnaire that was sent out to Swedish participants, a total of 24 participants answered and the gender balance was 50% female and 50% male. A majority of the participants (54.2%) were in an age span of 24-25 years old, the remaining 47.8% varied between 26-37 years old. The participant's occupations were broad, ranging from unemployed to engineers to students. Also the educational background was diverse ranging from high school to university.

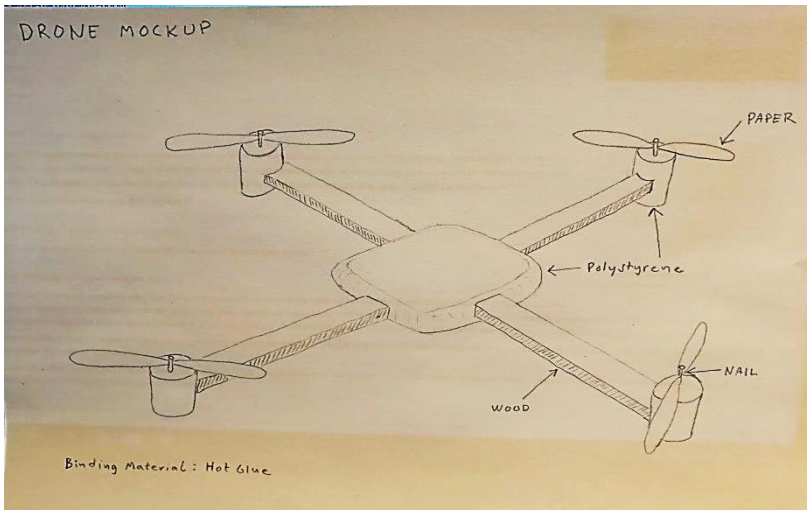
The questionnaire that was sent out to Japanese participants, a total of 24 participants answered and the gender balance was 45.9% female and 50% male where one person did not write the gender. The age span range between 19-50 years old, where the majority was between 21-24 years old (66.7%). Of the participants, 87.5% where students and the remaining 12.5% was either teacher researcher or office staff. The educational backgrounds were more diverse and ranged from Information Science and Technology to engineering to psychology, where the majority of the participants (58.3%) had either, Information Science and Technology or Engineering as background.

6.2.3 Analysing data

When the data was collected, next step was to discover different patterns and analyse other relevant findings. By creating a spreadsheet the data could be displayed together which facilitated the analysis. Because of the usage of Google Form a lot of graphs with the quantitative data were created which simplified the process of analysing. In this phase it is also time to examine why the participants think as they do and understand the actual needs in a broader perspective.

6.3 Workshops

Two workshops with six participants in one and four in the other were conducted in Sweden and one with nine participants in Japan. The intention was to design and create mock ups of perceived drone appearance and functionality of drone companions in a home environment. The workshops were executed as a part of the participatory design with users involved in the design process (Preece et. al., 2011 : Muller et. al., 1993). The purpose with prototyping was also to create a discussion on what features could be improved in design of drone companions. The basis for a prototype at the workshops consisted of a 'skeleton' mock-up of a drone which the participants elaborated their design upon, see figure 6.3 below.



(**Figure 6.3:** Sketch of drone mock-up for workshop)

6.3.1 Designing workshop

The workshops were based on four themes that are discussed throughout the session, 'Look and feel' which is the main concept of the drone companion, there can be different aspects of this such as form factors (size, gender and materials). 'Interaction mode' is another theme which describes how the users will interact with the drone; this can be either with speech, gestures, device or direct manipulation. It can also include interface design and the level of autonomy of the drone. The next theme is 'Social roles', it means what type of role the drone companion will have, such as a friend or assistant etc. The last theme is 'Desired tasks' and means what type of tasks or functions the users would want the drone to perform (Lee et. al., 2012).

Goal
The goal of the workshop is to find different design solutions/ideas of a drone companion's appearance and through the design solutions/ ideas elicit more additional functions for a drone companion.

Time and Location
The time of the workshop took place in the afternoon because of the availability of the participants.

The location in Sweden was at Lindholmen in a closed room where the workshop was performed without any disruptions. The location is also accessible, have a big variety of material to be used and easy to show presentations. In Japan, the location was in Takemura Lab where the participants could sit and create their design with materials bought to be as similar as possible to the Swedish workshops.

How to collect the data
The data collecting method that was used in the workshops was sound recording, because this is a good way to understand and remember the discussion. The participants can then speak freely and do not need to think and reflect over how to answer questions correctly.

6.3.2 Execution

The workshops began with a short presentation of the workshop and the study. Later, with some of the data from the questionnaire, a story about the drone companion was told in order to set the scene of what the drone companion could do, which environment it should be in and which size it

should have. The participants then decided if they wanted to start sketching on a drone companion on paper in order to get their head around how to design the drone or start directly with the low fidelity prototype. They were given 50 minutes to sketch and create their prototype. When the participants were done with the prototype they each discussed their prototype in steps of the four themes; Look and feel, interaction modes, social roles and desired tasks. Finally a questionnaire was handed out and the participants answered questions about what they thought about the workshop.

(**Figure 6.4:** Participants working on their prototypes in Swedish workshop)

Participants
By using theoretical representative sampling (Engelbrektsson, 2016) the choice of participants was specifically sampled from the target group (which in this case is the nationality). This sampling approach, instead of statistical representative sampling which focuses on random participants, Theoretical representative sampling chooses participants with a particular property, which is more suitable for our study since the intention is to create a basis for a cross-cultural explorative study between Sweden and Japan. The amount of participants should preferably be six because as Muller et. al. (1993) mention in the article *Participatory Design (1993)* and the gender balance should be as balanced as possible.

In Sweden, two workshops were conducted with six in the first one and four in the second one. The gender balance was 30% female and 70% male and the age ranged from 24-34 years old. The education varied from master degree to high school to informatics to interaction design. The majority of the participants were students (60%), the other participants were car painter, Nordic product manager, developer/designer or postman. 70% had no experience with drones before.

In Japan there was one workshop with nine participants. The gender balance was 44.4% female and 55.6% male. The age ranged from 21-41 years old and the majority of the participants (66.7%) were students while the other was either secretary, office staff or did not write. The education was either engineering science/information science (44.4%), Information Science and Technology (22.2%), Psychology (11.1%) or they did not specify. 77.8% had no experience with drones before.

6.3.3 Analysing data

The analysing phase started with transcribing the voice recordings and interpret the different sketches. From that the data was compiled into the four themes, described by Lee et. al. (2012), in order to get a better overview of what been said. When all the data was compiled, both the data

from the questionnaire and workshops were compared, which aimed to find statements that reinforced each other or appearances that participants has implied or mentioned in the questionnaire. The result is presented in the Chapter 7 section 2, Workshop.

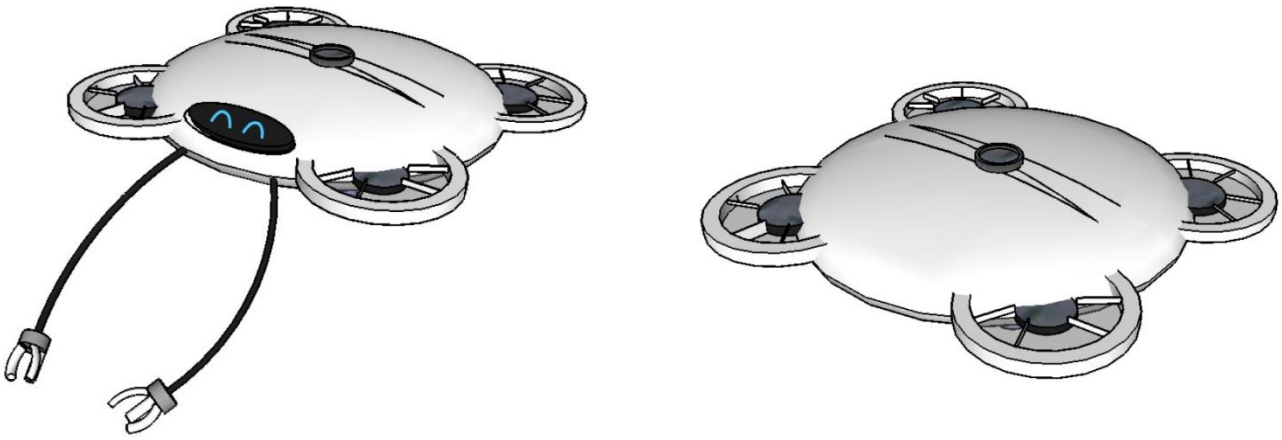
6.4 Prototyping for the User Study

When using VR there are some things to have in mind. How much programming will be involved? What kind of engine? How will the different tasks be solved?

For the purpose of our study, relatively simple solution containing a Wizard-of-Oz technique needed to be done. By using *HTC Vive* and its consoles, the drone could be connected to one of the consoles and be manipulated as wanted. The participants see a 3D environment and a flying drone while the facilitators are moving around in the real world.

In order to do the two different tasks, the setup needs to be carefully considered and the different tasks needs to be as realistic as possible. This setup needed to facilitate that one console would act as a cup in the VR environment, while the other was representations of two drones. The drones could be interchanged by a press of a button on the corresponding console in order to fit the different scenarios. The drones also needed to be able to communicate with the participant. This was solved by using recordings of one of the facilitator's voice, where questions and answers to the participant's different commands were made available.

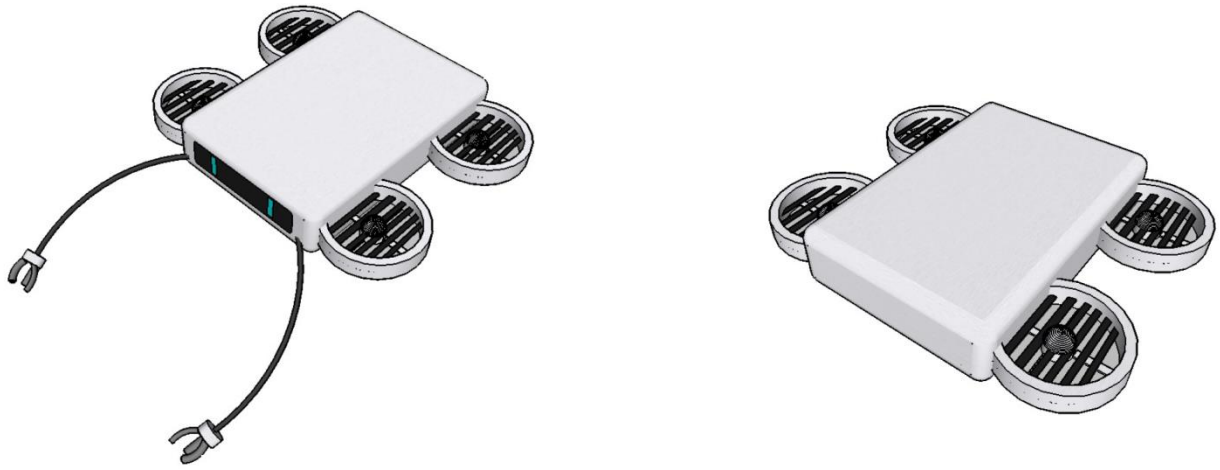
The VR environment was created within *Unity Game Engine*[3] which enabled quick and relatively easy deployment of 3D models for the scenarios. A premade home environment was utilized. The four different drone 3D models (two Sweden and two Japan) for the two scenarios were modelled in *Google SketchUp*[4]. The designs for each country were based upon the analysis of both questionnaires and workshops results (see Figure 6.5 and Figure 6.6).



(a) Drone A **(b)** Drone B

(**Figure 6.5:** Swedish drone design)

[3] https://unity3d.com/ [Accessed 2017-04-13]
[4] https://www.sketchup.com/ [Accessed 2017-04-13]



(a) Drone A **(b)** Drone B

(**Figure 6.6:** Japanese drone designs)

6.4.1 The Consistency of Experiment

In order to maintain consistency of the experiment there were certain aspects that needed to be fulfilled. Measures ensuring that the execution of the experiment was as consistent as possible were carefully taken into consideration. The experimental setting was set up in *Knowledge Lab* at Chalmers Lindholmen (in Sweden) and in Takemura Lab at Toyanaka Campus (in Japan) where appropriate equipment was available to conduct VR simulations. When designing the experiment space in the laboratory there needed to be enough room to fit the VR simulated environment, so that the Wizard of Oz approach would be able to be carried out in a satisfactory manner, this since the controls of the HTC Vive is used as objects that move around in the VR environment. The matching of scale in VR needed to correspond to that in real world, thus also distances. To be able to replicate the same scenario several times in the exact same manner, measurements were taken from the actual laboratory.

A height for the flight pattern of the virtual drone was set up by measuring the height in the actual room from the floor up to a certain level which fit the user's field of view. The height was 145 cm, and was maintained with measured bits of tape suspended from the ceiling. The flight path of the drone was eased with help of these measurements, as well as tape markings on the floor which showed the starting and stopping points. A marking was also placed on a chair which represented a couch in the VR environment, this was where the 'mug' was placed. The speed was maintained by the facilitator by measuring the time intervals which it took to complete a task, this could vary slightly due to the fact that the facilitator manually moves the drone in the room. However practiced well and the time difference could be kept minimal, around 1-2 seconds per performed task.

The physical limitations in the laboratories consisted of the actual coverage of the room sensors belonging to the HTC Vive system. This constricted the amount of space where the scenario would take place, but both laboratories were sufficient enough to fit the intended flying path and interaction with the drone and the user.

6.5 User Study

When the requirements were elicited and a prototype was made, a user study was conducted. This user study was inspired by Wood et. al. (2007) and Dautenhahn et. al. (2005) where both evaluate how people feel and react to a robot while doing different tasks.

Below the planned overall execution of the user study is presented.

6.5.1 Designing user study

In the design phase of the user study the focus was on what kind of tasks that the drone should perform and how many of them. The tasks that were chosen were defined by the tasks from the questionnaires that was most popular and feasible in terms of prototyping.

Goal
According to Goudey and Bonnin (2016), "The human appearance of a companion robot does not increase its acceptance by consumers. However, we show that a partially anthropomorphic appearance improves acceptance by people with practical experience of similar technology (the smartphone), while it reduces acceptance by other people". This means that by adding anthropomorphic features to a drone companion would not change the acceptance of the users. Although, the findings from the questionnaires and workshops show that there are no distinct answer if the drone companion should have an anthropomorphistic features or show emotions or not.
We believe that by interacting with a drone companion with anthropomorphistic features instead of imagine how it would be like will be different. The goal is therefore to examine the hypothesis:

By interacting with both a drone companion with no anthropomorphistic features and one with some anthropomorphistic features the participant's ideas and perceptions will change in favour for the later.

By confirm the hypothesis will help to answer the research question "*How can a drone be used as a companion instead of a tool?*" and the sub question "*Do users want the drone to possess anthropomorphistic features?*".

Time and Location
The time of the user study was held during two weeks where the participants will be given the opportunity to book different time slots that suits them the best. The sessions will be executed both during the day and afternoon.

The place where the study could be executed needs to be considered, with enough space and access to relevant technology such as powerful computer and VR-headset. The environment that the study will take place in could affect the outcome of the study. If it is held in a home environment the user may act differently comparing to an empty room with a high ceiling. The environment was therefore determined based on identified needs from the pre-study. The location of the user study in Sweden took place at Lindholmen, Knowledge Lab, where all the relevant equipment are and it is an appropriate place to do the study. In Japan, the user study took place in Takemura Lab where the relevant equipment could be used.

How to collect the data
In order to evaluate the results from the user study some questionnaires needed to be done before the study begins after. These questionnaires, as Wood et. al. (2007) did in their article "*Is This Robot*

Like Me? Links between Human and Robot Personality Traits" and Dautenhahn et. al. (2005) in their article "*What is a Robot Companion – Friend, Assistant or Butler?*", included (among other) Cogniron introductory questionnaire and Cogniron final questionnaire. These questionnaires were modified in order to fit our study. In addition to these, one questionnaire after each drone encounter will be given to the participant where he or she answers questions about the interaction with the particular drone companion.

6.5.2 Execution

This phase of the user study investigated the participant's attitudes and responses to the drone as a companion. The study consisted of single human participation and minimal participation from the facilitator. The facilitator only answered if the participant initiated to ask a question.

The user study will be conducted with two drones; one drone with no anthropomorphism implemented and another drone with some anthropomorphism features implemented. The study will be conducted using within subject design approach which means that the same participants conduct every condition in the experiment, and thus also act as their own control group. This methodology reduces the possible amount of errors which may otherwise arise from variance between individuals (Shuttleworth, 2009).

The sessions began with the participant signing a consent form and answer the introductory questionnaire. After the first questionnaire was answered, the participant put on the VR equipment and got some time to familiarise with the VR environment. When the participant was ready he or she receive information what to do. The participant was supposed to call for the drone, ask it to bring a coffee mug and then give Facebook status. Which drone the participant begins with is balanced in the order AB BA AB BA etc. It can either be drone A (with anthropomorphism features) or drone B (without anthropomorphism features). After the tasks have been performed the participant takes of the equipment and answer the corresponding drone questionnaire. Next the participant puts on the VR headset again and perform the exact the same tasks with the other drone. After the same tasks have been performed the participant answer an identical questionnaire but for the corresponding drone. Finally, the participant answers the final questionnaire were he or she writes about its thoughts and ideas about drone companions when having both drones in mind. The duration of each session ranged between 20 to 30 minutes.

(a) Facilitators instructing the participant

(b) Facilitators manoeuvring the drone

(c) What the participant sees in the VR environment

(**Figure 6.7:** User study session)

By letting the participants interact both with a drone that does not implement anthropomorphism features (which may be as the participant would like in the first place) and one drone with some anthropomorphism features, could validate or refute the stated hypothesis.

Participants
As with the choice of participants for the workshops, theoretical representative sampling (Engelbrektsson, 2016) was implemented for choosing participants from the target group for the user study. This since our study involves a cross-cultural explorative study, thus necessitating that the chosen participants has particular properties. The aim of number of participants was from 15-20 and the gender balance was supposed to be as balanced as possible. According to Six and Macefield (2016) the amount of participant for a usability study depends on the minimum percentage discovery and the average of percentage you hope to find. By having 15-20 participants the average percentages will be around 97-98 which covers enough for this study.

In Sweden there was 16 participants were 43.8% was female and 56.3% was male. The age ranged from 21-32 where the majority of the participants (56.3%) were between 25 and 26. 62.5% of the participants were students and the remaining 43.8% had a big variety from translator to laboratory engineer. 50% had no experience with drones before.

In Japan there was 16 participants were 43.8% was female and 56.3% was male. The age ranged from 18-59 years old and they can be seen as three groups; 18-24 (56.3%), 27-37 (25%) and 40-59 (18.6%). 68.8% of the participants were students, 12.5% were professors and the other three was either a faculty member, office staff or a technical assistant. 75% had no experience with drones before.

6.5.3 Analysing data

The data from the user study was analysed and examined for different patterns in the participant's thoughts and ideas, recurring behaviours and overall attitude towards drones as a companion. Before the data could be analysed it needed to be processed. This included transcribing of the recordings and summarising the questionnaires. The result will be presented in Chapter 7 section 3, User Study.

7

Result and analysis

In this chapter the result from the questionnaires, workshops and user studies will be presented. These three phases will be divided in subcategories where they are divided in Swedish and Japanese results.

7.1 Requirement elicitation Questionnaires

Two requirement elicitation questionnaires were sent out to both Japanese and Swedish participants with various education and occupation. The questionnaires covered, besides demographics, the following topics in relation to drone companions; What role it should have, If one would like to have a drone companion, what kind of tasks one would like it to do, what size the drone companion should have, how human-like it should be, if the drone companion should follow one around, how one would like to interact with it and if one would like the drone companion to have emotions. The definition of emotions is in this case showing feelings such as happiness, tiredness and sadness.

The result from these questionnaires was categorised in subcategories which was most prominent in the questionnaire.

7.1.1 The different roles of a drone companion

Below are the thoughts and ideas of what kind of roles a drone companion can have will be presented and divided into Swedish and Japanese result.

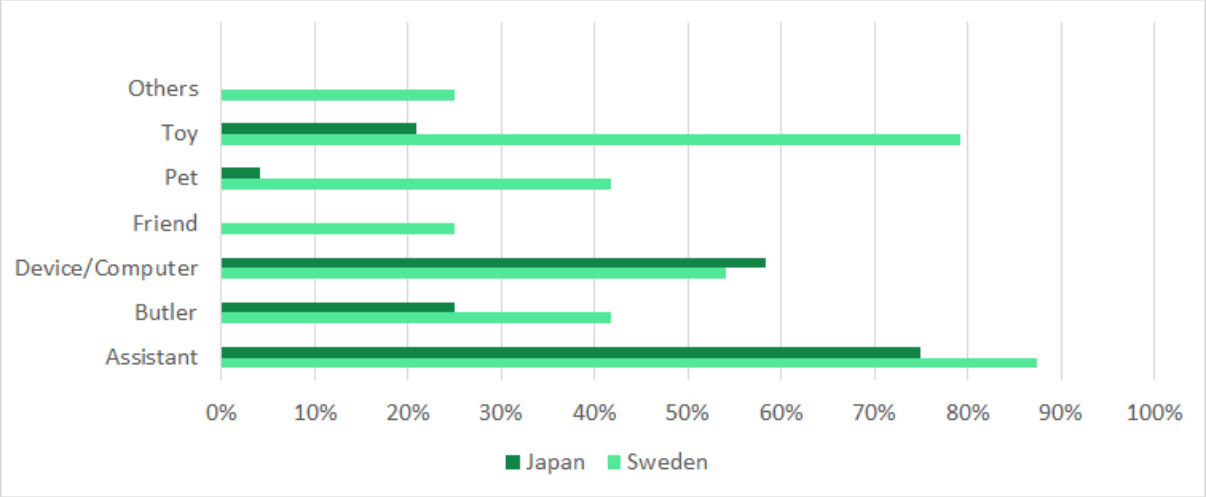
Sweden
87.5% of the participants see a drone companion as an assistant and 79.2% sees it as a toy. Of those who did not see the drone companion as an assistant sees it as a tool that either deliver things or guard the home. 50% of the participants that see the drone as a toy did not mention any playful traits that could indicate it is a toy, and saw it more as a helper that do different tasks.

The 66.7% of the participants that answered that they would like to have a drone companion as a friend did not want to the drone companion to show emotion but wanted the drone to follow around. Also, 83.3% of the participants who sees a drone companion as a friend would like the drone as company. Even though participants that answered they did not want to have the drone companion as a friend or a pet, seems that some of them still wanted to have conversations and play with the drone.

88.6% of the participants see a drone companion as an assistant who helps them in their daily life and help with everyday chores. Also, there are some who would like to have daily updates where the drone gives information about things such as reminders, weather conditions and other daily updates.

Japan
Of the different roles that a drone companion could have, 75% would like to have the drone companion as an assistant, and 25% would like to have it as a butler, while 58.3% wanted the drone to be a device or a computer. 20.8% also saw the drone as a toy.

Cross-cultural comparison
In both Sweden and Japan there is a clear preference regarding the most popular roles that a drone companion can have (as seen in Table 7.1).



(**Table 7.1:** Preferred roles in Sweden and Japan)

There are some clear differences in certain categories. Whereas 79.2% of the Swedish participants saw the drone as a toy, only 20.8% of the Japanese participants thought so. Likewise in categories such as Friend, where no Japanese participant preferred the drone companion to act as a friend. Also only 4.2% of Japanese participants saw the drone as a pet, but a total of 41.7% of the Swedish participants thought so. The preferences about a drone as a device/computer and an assistant were however quite alike among participants from both Sweden and Japan.

7.1.2 Why and why not having a drone as a companion

Below are the thoughts and ideas of why and why not having a drone companion will be presented and divided into Swedish and Japanese result.

Sweden
A couple of comments indicated that the drones sound too much to be useful as a companion with current technology. However many commented positively of having a drone as companion, and would like to have one that helps with household tasks. Many also mentioned that they would think that it was a fun and cool idea to have a drone companion.

"*Sure. It would be funny to see what kind of relationship one could develop with a drone and what services could be provided by it.*"

"*Fun thought. Useful as an aid within the home, etc. Opportunities and ideas are endless. Assisting in cooking, cleaning, carry heavy food bags. Etc.*"

70% that were negative towards a drone companion indicated in short answers without much elaboration, but those who did was concerned about the drone might frustrate the person, that the

drone might just become a gimmick, discomfort having a drone nearby and one person thought that the drone would best work for people with disabilities as a means of help. One person was concerned about the propellers which may hurt him or her.

"*No, I think I would get more frustrated on it than happy that it's there to help me.*"

"*Personally, I'm not particularly interested in a drone. Technology needs to be developed more to make it not just a gimmick. However, believe in it in industry or, for example, as a delivery method of packages.*"

"*No, not at this moment. But if I had a disability, it would have helped with a drone which could assist me and be at hand if I needed any help.*"

58.3% in total answered yes to having a drone as a companion. Of these 58.3%, half commented initially that they wanted the drone to help them with everyday tasks, 28.6% wanted the drone to get items for them and one person wanted the drone to act as a butler. Furthermore one person would like a drone to help him/her with experiments. Of these 58.3% only 21.4% want the drone to be very humanlike or rather human-like.

Japan

41.7% did not want a drone as a companion, while 54.2% wanted a drone as a companion, one participant did not know if he or she wanted a drone companion. Of the 54.2% that wanted a drone as a companion three individuals specifically thought that the drones would be good when there is a need to fetch items. A majority that was positive to a companion also thinks that it may be helpful with making daily life easier. Some negative comments about having a drone as a companion were, amongst others:

"A house is too small to fly a drone in"

"No, Drones as well as robots are just machines"

An answer also indicated that drones could be dangerous to people, according to the participant:

"I think drones are dangerous"

Being busy is also stated as a reason why a drone companion would be good to have, since a couple of participants thought that the drone could help out when they are doing other tasks. One participant mentioned that the drone companion could also play with them.

There were comments that indicated that participants thought that the notion of having a drone as a companion was unnecessary, and they could not imagine having one at home:

"It is weird if a machine becomes my companion"

Some positive comments about a drone companion could be:

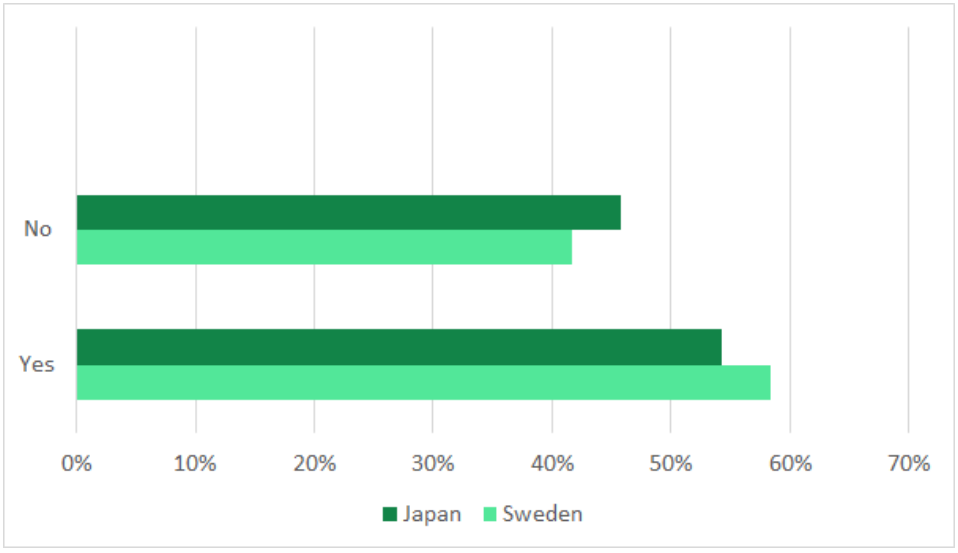
"Yes, I want a drone to make my life more convenient"

"Yes, a drone can help facilitate our daily life"

Many of the positive comments were regarding making life easier for the participants and that they could focus on other things instead for example resting.

Cross-cultural comparison

Both Japanese and Swedish participants did favour having a drone as a companion, as seen in table 7.2.



(**Table 7.2:** Preferences of having a drone companion in Sweden and Japan)

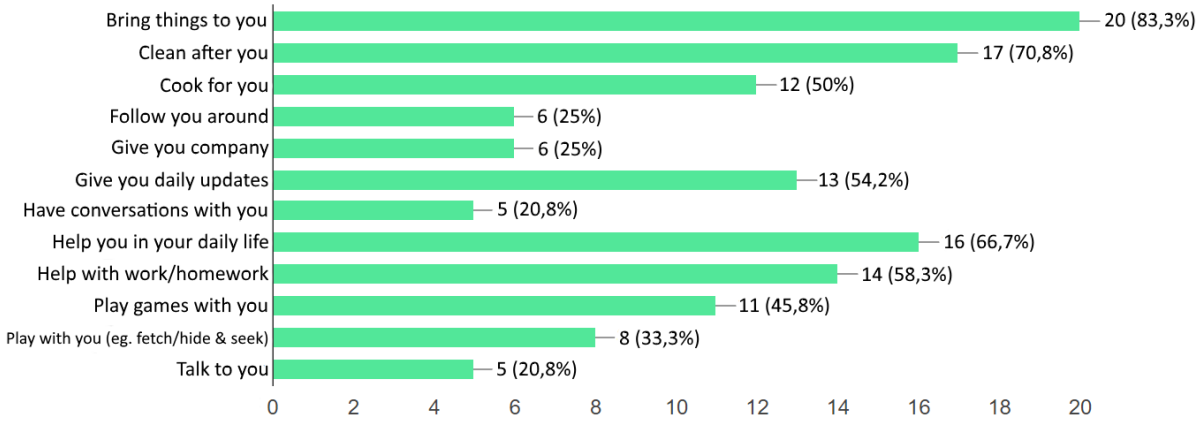
Of the Japanese participants, there were 54.2% that wanted a drone as a companion, but in Sweden the percentage was even higher with 58.3% wanting a drone as a companion.

7.1.3 Tasks of a future drone companion

Below the thoughts and ideas of what kind of tasks a future drone companion can have will be presented and divided into Swedish and Japanese result.

Sweden

The tasks that the participants would like the drone companion to do varied, but there were a clear distinction of the most popular task which was to bring things to the user. Cleaning and help you in the daily life were also tasks that was prominent. The table (table 7.3) below shows the distribution of the participants' preferences.



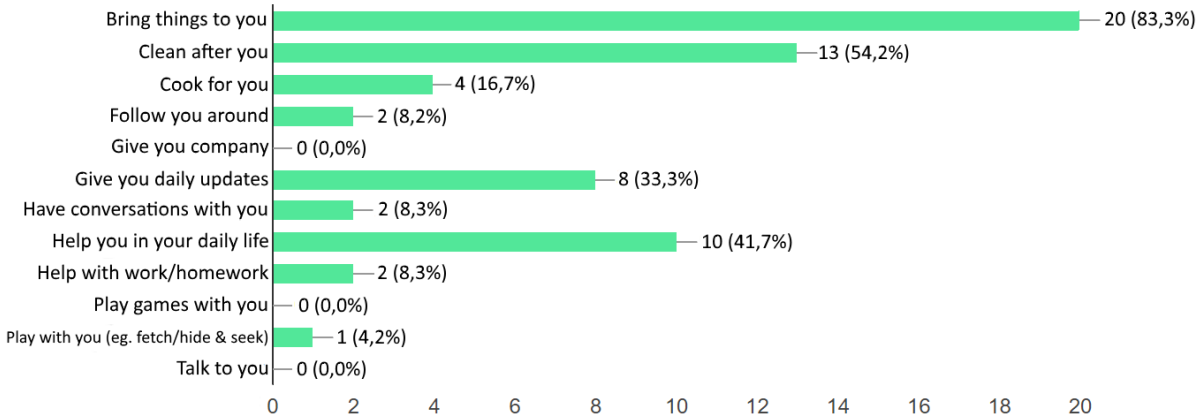
(**Table 7.3:** Preferred tasks in Sweden)

In addition to these tasks the participants were able to add other tasks that they would like the drone companion to do. Of these tasks one participant would like the drone companion to do simple tasks in the home, such as turn on/off lights, open doors, turn on the music. Two more would like the

drone companion to do everyday tasks such as make calls, answer when telemarketers call and inform when someone e.g. knocking on the door. One would like to have general reminders while another would like it to guard the house. Further there was one participant that would like the drone companion to help with directions and one that would like it to teach him or her things.

Japan

A clear majority of the participants wanted the drone to bring items to them, also many wanted the drone to clean and to be helpful in the daily life. The table below (table 7.4) shows the different tasks that were popular.

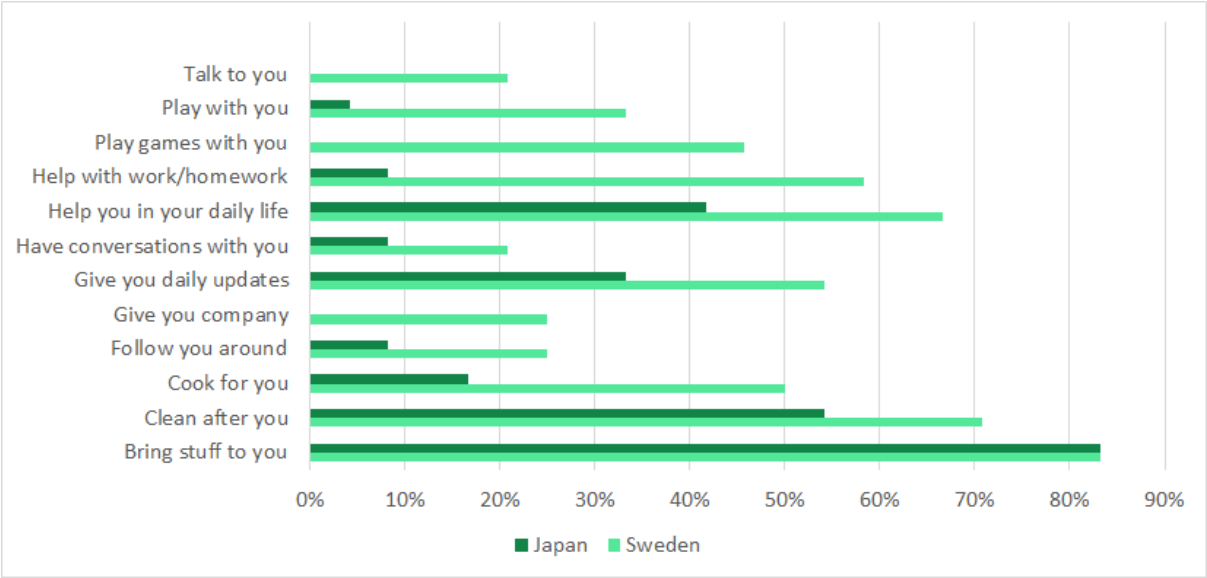


(**Table 7.4:** Preferred tasks in Japan)

83.3% participants wanted the drone to be able to bring different items to them. 54.2% wanted the drone to clean after the participants, and 41.7% would like the drone to be able to help out with daily life. Also 33.3% wished that the drone could give daily updates to them. Many of the participants who wanted the drone to bring them items thought that this task suit the drone very well. A couple of persons mentioned that they do not like household work, and thus a drone could be suitable for the task instead.

Cross-cultural comparison

Of the most preferred tasks that a drone companion would perform, the most prominent feature for both the Swedish and Japanese participants were 'bring stuff to you', as seen in Table 7.5.



(**Table 7.5:** Preferred tasks in Sweden and Japan)

A total of 83.3% of the participants, similarly in Japan and Sweden preferred the drone to bring items to them, the second most prominent task was 'clean after you' which 70.8% of the Swedish participants wanted, 54.2% of the participants also preferred this task in Japan. The third most popular task was 'help you in your daily life' both in Sweden (66.7%) and Japan (41.7%). However, tasks like 'give you company', 'play games with you' or 'talk to you' were not chosen by any of the Japanese participants. There is also a big difference in the category of 'help with work/homework', where only 8.3% of the Japanese participants wanted that feature in the drone companion, in Sweden 58.3% wanted to have this feature.

7.1.4 A drone companion that follows around

Below are the thoughts and ideas of whether the drone companion should follow the user or not will be presented and divided into Swedish and Japanese result.

Sweden

29.2% of the participants did not want the drone to follow around, they spoke about that it could be annoying, intrusive and they would feel surveilled. Although many of those who said they did not want it to follow you around wanted the drone to come if commanded.

"No, that is annoying. But I would like it to come if I call for it."

"*(...) A choice should be possible at any time, much like a dog: "Go to bed!*"

For those that wanted the drone to follow around liked the idea to have the drone close at hand, and some wanted it to be optional.

"*Yes, to some extent. It would be practical to have it within a couple of meters (or at least within the same room) so that it can still hear when you call for it."*

"*Yes but not if commanded otherwise*"

Overall, it seems like the drone should be close but not following around and come if the user commands and leave when commanded.

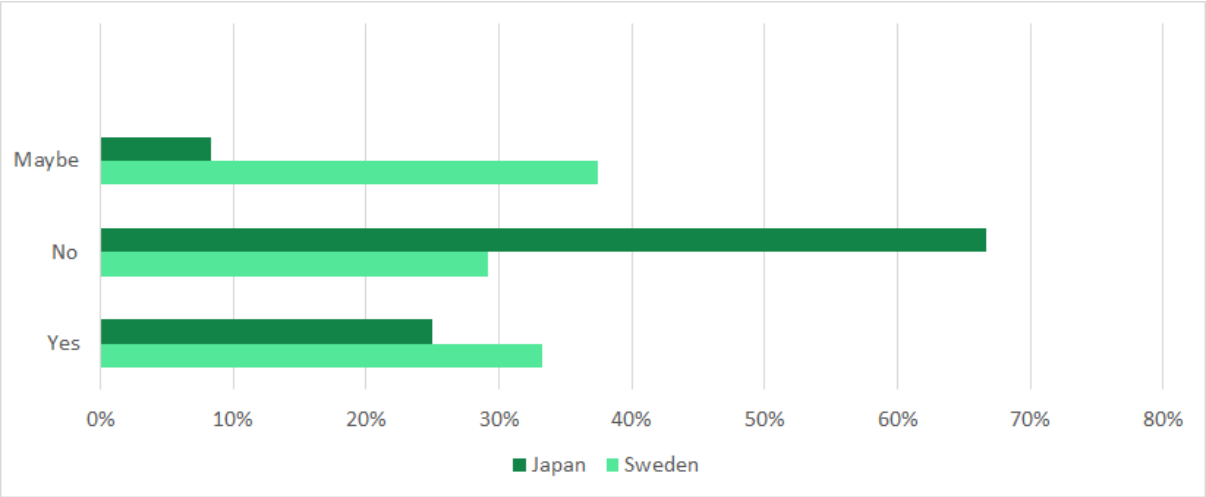
Japan

A majority, 66.7% did not want the drone to follow the participants around. Many of those thought that it actually would be annoying. Privacy issues was also a concern for many, they would not want the drone to be with them all the time since the drones would invade their privacy and that they would feel like being observed or that the drone's presence would be *"creepy"*.

25% thought that a drone following the participants around would be good, and that it would be convenient and helpful to have one. A comment was that the drone would be available all times when needed:

"Yes, I want a drone to do tasks immediately when needed (...)"

Cross-cultural comparison
If the drone companion should follow the user around, divided the opinion of the Swedish participants. The Japanese participants had a more clear preference, see Table 7.6 below.



(**Table 7.6:** Preference of having the drone to follow around in Sweden and Japan)

Having the drone companion to follow one around is something that the Swedish participants were not too sure about, neither 'yes' (33.3%) or 'no' (29.2%) got a majority of the opinions, and 37.5% answered 'maybe'. The Japanese results were clearer, with a majority of 66.7% saying 'no' to the notion of having a drone companion that follows around, only 25% of the Japanese participants were positive to it.

7.1.5 Emotions as a component in a future drone companion

Below the thoughts and ideas of having emotions in a drone companion will be presented and divided into Swedish and Japanese result.

Sweden
Of the participants that answered the questionnaire, 50% would like to have emotions in a drone, but some did not want the drone to have too many emotions or as one said;

"Don't see much of a reason for it, but can be kinda cute to have."

For some of those who did not want the drone to express emotions did not like the idea of machine/dead objects with emotions. One person also thinks it is not necessary, but would not mind if it possessed emotions. 66.7% of those who did not like the idea that the drone should have emotions where those who actually did not want to have a drone companion in the first place. The 33.3% who liked the idea of having a drone companion but not emotions in a drone either thought that would be scary, unnecessary or did not specify why.

"*Naaaah, wouldn't mind but not necessary*"

"*No, emotions. That is scary*"

For the 50% of the participants that liked the idea of drone companions with emotions thought that it is a fun/nice idea and could be helpful e.g. showing low battery. Some participants liked the idea of having emotions in a drone companion, but not too much.

"Yes, that would be very helpful"

"Some emotion to indicate low battery is useful. I don't think more is needed."

Japan

66.7% do not want drone companions to have emotions, many of the answers indicate that there is concern about that emotions in machines may become troublesome or scary, a couple of comments were also concerned about that people might get too attached to the drone, thus hindering the potential use of the drones. Only 25% of the participants were positive towards having emotions in a drone companion. 43.8% of the participants that were negative against emotions in a drone were also negative against the notion of having a drone as a companion in the first place. Of the few that were positive against emotions, a comment involved a technical combination of emotions and practicality:

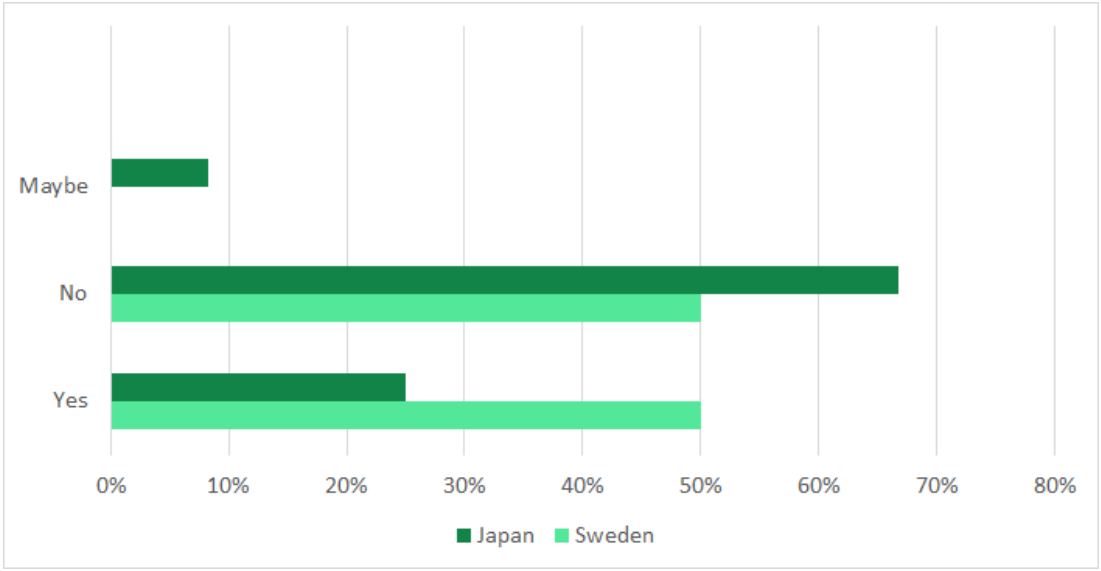
"It is a good idea to have an expression showing when the battery is low"

One participant commented that he or she thought it would be more fun if the drones are cuter:

"I think it will be more fun if drones are cuter"

Cross-cultural comparison

If the drone should have emotions divided the preferences among participants in both Sweden and Japan (see Table 7.7).



(**Table 7.7:** Preferences if the drone should have emotions in Sweden and Japan)

The Japanese participants preferred the drone to not have emotions with a clear 66.7%. There were some that were ambiguous (8.3%) among the Japanese participants also. The Swedish participants were however divided with 50% on both 'yes' or 'no'. In the Japanese result there is only 25% that said yes to emotions in a drone.

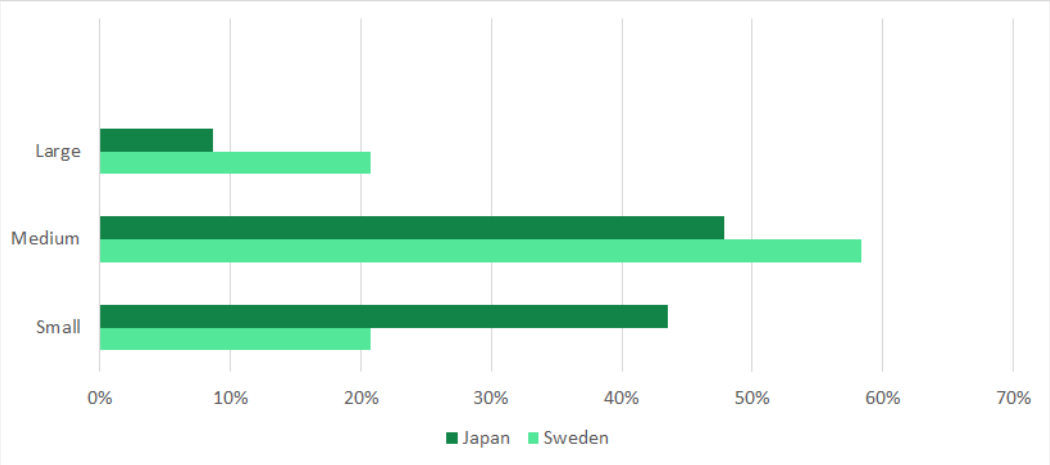
7.1.6 Size of the drone companion

Below are the thoughts of what kind of size a drone companion should have will be presented and divided into Swedish and Japanese result.

Sweden
58.3% of the participants would like the drone to be 'medium' in size, this was represented with an approximate estimation of size relative to a human, around 40 cm in diameter. Both the other alternatives, 'small' and 'large' were 20.8% each of participants' choices. Two participants who wanted the drone to be large in size indicated that the use of drones would be more of a tool instead of a companion, and their answers also pointed more toward practical usage e.g. as security for the home or deliveries of goods which may necessitate a larger size.

Japan
The results of the size question was somewhat divided, but a small majority (45.8%) want the drone to be medium in size. Medium size is related to a representation of a drone next to a human, and is approximately 40 cm in diameter. Almost as many who wanted the drone to be medium sized, answered that they prefer the drone to be 'small' sized (41.7%). While only 8.3% wanted the drone to be 'large' in size.

Cross-cultural comparison
The size preferences between Japanese and Swedish participants are alike in one aspect, but divided in others (see Table 7.8).



(Table 7.8: Preferred size of a drone companion in Sweden and Japan)

Size medium is what most participants, both Swedish and Japanese participants wanted in a drone companion with 58.3% of the Swedish and 47.8% of the Japanese participants. A difference was that more Japanese participants than Swedish would prefer a small drone companion, with 43.5% it is quite close to the participants who preferred the medium size.

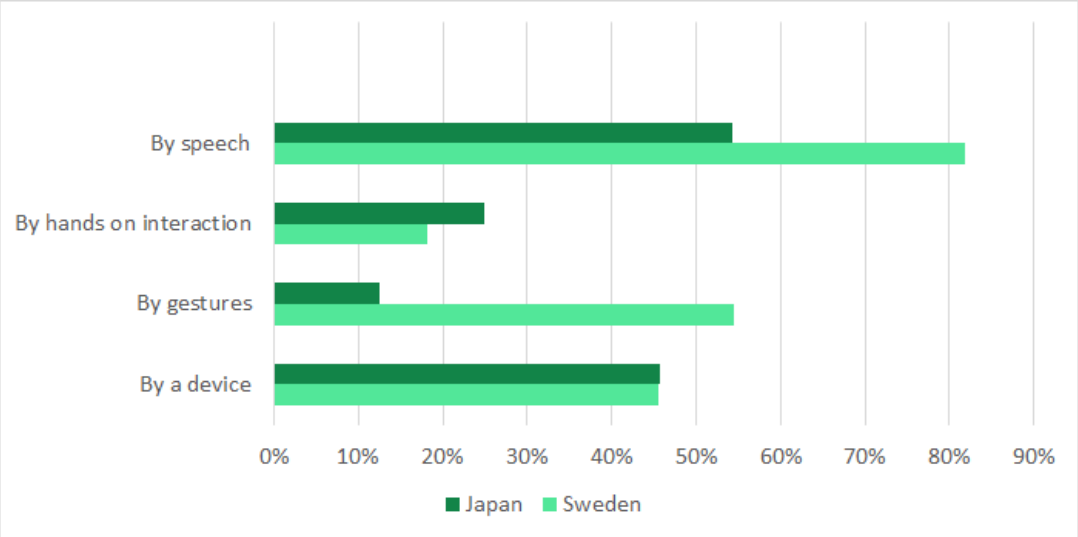
7.1.7 Interaction with the drone companion

Below the thoughts and ideas of what kind of interactions a drone companion should have will be presented and divided into Swedish and Japanese result.

Sweden
The majority of the participants wanted to interact with the drone via speech (81.8%), although many also wanted the drone to be able to recognize communication through gestures (54.5%). There were also 45.5% of the participants that would like to use some device for communication with the drone companion.

Japan
54.2% wanted to interact with the drone by speech. 50% would also want to be able to interact with the drone companion via device, and 25% would like the interaction to be done by 'hands on interaction'. Only 8.3% would like to interact via gestures.

Cross-cultural comparison
The different modes of interaction with the drone companion show some resemblance among both Swedish and Japanese participants, with one category that is significantly different between countries (see Table 7.9).



(**Table 7.9:** Preferred interaction with drone companion in Sweden and Japan)

The most preferred mode of interaction with a drone companion is by voice, for both the Swedish (81.8%) and Japanese (54.2%) participants, however the difference is quite large in this category. The rest of the results show quite similar patterns but there is one category that is a bit different, 'gestures' which 54.5% of the Swedish participants wanted, but only 12.5% of the Japanese participants preferred. Instead there is a small increase in 'hands on interaction' that 25% of the Japanese participants wanted.

7.2 Workshops

The data was extracted from transcribed audio recordings made from all of the sessions performed in both Sweden and Japan, and is presented below accordingly to four themes as described by Lee et. al. (2012). The themes are *Look and Feel*, *Interaction modes*, *social roles* and *desired tasks*. The first theme concerns the look and feel of the drone companion, and describes the physical characteristics, for example size, form or other prominent features. Interaction modes means in which way a user would communicate with the drone companion, with gestures, voice, devices or hands on interaction for example. The desired tasks theme consists of the tasks and functions that the user would like the drone companion to perform.

7.2.1 Look and Feel

Below are the thoughts and ideas about the appearance of a drone companion will be presented and divided into Swedish and Japanese result.

Sweden

Of the people that participated in both workshops 60% mentioned or designed that the drone should be round or have rounded features. 40% of the participants did not want a face on their drone companions, however 40% would like to have some kind of face to show emotions, while 20% did think that the appearance did not matter. Only 20% of the participants mentioned that the drone should be quiet.

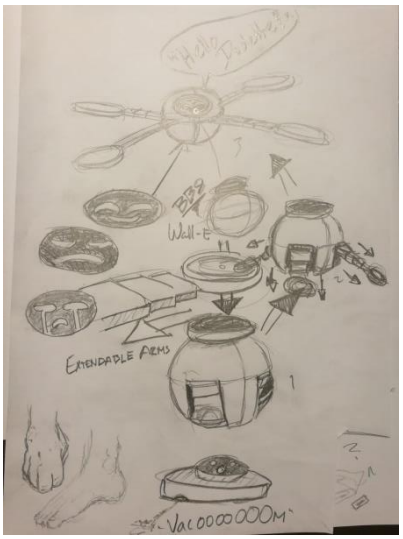
One participant described that it is not necessary for the drone to look comical, however if it is a companion it might as well look that way and also that the drone does not need to be really serious, rather more “easy going”. Another participant wanted a light on the drone because the it is supposed to be active at night, and the participant thought of the drone as a tool to kill mosquitoes, and the light should be there in order for the user to see where it is. Aesthetics does not matter according to the participant, but the drone could look happy when it found what it was looking for and cunning when it has killed mosquitoes.

The drone should be nurturing and caring, according to a participant, it should be able to check on animals, children and elderly. The appearance of the drone should be round, because it is soft and caring, and have a star shaped underside. The participant also talked about colours and would like the drone to be white if possible. However, the drone shall not have a face or even show emotions that would be too scary according to the participant. It is supposed to only be a machine that could assist.

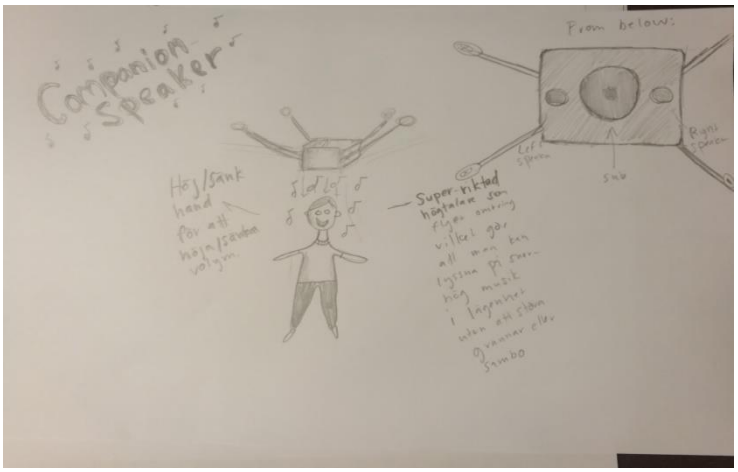
(a)

(b)

A participant would like that the drone can be BB8 (Star wars) or Wall-E (Disney) inspired, and not only fly around but also that it would be portable and move between things, for example a vacuum cleaner, thus the drone could be modular. It can also have a screen which shows emotions with a face. Another participant wanted a drone that follow the user around and play music, the person thought the drone does not need to be more than a speaker in the middle and have arms. The participant also mentioned that it should not have a face, it is a technical device, a machine.



(c)

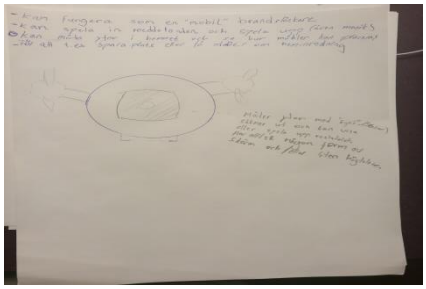


(d)

Some distant memories of a Swedish summer tv-program from the late nineties, or a lawnmower inspired a participant in the design of the drone. It should have arms with claws which are retractable and with help of these be able to carry large and small items. The participant also pointed out that the drone needs to be able to land. The shape could be round like a UFO. Even this participant would not want a face on the drone. A quite innovative feature would be the ability to be charged through touch, for example by having fur on the drone which charges the battery, it would also work as a way to connect with the drone as a companion. The participant would not want the drone to show emotions, just a display that shows the battery level.

Another opinion about the drones appearance was that the drone can be round or spherical, and be able to land with landing gear. It should also have at least two wings, but it is not that important how it looks any way according to the participant.

(e)



(f)

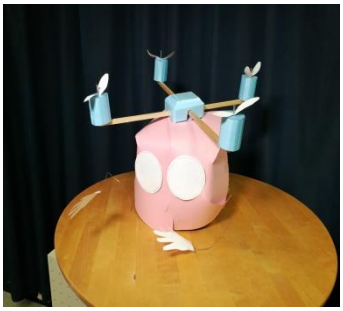
“Bionic Electronic Electric Retriever”, or as shortened “BEER” is what one participant called its conception. The idea came from the user’s need to be able to get beer in a comfortable way. The drone was designed with a rather cartoon look, since, as pointed out by the participant, if the drone has too much of realistic features it might become uncomfortable. The participant mentions that it should have big white gloves which are soft and nice. This participant also wanted the drone to show emotions, happy and nice when there is beer in the refrigerator but sad if there is none. The face feature is there in order to get the anthropomorphism feeling that it is a companion and a follower.

A view that the drone should be rather big and feel like an ordinary human head was mentioned by another participant. The participant wanted to have a Gigglypuff (Pokemón) inspired design for kids

and families. It should be recognizable and something cute in a sense that the user should like to play with it. It should have big eyes that take in information from the surroundings, so it can know where to throw a ball for example. The drone should have a lamp that blinks during the night so the user can see it, or a sensor that senses if the user is within two meters and starts to blink.

One of the last participants describes the drone as having flower like propellers, which would be nice looking since the intention for the drone is to water flowers. The person also thought that it would be 'creepy' if the drone has a face, which would look too much like a human.

(g)



(h)

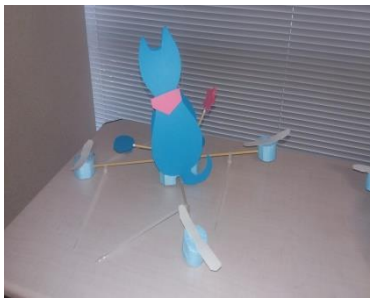
(i)

(**Figure 7.1**: The different designs from the Swedish workshops)

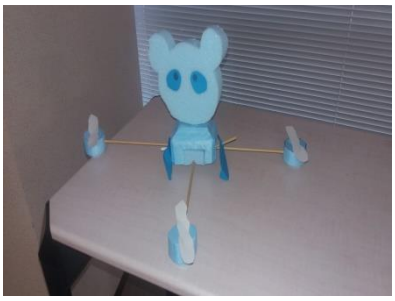
Japan

33.3% of the participants in the workshop said that they would like the drone to be cute and 55.6% said that they would like to have a face on the drone. 60% of the participants that would like to have a face said that they would feel closer to it or they would feel an affinity with the drone. Another participant said that it would look cute with a face. Of the 44.4% that thought the drone should not have a face, 50% said that it does not need it, one participant said that it is should look machine-like and one did not want it to have a face because it is a device.

Of the nine participants from the workshop there were a lot of different ideas about the drone companion's appearance. One participant loved cats and designed a drone that was supposed to be a leader of his or hers cats. It had hanging accessories that were supposed to play with cats. The drone should feel like it is something to rely on. Another participant designed a drone that supposed to look like flowers because he or she thought it looked nice. One participant wanted a cute panda with a sphere head and arms that could be extended. Another one created a drone that had a box body with a face in the front, an antenna and arms and hands in order to do many things.



(a)



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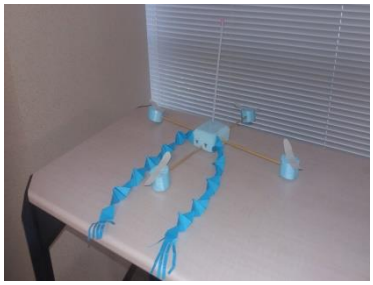

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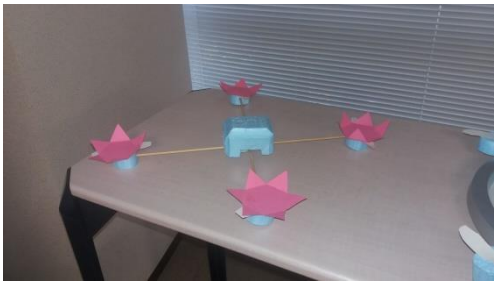
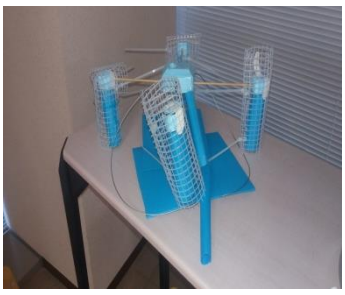


(d)

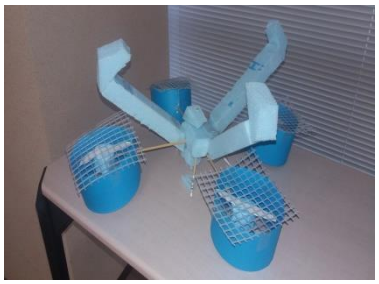
A participant wanted the drone to be in silver in order to make it look like a machine. There were supposed to be a microphone, speakers and in the middle of the drone should be a computer that shows a holographic character that speaks to you. This participant had a character called *Hatsune Miku* in mind which is a digitalised manga figure. Another participant wanted the drone to look like a machine with one arm and a hanging display with a speaker. The propellers need to be covered so they are safe and in the middle of the drone's body there should be a hole where it could vacuum up bugs.

(e)



(f)

One participant also thought that the propellers should be covered and the drone should have a big hand to grab things and it should have a camera. Another participant wanted the drone to have a container and pick things up. The design shows a round shovel, the drone's propellers should be covered and it should be safe to fly in a room. The last participant said that the drone should look strong, have a camera and show a face that can also display other things such as a map or similar. It should also have two hands on top of the drone that should be able to rotate 360 degrees and four legs.



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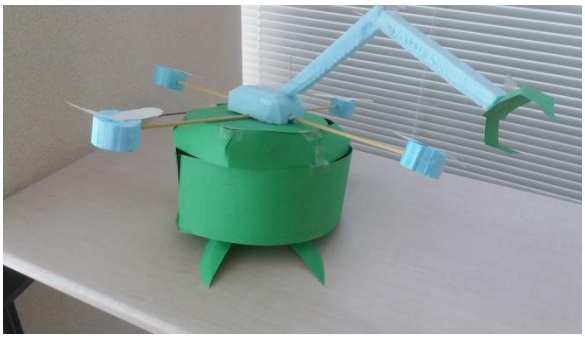
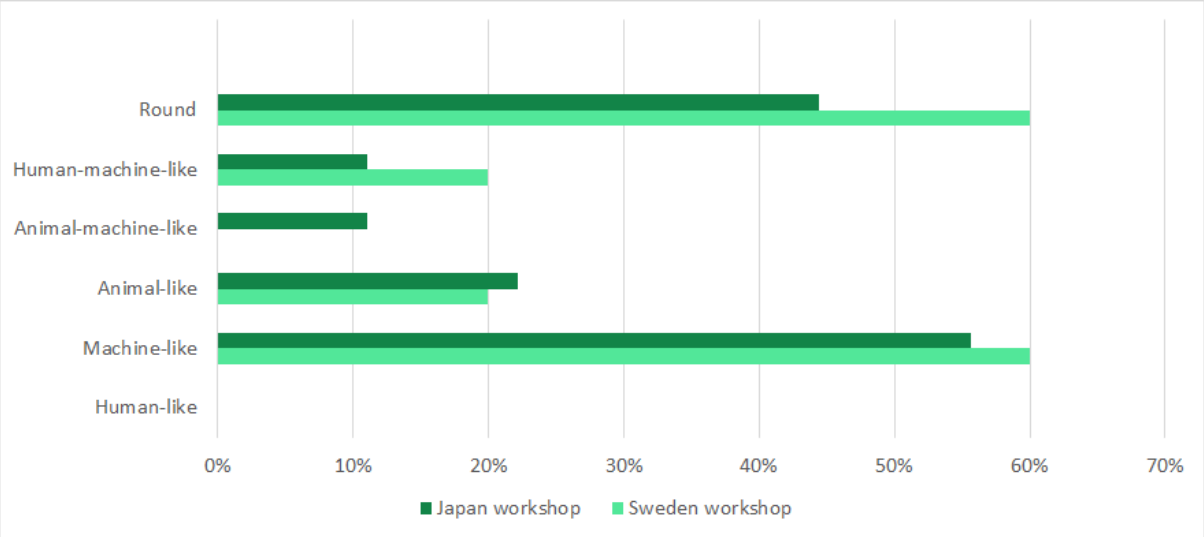


(i)

(**Figure 7.2:** The different designs from the Japanese workshop)

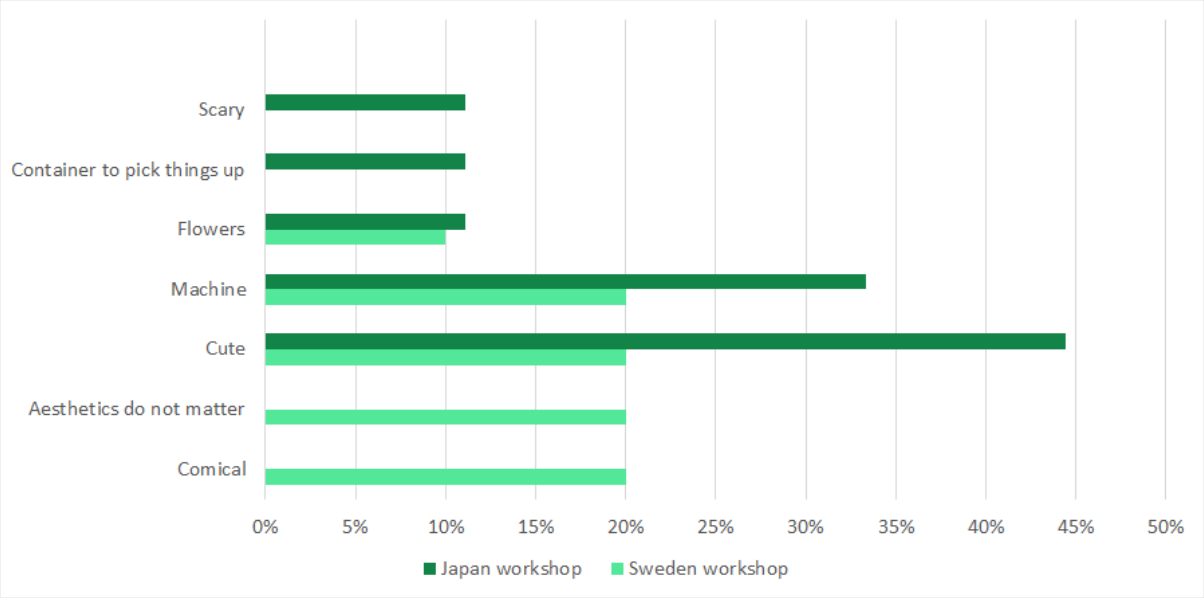
Cross-cultural comparison of the appearance of the drones

The workshops resulted in various different opinions about how the drone companions should be designed regarding the appearance and what features should be incorporated. Below is presented the differences between Swedish and Japanese workshop participants in different categories related to appearance (See tables 7.10, 7.11, 7.12 and 7.13X).



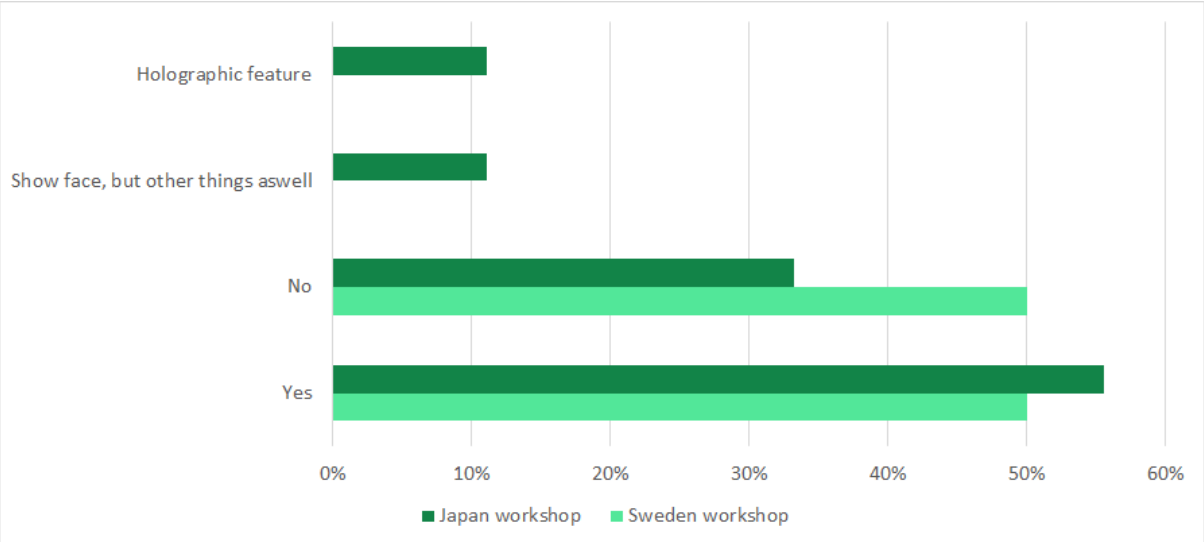
(**Table 7.10:** Preferred body shape in Sweden and Japan)

As presented above in table 7.10, there are similarities between Swedish and Japanese participants regarding which body shape a drone companion should have. In Sweden however there were two categories that stood out, with 60% each, the participants wanted to have a round and a machine-like drone. Among the Japanese participants there were no majority that wanted a round shape, however a more machine-like appearance was preferred by 55.6% of the participants. The overall trend is quite similar. The option 'Human-machine like' is defined as a drone companion that has both human and machine-like features, for example this could be arms, head, eyes, face and features that can be seen as machine-like such as metallic outer appearance, mechanical features, blinking lights etc. In the option 'Animal-machine like', it is the same as described above regarding partly 'machine-like', however instead of partly 'human-like' features, the drone companion could incorporate 'animal-like' features such as fur, animal-like face, paws etc.



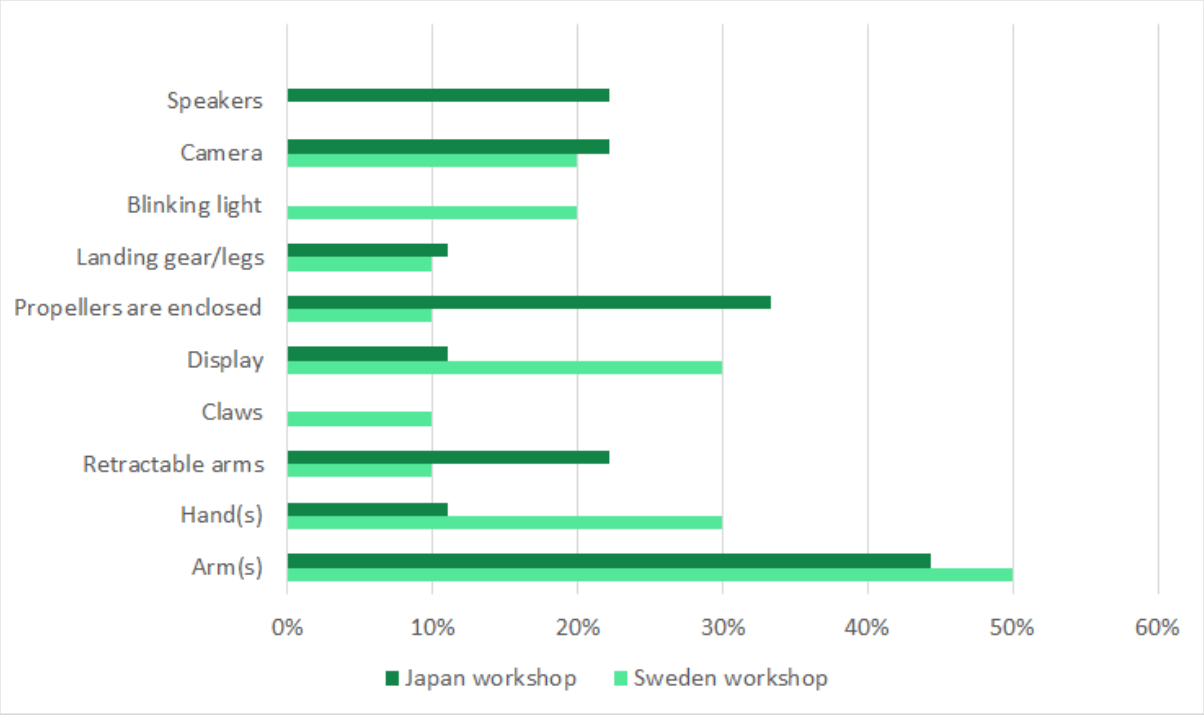
(**Table 7.11:** Preferences in the category 'Looks like' in Sweden and Japan)

In table 7.11 above there are larger differences between Swedish and Japanese participants in the opinions about the drone companions appearance, such as that the Japanese participants wanted a 'cute' (44.4%) and a machine-like drone. Whereas Swedish participants were more divided with a percentage of only 20% each in the different categories.



(**Table 7.12:** Preferences in the category 'facial features' in Sweden and Japan)

As the table 7.12 shows above, Swedish participants were divided in the matter of having facial features on a drone companion with 50% of each 'yes' and 'no'. The Japanese participants wanted facial features in a drone companion with 55.6%, however there were some other features that were added to the wish list as well, such as 'holographic features'.



(**Table 7.13:** Preferred 'Characteristics' in Sweden and Japan)

Table 7.13 shows the different characteristics that were wanted by the participants in Sweden and Japan. The participants seemed to like many different options, with arms being the most popular feature for both Swedish (50%) and Japanese participants (44.4%). For the Japanese participants the feature 'enclosed propellers' was the second most wanted option with 33.3%. Whereas 30% of the Swedish participants wanted both 'hands' and 'display' on their drone companion.

7.2.2 Interaction Mode

Below are the thoughts and ideas of what kind of interaction modes a drone companion can have will be presented and divided into Swedish and Japanese result.

Sweden

In both of the workshops the interaction mode was described in four categories, voice controlled, smartphone controlled, autonomous and gesture controlled. 60% wanted the drone to be voice controlled, 30% wanted it to be controlled with a smartphone, 20% wanted it to be autonomous and 20% also wanted the drone to be able to listen to gestures.

One participant suggested that the drone should be controlled by gestures, and it would be fun to teach it to do "fist bumping". The participant also mentioned the gesture of pointing, since it is a natural way to interact with humans. The drone should be able to follow the user's gaze, which is why the drone has eyes. The use of the drones built in hands would work as If asked for directions, it could look and point in a direction. The drone would also be voice controlled and have the ability to talk. The participant also thought that the drone should show feelings, which is an interlaced feature

with the eyes. Although the drone has all these mentioned traits, the participant does not want to have a friendship with it.

There were also other opinions about how to interact with the drone companion, one participant simply wanted the interaction to be made through the use of a phone.

A participant suggested a more technological approach towards interaction, the drone should be able to show how many mosquitoes the drone has killed on a display and that It should be autonomous. Another participant mentioned that the drone should be programmable, and the user should be able to talk to the drone since it could be as a cute robot. A more technical oriented participant thought that the interaction with the drone should be with hand gestures in order to be able to raise and lower volume of the sound emitted from the speaker which is situated in the middle of the suggested drone design.

A participant mentions a couple of ways to interact with the drone, either by voice or an application on a device. The person also wanted the drone to react to some kind of touch.

Another participant wanted also the drone to be voice controlled, or maybe even have a start button. The last participant of the first workshop would like the drone to use its hands for games and it is also voice controlled. This participant did not either want the drone to show emotions since the participant did not think it is necessary.

The “BEER” drone companion is voice commanded and it also answers with voice, according to the participant who constructed this specific drone.

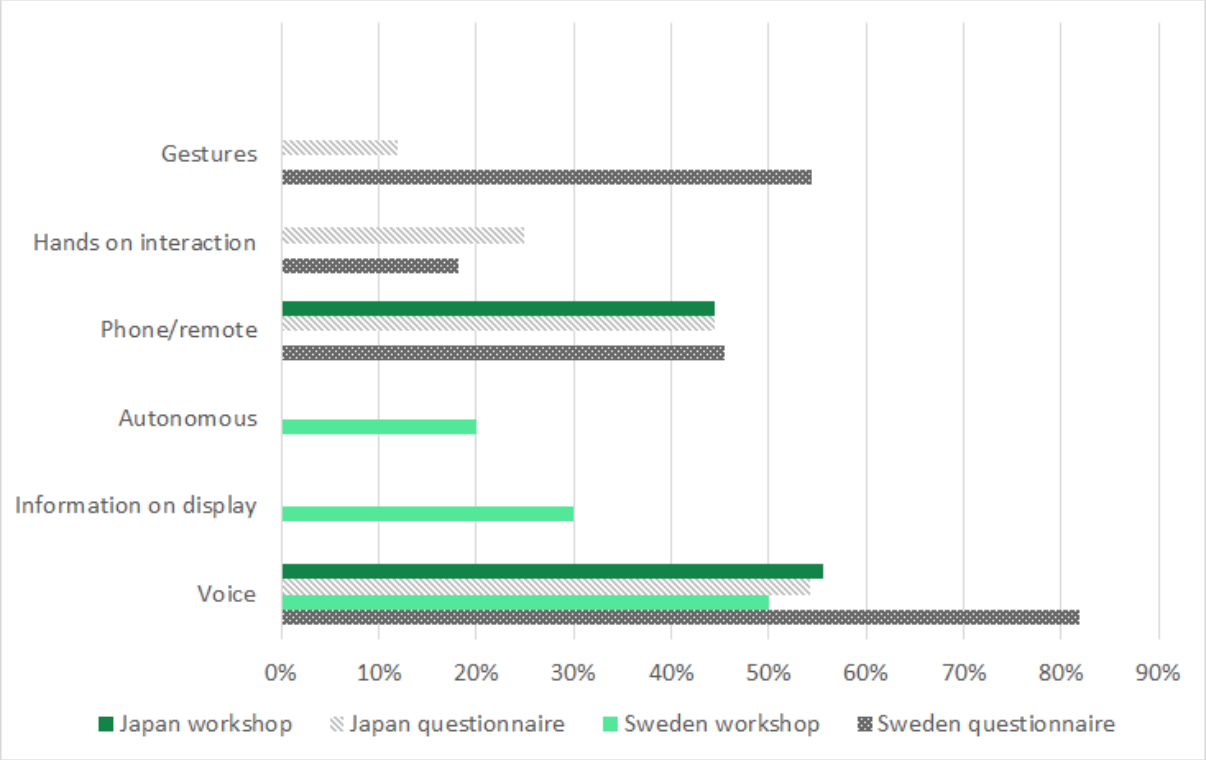
A flower watering drone should be autonomous and flies around and feels when flowers need water. It should have a programmed route thus it does not need that much interaction with the users according to a participant.

Japan
How to interact with the drones was relatively unanimous and 77.8% said that they wanted to control it by voice. 44.4% said that they also said that they would like to control the drone by a remote control or a smartphone.

One participant said that he or she wanted the drone to be voice controlled and when the drone is away, it should be controlled by a smartphone. Another participant wanted to interact via a smartphone in order to see the house and do different tasks when he or she is not home. One participant said that he or she wanted the drone to be able to communicate without speaking and be controlled by the user’s mind.

Cross-cultural comparison

The table (7.14) below shows data from both the workshops done in Japan and Sweden, as well as some data from the requirement elicitation questionnaires done by Swedish and Japanese participants.



(Table 7.14: Preferred 'interaction mode' in Sweden and Japan**)**

The table above (7.14) shows that there are some similarities between the Swedish and Japanese results from both the requirement elicitation questionnaires and workshops. The feature that stands out is the Swedish questionnaire answer that indicates a preference of voice control with 81.8% of the participants wanting the feature. Even among the Japanese workshop participants' voice control was popular with 55.6%. Gesture control was also popular with the Swedish questionnaire participants with 54.5%. To control the drone with the help of a phone/remote was quite popular also with Japanese participants from both the workshop and questionnaire (44.4%) and Swedish questionnaire participants (45.5%).

7.2.3 Social Roles

Below are the thoughts and ideas of what kind of social roles a drone companion can have will be presented and divided into Swedish and Japanese result.

Sweden

60% of the participants would like the drone to be an assistant, while 30% also saw it as a helper in the home and 20% sees the drone as some sort of butler. A drone as a pet is what 10% suggested that a drone companion could be. Another 10% thought the drone can be a companion and a friend and 10% could see the drone as a caretaker.

A participant wanted the drone to be like "Alfred to Batman", thus more a servant than a companion. There were also a participant that saw the drone more like a safeguard, a protector, helper and an assistant it could help with things that could irritate the user.

Japan
Which social role the participant in the workshop thought the drone companion should have could be categorized in three roles; servant, assistant and security or surveillance. 44.4% saw the drone companion as a servant, 33.3% as an assistant and 22% security or surveillance. In addition to this there were participants that also saw the drone companion as a pet leader, secretary, something that support the user in the daily life or just a convenient device.

7.2.4 Desired Tasks

Below are the thoughts and ideas of what tasks a drone companion can perform will be presented and divided into Swedish and Japanese result.

Sweden
50% of the participants in the workshops mentioned that the drone should help out with things around the house and 40% of these persons wanted help especially with pets. 50% of the participants wanted the drone to bring them items and 10% would like the drone that follow the user around.

The ability to bring items was mentioned by a participant, and the drone should have the ability to agree with the user, or disagree when the user is seriously wrong on some topic. The participant would also like the possibility to make the drone follow the user around if desired. Another participant would like the drone to kill mosquitoes and be quiet when doing so. The participant also mentioned other areas of interest, such as the drone being a household assistant which could clean dirty laundry and lastly be able to bring drinks. The drone could also help finding things, and light up where it finds items.

One of the participants had a care oriented view of the drone companion, so the person wanted the drone to be able to heat up a freezing person, for example with infra heat. It could also have arms so that the drone would be able to bring items to persons that has bad joints and cannot get out of bed. Also mentioned was that it would be able to switch on lights and other electrical equipment.

One participant also mentioned that it would be desirable if the drone could clean and check the refrigerator and write a shopping list of items that needs to be replenished, it should also be able to talk with the user. Another participant wished for the drone to follow around and play music, this so that neighbours do not get irritated over loud music since the music is only directed at the user, the drone should be able to do some other functions as long as it does not get too complex, otherwise not elaborated further by the participant.

A drone that people play with, by throwing balls, teasing it and play ‘hide and seek’ with it, is suggested by a participant. The person also sees the drone being able to do everyday chores, bring items having the drone as a companion. It could even hold things for the user, like paintings or similar. The drone should also be able to perform surveillance and bring the mail.

The drone could be an interior design assistant one participant thought, and it should incorporate a sensor, as a big eye that measures space in the home to calculate where it is practical to put furniture, and to furnish in an efficient way. The information would be shown on a screen or emitted through speakers.

The tasks that a drone could do, which were wanted by a participant included, bring beer, bring additional items, ability to give ‘high fives’ and maybe even give massages. It could also potentially clean since it got hands.

A participant suggested that the drone should be able to play with the user's pets, and also feed them and empty the litter box or similar activities regarding pets. The user should be able to talk with the drone and set some preferences.

Another participant mentioned that the drone should help with different things, as for example, water the flowers, lift heavy furniture and maybe feed the cat.

Japan
The desired tasks that the participants from the workshop would like the drone to do were very divided, but there were tasks that several participants thought of. 44.4% said explicit that the drone should bring things, 44.4% said that the drone should clean for example high places, 22.2% wanted the drone to turn the lights on and off and 22.2% wanted the drone to wake them up when needed.

One participant saw the drone companion as a one task assistant that should look after cats. It plays with the cats and report to the owner if something happens and when a cat is sick, it sends an alarming message or video. Another participant wanted the drone to do all kinds of housework but especially cleaning, washing and cooking. The participant also wanted the drone to send him or her off to work and welcome back home. The drone should also protect the participant and be able to attack.

One participant wanted the do tasks such as go and buy things, look after children, see the children off and clean ceilings and other high places. The drone should have extending arms in order to hand out tea, bring things and serve food. In addition to this the drone should have built in showers that the drone can use to water the flowers in the garden.

Another participant wanted the drone to bring things, clean high places, get rid of garbage and keep things tidy. He or she also wanted the drone to collect clothes when it's raining, organise mail and documents, open/close windows, turn on/off lights and tell the person when something is needed e.g. turn on a fan when it is hot.

One participant wanted the drone companion to tell today's schedule, remind of upcoming events, wake the participant up when he or she is sleeping and automatically charge the battery when it is low. Another participant wanted the drone to carry things by using the arms and put the object on its body. The drone should also be able to fly to the user and with its hanging display show movies or an ordinary computer display. In addition to this it could also be an alarm clock or guide the way to different places.

A participant thought that the drone should bring and move things, lock the door, turn on the lights and see if the door is locked or not and lights are on or off. The drone should also report if someone invades the house. Another participant thought that the drone should pick up things, clean high places and play with the user. In addition to this the user could decorate the drone as a hobby. Lastly, one participant thought that the drone should bring things from high places and clan light bulbs.

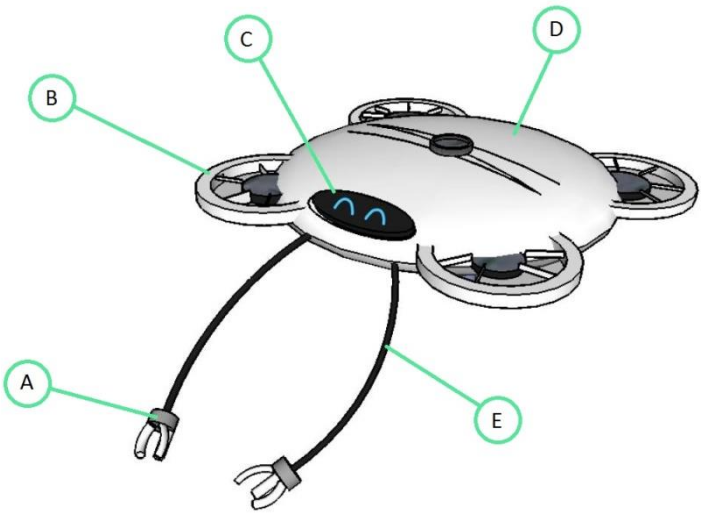
7.2.5 Interpretation of drone designs

Based on the results from the questionnaires and workshops four different drone designs emerged. Two which represent the Swedish result and two which represent the Japanese result. Some of the common attributes that is present in all of the four designs are that the drones have the same outer dimensions and that they have a quadcopter basic layout with four propellers in an 'x-formation'.

There are two different designs of each country's main designs, one drone with anthropomorphistic features and one drone without this is due to the design of the user study where the purpose was to test a hypothesis, as further explained in chapter 6.5.1.

Sweden
The Swedish result shows that there are some preferences that forms how the Swedish design of the drone companion should look. The interpretation has been done with themes described by Obaid et. al. (2015) in mind.

The Swedish drone design is based on findings mainly from the workshop results but also partially from the questionnaire results.



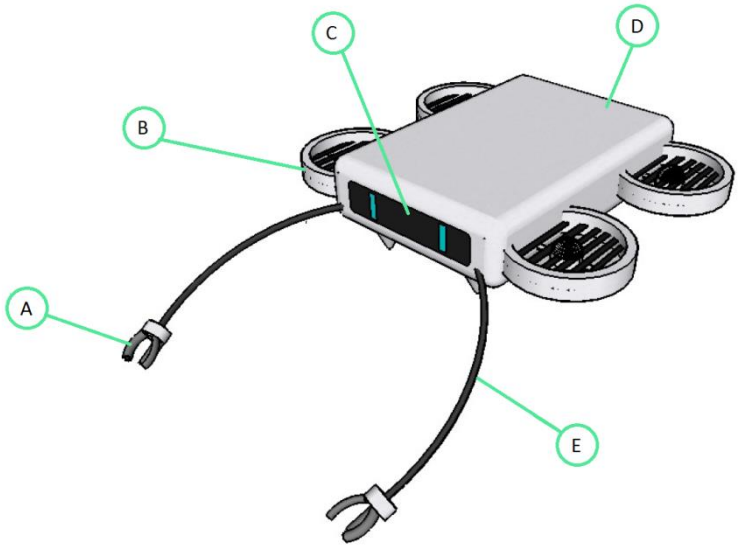
(**Figure 7.3:** Swedish Drone A, with annotations)

As depicted in figure 7.3, “drone A” has some prominent features as described: The drone has hands (A) which are features that are derived partly from the workshop results that showed that 50% of the participants wanted the drone to have arms, and explicitly 30% that wanted hands, it can be argued also that in order to make the drone to be able to bring items to users, which 83.3% of questionnaire participants wanted, it will need to have apparatus supporting the task. The feature marked (B) in figure 7.3, is that the propellers of the drone are covered in a protective casing to prevent damage to the drone or injury to users. This feature is derived partly from participants visioning it in the workshop (10%), and partly that some participants has commented in the requirement elicitation questionnaire that there is a risk of injury, also it can be argued that it is a general safety feature which is used on quadcopter designs in the market today. Feature (C) on the drone is a display which shows representations of eyes, this is to convey to the user that it has anthropomorphistic features, 50% of the workshop participants wanted explicitly facial features on a drone. The feature marked (D) on the figure is the drone’s body, this is a formed as a round shape which is based on the requirements elicited by 60% of the workshop participants, 60% also wanted that the drone should be machine-like which is articulated through the general design of the drone. Feature (E) is the drone’s arms, these are featured since 50% of the workshop participants explicitly wanted the drone to have arms. There are also some features on the drone that are not shown above, such as that the drone is voice controlled, which 81.8% of the questionnaire participants and 50% of the workshop participants wanted.

Japan

Likewise as with the Swedish results, there are some preferences that forms how the japanese design of the drone companion should look. As with the Swedish drone design, the interpretation has been done with themes described by Obaid et. al. (2015) in mind.

The Japanese drone design is based on findings mainly from the workshop results but also partially from the questionnaire results.



(**Figure 7.4:** Japanese Drone A, with annotations)

There are prominent features on the Japanese "drone A", which are pictured in Figure 7.4 above, these are: (A) Hands, they are derived from the data from the Japanese workshop in which 11.1% of the participants explicitly wanted hands on the drone, and the argument since also 83.3% of the questionnaire participants wanted the drone to be able to bring items to the user, the function needs to be facilitated in a good way, thus hands are represented on the design. The feature marked (B) in the figure 7.4, are propellers that are covered in protective casings, and likewise with the Swedish drone design this feature is derived partly from the Japanese workshop where 33.3% of the participants wanted it, and there can be an argument that it also acts as a general safety feature. Feature (C) is a display which shows some anthropomorphistic features like eyes, 55.6% of the participants of the Japanese workshop wanted facial features on a drone design. The body of the drone is marked as feature (D) in Figure 7.4 above, 55.6% of the participants of the workshop wanted the drone to be machine-like. The interpretation of the body shape was also further supported by Woods (2006) article "*Exploring the design space of robots: Children's perspectives*". The feature marked (E) is the drone's arms, 44.4% of the workshop participants explicitly wanted to have arms on the drone companion. Another feature that participants wanted to have on the drone is the ability to be voice controlled, 54.2% of the questionnaire and 55.6% of the workshop participants wanted the feature.

7.3 User Study

The data was extracted from the three questionnaires the participants answered and compiled in subcategories which were most prominent in the user study.

7.3.1 Drone companion in the home

Sweden
Having computer technology as a part of the home environment was something the participants of the user study rather liked and strongly liked. 43.8% said that they strongly liked the idea of having computer technology in the home, 43.8% rather liked the idea and 12.5% was moderate interested in having computer technology in the home. The idea of having a drone companion in the home was less popular than having computer technology at home, but was still quite popular. 62.5% said that they rather liked the idea of having a drone companion in the home, while 31.3% said that they were moderately interested and one participant said that he or she liked the idea a little.

After interacting with the different drone companions the participants saw the drone companion as a assistant, device or a toy. The most prominent tasks that the participants would like the drone companion to do are bring things (87.5%), clean (81.3%), help in the daily life (81.3%) and daily updates (62.5%).

Japan
Computer technology in the home was something that most participants strongly like, or rather liked. 43.8% strongly liked having computer technology at home, while 43.8% rather liked it. Only 12.5% was moderately interested.

When the participants had interacted with the different drone companions the majority (87.5%) saw the drone as an assistant, while 50% saw the drone as a device or a computer. 12.5% saw it as a toy and 12.5% thought the drone could be a pet, additionally 12.5% saw the drone as a butler. Only one participant saw the drone companion as a friend. When asked about which tasks the participants would like the drone companion to do, the top answers were, 81.3% answered that the drone should bring stuff to them, 62.5% wanted the drone to be able to clean after them, 62.5% would also want the drone to give them daily updates and 68.8% wanted it to help them in their daily life.

7.3.2 Animal-like features in a drone companion

Sweden
The idea of how animal-like the drone companion should look was widely divided among the participants. 37.5% thought that it should not look animal-like at all, while 12.5% thought it should look very animal-like. 12.5% thought that the drone should be rather animal like, 25% moderate animal-like and 12.5% a little human-like. Of the participants that would not like the drone companion to look animal-like at all said that animals have emotions which he or she did not see in the drone, there was no particular reason for it or it depended on what it was for but if it would do things for the user, it should not be animal-like. Another participant said that he or she wanted a clear distinction between animals and technology.

" It's not an animal, must be a clear distinction between animals and technology."

One participant thought that he or she wanted to be aware of that it is a robot you talk to and not starting to convince yourself it is not. Another participant thought it would be weird if a drone, which he or she sees as a tool, should have animal-like appearance because it is not seen as a tool in that way.

For the 12.5% that thought that the drone companion should have a very animal-like appearance liked the idea of having the drone more alive than as a robot or they thought that you would be more attached to it if the drone was more as a pet. The 12.5% that would like to have a rather animal-like

appearance say that people are simply used to pets or there should be options and if there are people that want a pet it should look like a pet and otherwise it should be more neutral.

"*I think there should be a lot of different to suit everyone's different needs. If you want an animal, it should look like an animal and otherwise a little more neutral.*"

The 18.6% that thought the drone should look moderate animal-like said that it depends on the person, in case if the drone should be a more emotional being or that an animal-like drone should more suit children than adults.

"*It's hard to predict what appearance would create the right feeling. More animal-like for children, maybe more robotic for adults.*"

Of the 12.5% of the participants that thought the drone should look a little animal-like, one said that it do not matter if it looks like a robot or a pet, but preferable like a robot. Another one said that the drone should look like they do in sci-fi movies.

Also, the idea of how animal-like the drone companion should behave was divided. 12.5% said that the drone should behave very animal-like. One participant said that if it is not a tool, it could be very cute to have. Another participant said that he or she rather see an animal behaviour than a human behaviour because the participant does not want to lose the human contact.

"*I would rather have an animal behaviour than a human behaviour on a drone just because you should not lose the human contact more than we have already done in our digitized world.*"

12.5% thought that the drone should behave rather animal-like. One participant said that people like pets because they do cute things and another participant said that he or she personally wanted to have an animal-like drone instead of a human-like. 25% of the participants said that they would like the drone to behave moderate animal-like. One participant thought it should obey but still move like an animal, another one thought it should be more decent regarding the design and one thought it depends on which tasks it should do.

"*Depending on which tasks it should do for me/which tasks I would prioritize the most...Being animal-like wouldn't be helpful in order to for example clean after me but it could perhaps bring me stuffs anyway..*"

25% of the participants that thought the drone should behave a little like an animal. 12.5% though it depends on the user and one of them said that it is good to tone down the animal behaviour because it can be seen as unknown and create misunderstandings and another one said it also could depend on the needs. One participant said that the drone would be a little like a pet when you ask it to get something, but it still differ from what an animal can do. Another participant said that he or she would think of the drone as a pet, but would not want it to behave as one.

"*I would think of it as a bit of a pet, but I wouldn't want it to behave as one - to come and go as it pleases, follow me around everywhere, try to cuddle, or slobber at me. It's still a robot.*"

25% of the participants thought that the drone should not behave animal-like at all. One said that the drone is not an animal, another said there is no need for it and one does not see animals as servants. Another one said that he or she does not want an animal-like behaviour because the drone should primarily be spoken with as a human or perform services as a robot which it actually is.

Japan

If a drone should look animal-like was quite divided among the participants. Only two participants would like the drone companion to look very much like an animal. While 37.5% would like the drone to look rather animal-like, only two participants would like the drone to look moderately animal-like. Some participants (31.3%) wanted the drone to be little animal-like, but only one did not want the drone to look animal-like at all. The participant who did not want any animal-like features at all commented that he or she thinks that the functions of the drone should be prioritized.

"We should prioritize the functions of the drone"

The participants that thought the drone should be little animal-like commented that drones should look like drones, and that it might be scary at night or that the drone should be differentiable from pets. Of those 12.5% who liked the drone to be as animal-like as possible, the comments were that if drones look like animals, they would be cute and look friendly, and that machine-like drones could be boring. Another comment was that the participant saw the drone as a living thing but not as a human.

About animal like behaviour, only one participant wanted the drone to have very strong animal-like behaviour and commented that if drones move like animals, then it would be easier to play with them as pets:

"If drones move like animals, we can play with them as pets"

31.3% of the participants rather liked the idea of having a drone to behave like an animal, they thought that it would be cute, or the drone would be like a pet if it looked like an animal. Another comment was about that it would be nice if the drone looked like a small bird.

25% moderately wanted a drone to behave as an animal, and one of the participants thought that animal like behaviours could make the drone look friendlier. Another participant commented that he or she could feel attached to the drone if it had animal like behaviour. One participant thought that communication with the drone was important, however he or she did not want the drone to look too much like an animal:

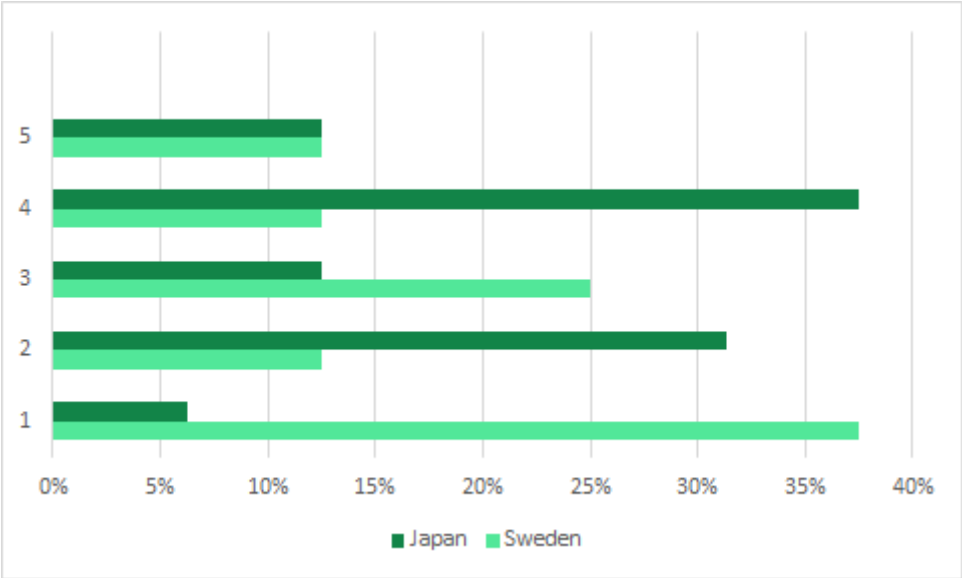
"Drones should communicate smoothly, but they should look different from pets"

Another 31.3% of the participants wanted the drone to have little animal-like behaviour. Of these participants comments could be that drones do not have to look like pets when they are not treated like pets, and another comment indicated that the participant did not care how the drone behaved as long as it did tasks for him or her. Another participant thought that he or she did not expect any other behaviours than the ones only drones could do. One participant was concerned about if the drone would have animal-like behaviour:

"I can't predict precisely the movements of animals. If drone moves like an animal, I would be scared about how it moves"

Another participant thought that the drones are not either humans or animals, only machines that are controlled by humans. Only one participant did like the notion of having animal-like behaviour at all, he or she just commented that it is not necessary.

Cross-cultural comparison



(Table 7.15: Swedish and Japanese opinions of a drone with animal-like features)

Table 7.15 above shows opinions on a five point Likert scale regarding to which extent a drone companion should be animal-like. The scale is weighted as (1) being the lowest score, and (5) being the highest. Looking at the data there are some clear differences between the Swedish and Japanese answers. In Sweden 37.5% did not like the idea of having animal-like features, however the Japanese participants rather liked the idea of animal-like features with 37.5% scoring (4) on the Likert scale.

7.3.3 Machine-like features in a drone companion

Sweden

The participants of the user study had divided opinions whether the drone companion should look machine-like or not and there are no distinct answer that stands out. 12.5% would like the drone to look very machine-like where one said that it would be really cool. 31.3% would like the drone to look rather machine-like. 60% of these participants thought that because it is a drone it should look like a drone and 40% also thought that some kind of expressions from animals/humans or eyes so it looks like it is looking at the user.

"*Because it's a machine, I think you should see it too.*
But that it has eyes so it looks like it sees me, that is after all nice."

One participant said that according to him or her, the design aspects is nicer such as ASIMO or similar. 12.5% thought that the drone should look moderate machine-like. One person said that you should still see that it is a machine and not something that lives, and another participant said that it depends on age, but simplicity has always its benefits. 18.8% said that the drone should look a little machine-like where one person said that more people could interact with it then, another said that it should not look too much like a machine, but a little is ok. Another participant said that the drone should look a little robot-like but not too much so that it feels like something that is alive. 12.5% said that the drone should not look machine-like at all. One participant said that there is no need for it and the machine's look should help in the interaction.

The participants were more in favour of moderate and less machine-like behaviour. 31.3% said that the drone should have a moderate machine-like behaviour. 40% of those participants thought that a

combination between human and machine-like behaviour is the best, another participant thought that it should behave predictably and reliably like a machine and another one would not like the drone to have too much machine-like behaviour so that the interaction becomes uncomfortable or unnatural.

"*Not too much because the interaction becomes uncomfortable, or unnatural of any kind. However, I think it must be machine-like so that the user can still determine whether it is a technology tool or not*"

31.3% thought that the drone should behave a little machine-like. 40% of these participants said that if the drone is too machine like it can get boring.

"*If it's too machine like then it can get boring*"

"*We're already embracing so many dull machines, so more life for the devices!*"

Another said that the drone would appear cold and maybe unfriendly if it is to machine-like and another one said that then all people could interact with it. Also, one participant said that the more machine-like the drone is, the less realistic the experience get. 12.5% did not want the drone to behave machine-like at all. One participant thought that there was no need for it and another one preferred more animal-like or human-like behaviour. 18.8% thought that the drone should behave rather machine-like. One participant thinks it is a machine and therefore would be more comfortable if the drone act like a machine and another one said that it depends on the tasks and user. One participant thought that the drone should behave really machine-like and said that if it is a tool which clean and cooks for the user, he or she would like the drone not to be traditionally machine-like but something neither animal-, human- or stereotypically machine-like.

"*If it is a tool that cleans and cooks for me. Would love that, but I don't want to feel like a slave-keeper ;) But maybe not machine-like traditionally but something new that is neither animal, human or stereotypically machine. Or like the ones in star wars!*"

Japan

The answers from the user study shows that the participants were quite divided about if the drone should be machine-like or not. Only one participant wanted the drone to be very machine-like. However 37.5% wanted the drone to be rather machine-like, of these 33.4% thinks that a machine-like appearance would make it easier to command the drone since it is only a machine. One participant thought that the drone should blend in with the home environment and another one commented that the drone would become useless if they lose the function of being a device.

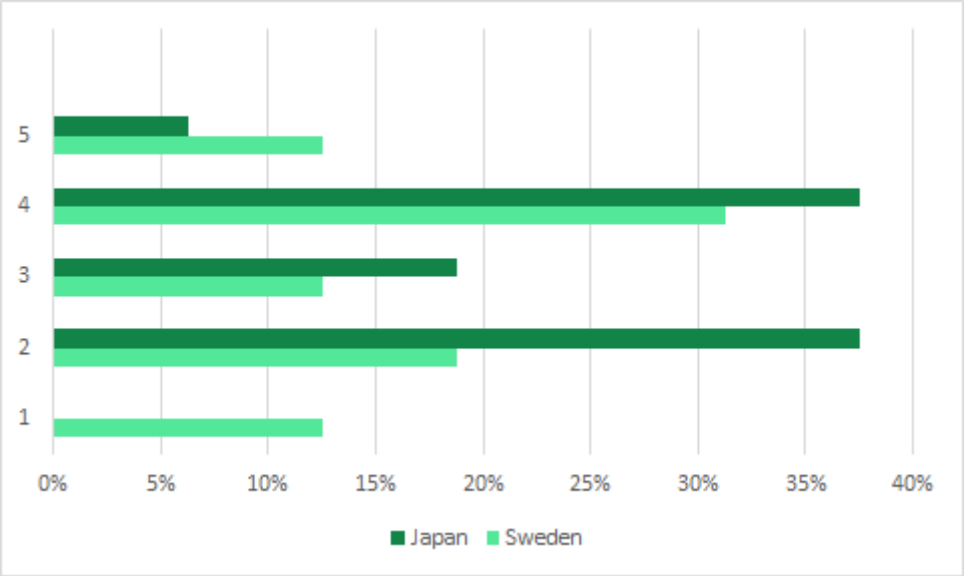
18.8% wanted the drone to be moderately machine-like, and 66.7% of these participants commented that drones are machines and it would be strange to have too many animal-like features on a drone. One participant thought that drones should do tasks like any other machine.

"I think that drones should also do tasks like other machines"

Also many participants (37.5%) thought that drones should be a little machine-like, and 66.7% of these comments indicated that it might be hard to feel attached to the drones if they look too much like machines. Also some participants thought that it would be weird to have machines moving automatically in the daily life, and it would be scary if a lifeless thing talks. Only 6.3% thought that the drone should behave very much like a machine. 25% wanted the drone to behave rather like a machine and 18.8% moderately wanted the drone to behave machine-like. However, 37.5% thought

that the drone should behave little machine-like, and only one participant indicated that he or she did not want the drone to behave machine-like at all.

Cross-cultural comparison



(**Table 7.16:** Swedish and Japanese opinions of a drone with machine-like features)

In table 7.16 above the preferences of having machine-like features on a drone is shown, the opinions are represented in a five point Likert scale, where (1) is the lowest score and (5) is the highest. With 31.3% Swedish participants wanted the drone to be rather machine-like, and the Japanese participants also with 37.5%. However, it was divided in Japan, where also 37.5% gave a low score of (2) on the Likert scale.

7.3.4 Human-like behaviours in a drone companion

Sweden

Even though a lot of people do not want human-like features, they seem to want the drone to behave human-like. 12.5% would like the drone companion to behave very human-like, 31.3% want the drone to be rather human-like and 31.3% wanted it to be moderate human-like.

A few comments from the participants are somewhat negative:

"There is no need for it"

"It's not a human, but it could have some human like elements (...)"

Some participants thought that the drone should behave like a human but still have differences compared to a human, and another comment that it should behave as a human and you should be able to communicate with it in a human like manner. Other comments was that a robot should be just a robot, and some thoughts about that the drone should not have own free will and it should only obey orders. A comment indicated that the drone would "*creep out*" the participant if it was too human like, although he or she differentiated between intended use where a tool does not need to have human like features but a companion might have some human like features.

Many participants were ambivalent about the drone's behaviour, they thought that it could have some elements of human behaviour but not too much. A positive comment was:

"Easier to communicate and I believe it would perform human like tasks in a better way if it would behave more human like!"

Japan

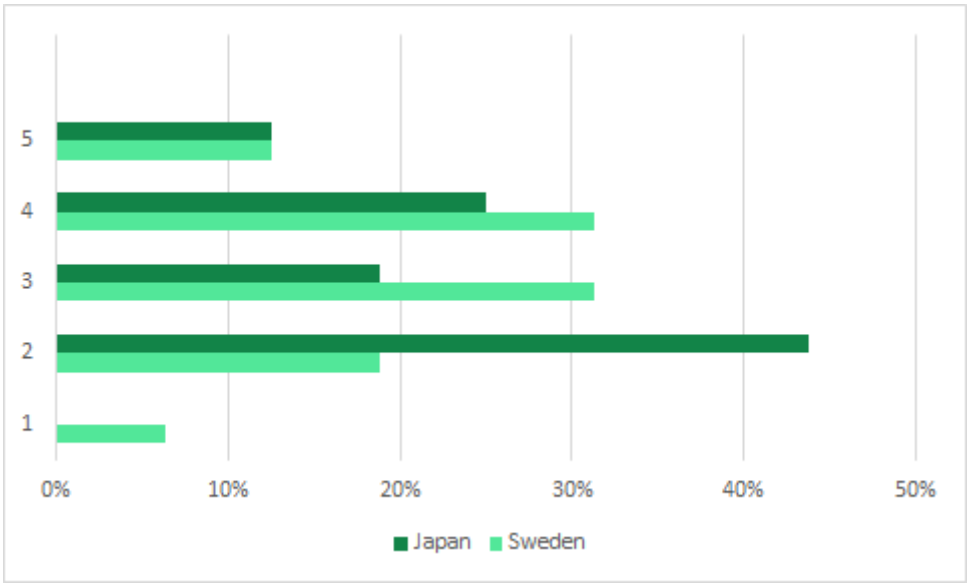
Of the participants, 12.5% thought that the drone should behave very much like a human as they thought that it would be easier to communicate with the drone and it would be easier to ask for help if so. 25% of the participants wanted the drone to behave rather much like a human. Some of the comments from the participants indicated that, the drone would look friendlier if it behaved like a human and also one commented that it would be more convenient for the participant. One participant mentioned that if the drone behaved as a human, the instructions given by speech would not be so awkward. Another comment was that it would feel better if drones move smoothly like humans because it would be safe, but the participant would not want the drone to come too close to them.

18.8% liked the drone to behave moderately as a human, and one of the participants thought that the drone should behave more like an animal rather than human-like. Whilst one participant commented that the drone should communicate smoothly but still it should be differentiated from humans. Another wanted the drone to behave as they do, but they should talk like humans.

A total of 43.8% of the participants wanted the drone to behave a little human-like. Of these 33.3% thought it might be scary or weird if the drone looks or behaves human-like. Other comments were that drones might even steal people's jobs if they become too human-like, or that participants may not care even how the drone behaves as long as they do the tasks they were instructed to do.

"If drones do tasks for me I don't care about how they behave"

Cross-cultural comparison



(**Table 7.17:** Swedish and Japanese opinions of a drone with human-like behaviour)

As table 7.17 above shows, there is some differences between Swedish and Japanese preferences in if there is a need for human-like behaviour in a drone companion. Swedish participants were quite divided and 31.3% rather liked, or moderately liked the idea of human-like behaviour, whereas Japanese participants showed more distinctly that they liked the idea a little of having human-like

behaviour in a drone with 43.8%. Only 6.3% of the Swedish participants did not want any human-like behaviour.

7.3.5 Anthropomorphism in drone companions

This section analyses the results regarding both the anthropomorphistic and non-anthropomorphistic drones that have been used in the user study.

Drone companions with anthropomorphistic features

The section below describes the opinions collected from the user study of the drone with anthropomorphistic features, these are divided in respectively Swedish and Japanese answers. Note that the drone with anthropomorphistic features also can be referred to as 'drone A'.

Sweden

The first impression of the drone was very positive for the majority of the participants. 12.5% of the participants thought the drone was cute, 12.5% thought it was good looking and 12.5% thought looked cool. Other participants thought that it was friendly, awesome, gave a wow feeling or they got a happy feeling interacting with it.

12.5% of the participants thought that the drone looked how you would expect a drone to look, while one thought that it was as a regular drone but with arms. Another participant thought it looked generic, but as expected. 25% of the participants explicitly said that they liked the appearance and 12.5% of the participants said they thought it looked friendly. Because of the drone's happy appearance, one participant thought that he or she was more comfortable with interacting with the drone. Another participant thought it was good looking, not flashy and looked futuristic.

While there were many of the participants that were positive to the drone, there was some doubts about the appearance. One participant was not sure if he or she liked the appearance, the arms gave an insect-like feeling and the eyes looked constantly overly happy, which for the participant felt a little sinister.

37.5% of the participants saw the drone as a companion while 62.5% saw it as a tool. Of those who saw the drone as a companion, 12.5% saw it as a companion because of the human-like features or because of the voice and the face.

"*It has a voice and a face and can move around, like a pet.*"

One person thought it was a companion because it had emotions, another one because of the comfortable interaction, one because it was more for help than pleasure and lastly one because it did not listened to specific commands and listened to what he or she said.

"*Because it was kind and behaved in a way that made me feel comfortable in the interaction with it, I probably thought more that it seemed like a "companion" more than one tool.*"

Of those who saw the drone as a tool, 12.5% saw it as a tool because it did not have a free will, 12.5% because of the assisting features, 12.5% because it does not show any emotions and 12.5% because of no human-like features.

56.3% of the participants did like the drone with anthropomorphistic features the best. 12.5% believed that because of the drone's happy appearance, they liked it the best and one of them also said that the drone felt friendlier and kinder. One participant thought that the face gave a connection to wanting to interact with the drone and that was why he or she liked the drone the best. Another

participant liked the drone the best because of the eyes, another one because of its expressions, another one because of the interface, another because it looked the most realistic and one because of the arms and eyes which felt more responsive. One participant liked the drone because it looked more cute and appealed more to the participants because it showed feelings and did not looked and behaved as a machine.

Although the remaining 43.8% said the drone without any anthropomorphistic features was the better drone, some participants still said they wanted anthropomorphistic features. One participant said that a face was essential:

"*A must! Facial expression do a lot*"

Another person thought it would be more fun and would choose it if possible:

"*More fun and I would choose it after all...*"

Of the 43.8%, there were also participants that would like to have emotions in the drone. One participant wants the drone to sound as human-like as possible and show different personalities.

"*Mixed feelings, mostly positive. I'd definitely want it to sound as human-like and natural as possible when talking to it and be able to choose between different voices and "personalities". (...)*"

12.5% said that they did not notice any difference, while one participant thought it communicated better and moved better while in fact there was no difference.

Japan

The first impressions of the drone were mostly positive with 31.3% plainly remarking that it looked cute. Some of the anthropomorphistic features were also commented initially, such as the eyes and arms. One comment was that the drone looked like a "pet robot" and another was that it is an assistant robot. 18.8% thought that the drone looked square, pale and thin and that it looks very robotic or like a machine.

43.8% thought that the drone was cute, this since many thought that the face and eyes were a contributing factor and that it looked friendly. 18.8% thought that the arms also contributed to the feelings of friendliness.

"It looks friendly and I think it can be a good friend"

However 18.8% thought that the drone could be cuter or that the drone looked plain and monotone or that it just looked simple.

56.3% of the participants thought that the drone was a companion, while 43.8% saw it as a tool. Participants that saw the drone as a companion commented for example that it was cute like a small animal, or that the drone responded to the user. Of these also 22.2% thought that it looked friendly. That the drone actually responded was a factor which 25% of the participants liked. 12.5% also thought that the eyes were important to make the drone feel like a companion.

On the other hand of the 43.8% of the participants that thought it felt more like a tool, 42.9% commented that the drone was lifeless, a cold machine or that it looked like an appliance due to the colour. 12.5% did not want to talk to the drone. One participant commented that he or she thought that the drone could not handle more commands than the given.

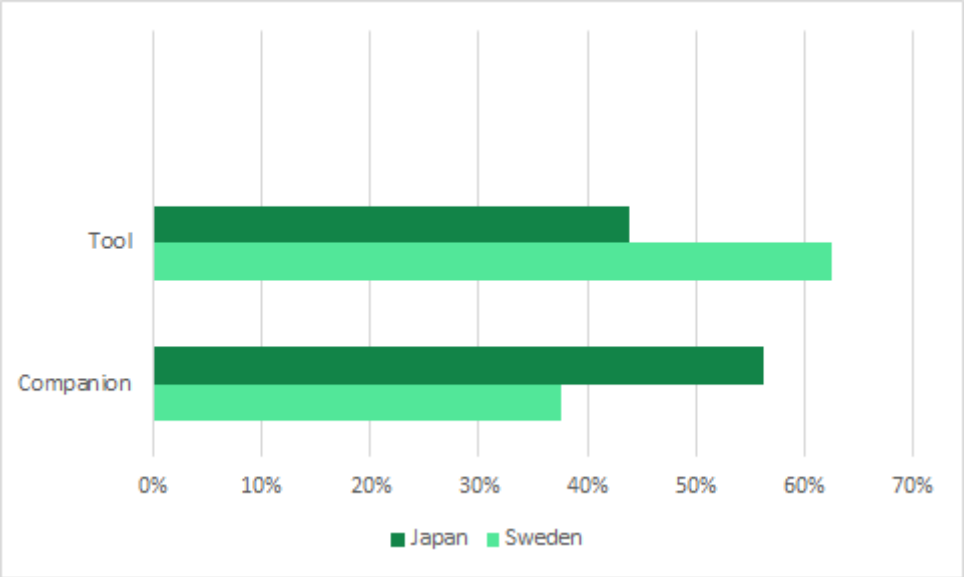
"I think it is just convenient but I don't want to talk with it"

87.5% liked the drone with the anthropomorphistic features the best, which is a majority of the participants. Some of the mentioned reasons for this were that the drone had a face (50%), and that the drone had good appearance, the participants could feel more attached to the drone, that the arms were convenient and that it would be easier to treat this drone as a pet. One positive comment was:

"it looks friendly with the face and arms"

Only one participant thought that the drone had emotions. The remaining 93.8% thought that the drone was emotionless.

Cross-cultural comparison



(**Table 7.18:** Swedish and Japanese opinions of a drone with anthropomorphistic features as tool or companion)

The table above (Table 7.18) shows that there are different perceptions among Japanese and Swedish participants whether the drone with anthropomorphistic features is a companion or not. Here the opinions are shifted, the Japanese participants thought that it is indeed a companion with 56.3%. But the Swedes thought that it is a tool (62.5%).

Drone companion without anthropomorphistic features

Below the description of the user study with the non-anthropomorphistic drone is situated, divided in both Swedish and Japanese results. Note that the drone without anthropomorphistic features also is referred to as 'drone B'.

Sweden

The first impressions of the drone without anthropomorphistic features was quite divided, 50% of the participants were positive in their remarks about the drone. The other 50% thought that the drone had some issues, such as that the drone felt a bit flat, and some thought the drone was too simple and boring. Whilst some of the positive comments were amongst others, that it had a *"clean*

design" and that it *"looked real"* and that it was *"Cute"*. A participant thought that the drone did not show any emotions compared with the drone with anthropomorphistic features:

"Worse than drone A, not so much emotions"

Another participant thought that the drone without anthropomorphistic features was scary and unnecessary because he or she did not know what to do with it:

"Did not know what to do with it, felt unnecessary and scary"

There was also a comment that indicated that the use of the drone could lead to new possibilities for convenience:

"New possibilities for laziness, nice"

A participant commented that he or she liked the drone without anthropomorphistic features the best because of the design, and a contributing factor also was that the participant did not think the interaction felt natural. Another person thought that the drone without anthropomorphistic features was not as fun as the drone with anthropomorphistic features.

The drone's appearance also divided the participants' opinions. 31.3% of the participants liked the appearance of the drone and was positive against the look, while 31.3% thought that the drone looks robotic or as technology in a negative manner. 37.4% had neither distinctively good nor bad opinions of the drone's appearance, some of the comments could be:

"Nothing special, neither good or bad"

Another participant thought that the drone had a simple design, and had an opinion about the size:

"Simple but rather big"

One of the participants thought the drone looked decent but not as good as drone A, totally 12.5% thought that drone B did not look as good as drone A. There was also a comment about how the drone looked in the 3D environment, that it looked real and another comment that it felt less personal in the look and voice.

75% of the participants considered drone B as a tool and 25% did consider it as a companion. Some comments of those who considered the drone as a companion indicated that the presence of a voice and other abilities than just being able to pick up a coffee mug made the drone have characteristics that did it felt less like a machine. Some comments from the participants that thought the drone was a tool could be:

"It does not elicit any emotions back, and thus it becomes just a tool"

Other participants thought that the drone lacks emotions and human like features, which renders the drone to become just as a tool, also comments about that it looked too much like a machine. 43.8% liked drone B the best and a response indicated for example that a participant preferred when the drone had no face and no spindly arms and that it was compact and cute. One participant thought that drone A seemed sad, thus he or she liked drone B better. 12.5% did not see any difference between drone A and B. Another person thought that drone B was better at communicating with him or her and had better movement than drone A. A comment about drone B said:

"The design appealed to me more"

57.1% of the participants that preferred drone B thought that there was no need to change anything on the drone's design. However 28.6% would like the drone to have animal like appearance.

Of the participants that preferred drone B, 57.1% thought it would be creepy, or weird to have a human like face on a drone. While 28.6% of the participants commented that it is a must or could be fun, that facial expressions does a lot. Another person thought that a voice is more important than a face:

"A voice is more important than a face. I'll probably won't be looking at it (...)"

42.9% of the participants who liked drone B the best did not appreciate having emotions in a drone, whilst other 42.9% had mixed feelings about having emotions, it could for example depend on which use the drone will have. One participant commented that he or she would be positive to having emotions on the drone if it would have animal like features.

Japan

The first impressions of the drone without anthropomorphistic features were mixed, however only 12.5% were initially positive towards it and thought that it was sophisticated and that it was smarter than expected. The other comments indicate that the design is dull, and that it looks more like a machine or that it was mechanical. 12.5% of the participants also mentioned that it looked like a UFO or a "UFO catcher". Another 12.5% also commented that the drone lacked the presence of a face.

Other comments showed that the appearance was not fully appreciated amongst the participants, and one of the comments was:

"Looks strange"

A couple of the participants had initially difficulties to imagine how the drone would be used, and a comment was:

"I could not imagine how I use it. A little surprised"

Appearance of the drone was something that invoked different opinions among the participants, one participant thought it looked 'cute', while 37.5% of the participants thought that the drone looked machine-like. Other positive comments were that the drone looked futuristic and that it looked simple and had the right size. However, one participant would have wanted the drone to look more pet-like and another wanted the drone to look friendlier.

A total of 81.3% of the participants saw the drone without anthropomorphistic features as a tool. 18.7% considered the drone as a companion. Some of the comments point to that participants did not see the drone as a companion since it lacked features such as a face or eyes, and also that it did not look friendly or it did not move like a living thing. There were also features that made some of the participants consider the drone to be a companion, such as that the drone could respond to the user, which made it more like a companion according to a participant. The communication was important for two out of three that considered the drone to be a companion.
Some of those that considered drone B as a tool commented:

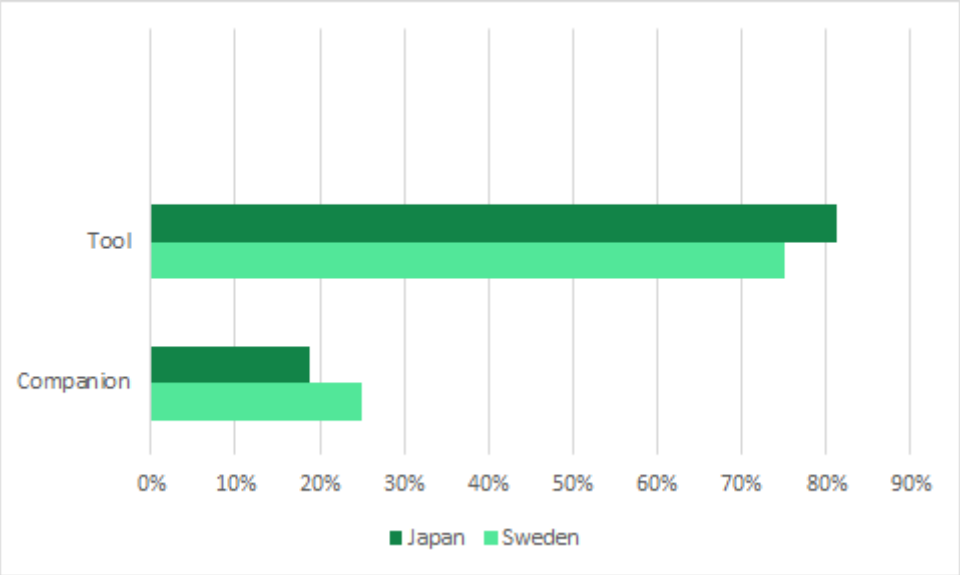
"Without a face, it looks like an object"

"I see it just as a device"

87.5% of the participants did not think that the drone had any emotions, and just one participant commented that the voice of the drone was "monotone". Only 12.5% thought that the drone had emotions, and comments concerned that the drone responded to commands.

12.5% of the participants preferred the drone without anthropomorphistic features the best, and the comments indicate that they preferred it because they thought it communicated better, and that it was easier instructing the drone after being subjected to drone A, thus it was easier to interact with it, and also that drone B had a better appearance.

Cross-cultural comparison

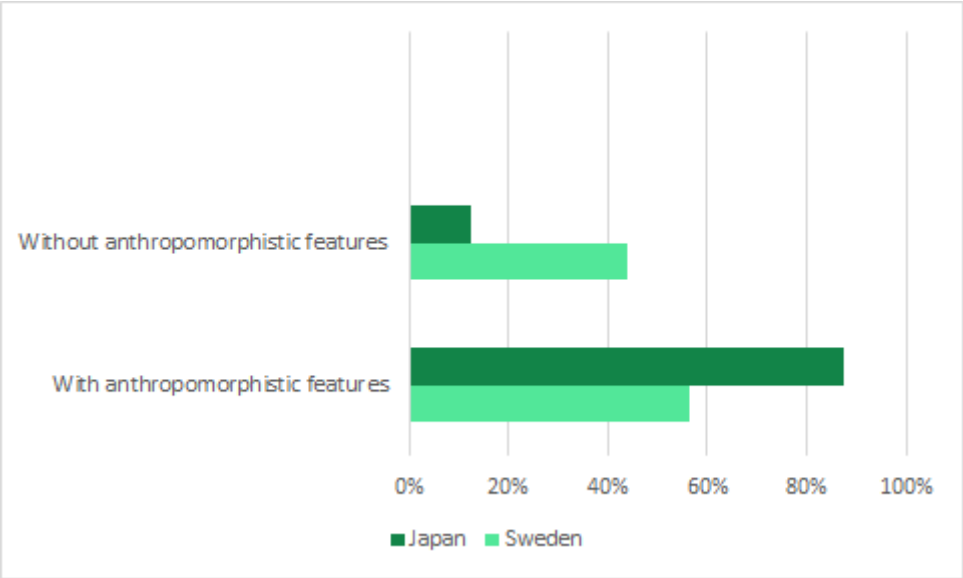


(**Table 7.19:** Swedish and Japanese opinions of a drone without anthropomorphistic features as tool or companion)

As the table (7.19) above shows, the similarity between Swedish and Japanese participants regarding the drone without anthropomorphistic features is quite obvious, a majority of in both Sweden (75%) and Japan (81.3%) thought that the drone can be considered a tool. Only 18.7% of the Japanese participants considered the drone as a companion, likewise just 25% of the Swedish participants.

Cross-cultural comparison of preference of drone companion

After the user study had been performed, the participants in both Sweden and Japan were asked to declare which type of drone they considered to be their favourite.



(**Table 7.20:** Swedish and Japanese opinions of a drone with or without anthropomorphistic features)

Table 7.20 is showing that there is a preference towards the drone with anthropomorphistic features in both the Japanese and Swedish participants. In Japan the result was clearer, a total of 87.5% were positive to the anthropomorphistic drone, while only 12.5% were more positive to the drone without anthropomorphistic features. The Swedish results are also showing that the preference is toward the drone with anthropomorphistic features (56.3%), but the difference is not as remarkable as seen in the Japanese result. In Sweden, 43.8% preferred the drone without the anthropomorphistic features.

8

Design implications

Based on the result from the requirement elicitation questionnaires, workshops and user studies, ten different design implications emerged. The design implications are based on both the Swedish and Japanese result. These implications are aimed to facilitate future developers when designing drones for a home environment. The different design implications will be presented below in alphabetic order.

8.1 Animal-like appearance and behaviour

Animal-like appearance and behaviours refers to how animal the drone companion should look and act.

In Sweden the idea of how animal-like the behaviour and look of the drone was divided and there is no clear indication of what the participants wanted. 43.8% want it to behave moderate to very animal-like and 50% would like the drone to look moderate to very animal-like.

In Japan the idea of how animal-like the drone companion should look is also divided among the participants were 62.5% wanted it to look moderate to very animal-like. The majority of the Japanese participants (62.5%) would like the drone companion to behave moderate to very animal-like.

"*Animal-like behaviors can make drones look more friendly.*"

"*If drones move like animals, we can play with them like pets.*"

In Japan the participants would like to both have animal-like behaviours and animal-like appearance more than the Swedish participants.

8.2 Anthropomorphistic features on a drone

Anthropomorphistic features in a drone means that the drone implements anthropomorphistic features such as eyes, a face, arms or voice. When designing for drone companions with anthropomorphistic features it is important to consider the Uncanny Valley and avoid making the drone look scary or unpleasant.

Swedes seem to be divided if they would like to have anthropomorphistic features or not, but after interacting with one drone without and one with anthropomorphistic appearance, they seem to be more in favour of having some anthropomorphistic features. By having eyes and arms on the drone will make the user comfortable with it and makes the user positive to interact with it.

"*It felt more responsive because of its arms and eyes*"

"*It was happy. It gave me a sense of security because it seemed sympathetic and that made me willing to interact with the more.*"

"*I like it because it looked much sweeter. I think it attracted me more because it showed some feelings and did not just look and act like a machine.*"

Swedes do not like the drone to look too human-like but prefer a more human-like behaviour. 75% said that they would like the drone to behave moderate human-like to very human-like. They would like the drone to have human attributes such as being able to talk and behave like a human. Still, some people do not want the drone to have free will as humans do.

"*It is not a human, but it should be able to have human elements. (...)*"

"*Not necessarily perfectly humanlike, that would probably approach the uncanny valley. But it is nice to be able to speak freely to it*."

"*It's good if it feels personable, but it hardly needs an entire personality and free will. (...)*"

Even though the majority of the participants in the Swedish workshop said that they did not want the drone to have human-like features, their design still indicated that they would like some anthropomorphistic features such as arms.

In Japan the idea of having a drone with human-like appearance was relative negative before interacting with the both drones in the user study, were 60.9% did not want the drone to look human-like at all. After interacting with both drones in the user study, 87.5% did like the drone with anthropomorphistic features. The features such as eyes, arms and face appealed to them more because it was friendly and easier to communicate with.

"*It looks friendly with the eyes.*"

"It was easier to communicate."

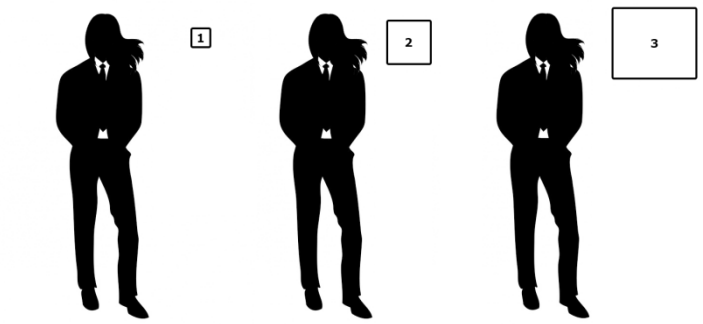
In Japan 56.3% want the drone to behave moderate human-like to very human like. It will then, according to the Japanese participants, be easier to communicate with, it will be more friendly and convenient for the user.

"(...) *talking with something that doesn't act like a human would be a little awkward. Drone having interaction with physical objects makes it better to have human-like behavior, because many physical objects are designed for human to use*"

In the Japanese workshop, it seemed divided whether the drone should have anthropomorphistic features or not. 66.7% of the participants' designs showed some anthropomorphistic features where all the 66.7% designed a drone with one or two arms.
Whether the drone should implement anthropomorphistic features or not are not that divided among the countries. What both Sweden and Japan has in common is that they are positive to a drone with anthropomorphistic features such as eyes and arms.

8.3 Drone size

The size of the drone can be small, medium or large. The size was compared to a person in order to give the participants a reference point (see figure 8.1).



(**Figure 8.1:** Size reference)

In Sweden the medium size was preferred, 58.3% of the participants said they would like a medium sized drone comparing to the 20.8% that would like a small and 20.8% that would like a large drone. A medium sized drone which in this case (during the workshop and user study) has the measure 40 cm in diameter.

In Japan the ideas of size were divided, 47.8% wanted the drone to be medium and 43.5% wanted the drone to be small. A medium sized drone is, as mentioned before, around 40 cm in diameter while a small drone would be around 15 cm.

The majority in both countries would like to have a medium sized drone companion. Although, in Japan the idea of having a small drone was still relatively prominent compared to Sweden.

8.4 Emotions in a drone

Emotions in drones mean that it could show some sort of expression of feelings by either a face, eyes or body language. Emotions could differ in anger, happiness, sadness, weariness etc.

In Sweden the idea of having a drone with emotions was much divided and 50% were positive against the idea of having a drone that could express feelings. More people were positive against the idea after interacting with a drone which showed some emotions and one which did not compared to the people that only answered a questionnaire. Even though people are positive to the idea of having emotions in drones, the amount should be moderate. Two emotions such as tired when low battery and happiness were mentioned:

"*Some emotion to indicate low battery is useful. I don't think more is needed.*"

"*(...) It should always be happy*"

Some people also thought that if the drone is seen as a companion, it could be useful with emotions but not if it is a tool.

"*Depending on how it would affect the drone and depending on how I would use it. If it was mostly a companion drone, sure why not. But if it was used as a helper drone then perhaps not.* "

An example of this could be when the drone is doing a task or helping the user and the battery is beginning to get low. The drone then either shows with body language or with the screen that it is tired. Another example is that the drone shows it is happy by either body language, voice or with 'happy' eyes.

Japanese participants seem to think that there should not be emotions in a drone companion. Although, after interacting with a drone, it turned out they are more positive to it. Based on the requirement elicitation questionnaire, workshop and user study there are still 61.2% that did not want a drone with emotions. According to the Japanese participants, having emotions in a drone would be scary, annoying, not necessary or something only living things should have.

"*Shouldn't have emotions because drones might not be differentiable from humans. I think we should have some limits between humans and robots.*"

"*No. Emotions are something that only living things should have.*"

The culture difference between Sweden and Japan is that Swedish participants seem to be more in favour of emotions than Japan. Swedes want emotions but not too many, while Japanese seem to not want emotions at all.

8.5 Face on a drone companion

The definition of what face is can differ from person to person. For some, a face could be a human face while for others it also includes animal faces. Here, the definition of a face include everything that has two eyes.

In Sweden the idea of having a face on a drone could be considered creepy or that it is a technical device and should therefore not have a face. 50% in the workshop did not want a face on the drone, however, after interacting with the two drones in the user study, 75% would like to have a face on the drone. By having a face, the drone will seem nicer and will make the interaction easier and comfortable for the user.

"*I'd rather want it to have a face because it felt much nicer. If it is to function as a company, it still needs to remind you that it is not just a machine.*"

"*It's easier to interpret what it is trying to do*"

18.6% of the participants in the user study said that they would like to have a face on the drone, but not a human-like face. They said that it would be scary if the drone companion would be human-like and if the face would be more animal-like it would appear less uncomfortable.

"*Yes, but does not have to be a human face, better with an animal face maybe, otherwise it may be a little unpleasant*"

In Japan 93.8% liked the idea of having a face on the drone companion after the interaction with the both drones in the user study. With a face, the drone becomes more friendly and cute. The drone will become more like a companion, gives a positive impression and will become easier to communicate with.

"*Drones look cuter with a face.*"

"*It would be great because having a face can give much more positive impression.*"
"*A face can make me feel like I can actually talk to drones.*"

In the Japanese workshop there were 22.2% of the participants that would like to have a animal-like face on the drone.

Both Swedish and Japanese participants would like to have a drone with a face. Also, both in Sweden and Japan there are some people that want a drone with something else than a human face, such as an animal-like face.

8.6 Interaction with the drone

There are several different ways to interact with a drone; voice, gesture, remote control and by hands on interaction.

In Sweden the majority (81.8%) would like the drone to be voice controlled. Even though the majority prefer voice controlled, people seem to also want to interact with the drone by gesture (54.5%) and remote control (45.5%).

In Japan the majority of the participants (54.2%) wanted to control the drone by voice. In addition to this 44.4% also wanted the drone to be controlled by a remote control such as a smartphone.

A voiced controlled drone is when the user speaks to the drone and command the drone what to do and the drone performs the task. An example of this is to tell the drone to go and get coffee and the drone returns with coffee.
Both Sweden and Japan were unanimous in how the user should interact with the drone, voice controlling the drone was prominent in both countries. In Sweden the idea of controlling the drone with gestures was more popular than in Japan while in Japan remote controlled was more popular.

8.7 Machine-like appearance and behaviour

In Sweden the majority of the participants (68.8%) would like the drone to look moderate to very machine-like. The participants thought that it is a machine and should therefore look like a machine, but according to some participants' eyes or something to indicate expressions are beneficial.

"Because it's a machine, I think you should see it too.
But having eyes so it looks like it sees me, Is after all nice."

The idea of how machine-like the behaviour should be is divided and there is no clear indication of what the participants wanted. 50% want the drone to behave moderate to very machine-like.

In Japan the idea of how machine-like the drone companion should look was divided. 62.5% wanted the drone to look moderate to very machine-like.

"*I think it might be weird if drones look like animals because the way they move is not animal-like.*"
"*If it looks cute like a pet, I think I can feel closer to it.*"

8.8 Social role of drone

A drone companion could have different roles such as assistant, butler, device, friend, pet or a toy. These roles are how the user sees the drone and how the drone should act towards the user.

In Sweden many people sees a drone companion as an assistant which helps with different tasks in the home. 87.5% said that they would like to have the drone companion as an assistant. Even though people see the drone as an assistant that do different tasks in the home, 79.2% still sees it as a toy and 54.1% as a device/computer.

In Japan the majority of the participants (75%) sees the drone as an assistant. While people in Japan sees the drone as an assistant, there are also people that sees it as a device/computer (58.3%).

Both in Sweden and Japan the majority of the participants saw the drone as an assistant, which is the same result as Dautenhahn et. al (2005) show in their study. This shows that the cultural differences does not affect the participant's view of the social roles of a drone companion. However, what differentiates the two countries is that in Sweden many people also see a drone as a toy compared to Japan where they also see the drone as a device.

8.9 Tasks of the future drone

There are several tasks that a drone companion can do, but this is focused on the tasks mentioned earlier in the report.

The Swedish opinions about what the drone companion should do were divided, but there were some tasks that were prominent. Bringing things to the user is something that 83.3% of the Swedish participants wanted. Bringing things could be everything from a cup of coffee to car keys. 54.2% of the Swedish participants also wanted the drone to give daily updates. This means that the user could ask the drone for updates such as the weather forecast, social media updates and much more.

Also, households tasks were something that were prominent among the Swedish participants. 70.8% wanted the drone to clean after them and 50.0% wanted the drone to cook for them. In addition to this, 66.7% wanted the drone to help in the daily life. An example of this could be that the drone gives the user general reminders, tell if someone is knocking on the door, give information about different things etc.

In Japan the ideas of what the drone companion should do were relative unanimous. 83.3% wanted the drone to bring things and 54.2% wanted the drone to clean after them. Also, 33.3% wanted the drone to give daily updates while 41.7% wanted the drone to help in the everyday life. Help in the everyday life could be guarding the home, walk the dog, monitoring children etc.
In both Sweden and Japan the tasks to bring things, clean, daily updates and help in the daily life were the most prominent tasks that the Swedes and Japanese would like the drone to do. In contrast to Japan, Swedes seem to also want the drone companion to cook for them. Over all, if you look at figure 7.5 you can see that the Swedish participants can imagine the drone companion to do more different tasks than the Japanese participants did.

8.9.1 How the drone should follow around

This design implication is about how people feel about having a drone that follows the user wherever he or she goes.

Swedes do like the idea of having a drone that follows around, but it should be optional. The drone could be commanded to follow around and when the user does not want the drone to follow around anymore he or she commands the drone to stop following around and go back to its tasks, or the place the drone is usually situated. For example, as participants said;

"*It should be optional*"

"*Only if I ask the drone*"

"*It should listen to the commands so that it comes and goes as I command.*"

An example of this could be when a user wants to record something that he or she does. By calling for the drone and demand it to follow around and record, the drone will come and do so until the user is done and tells the drone to go back and proceed with its previous task.

Japanese participants do not want the drone to follow around because they have a tendency to think it is annoying and intrusive on their privacy. 66.7% of the Japanese participants said that they did not want the drone to follow the user around.

"*No. I don't want to feel like being observed.*"

"*No. I want a drone to help me just when I need it.*"

There are no big cultural differences when it comes to if the drone should follow the user or not. Both countries seem not like the idea of being followed around, although Swedes would like to have it optional compared to Japanese who did not want the drone to follow at all.

9

Discussion

In the section below we discuss the different results, the impact of cultural differences, our overall study process, eventual ethical issues with our study and some suggestions for future work in the field of research.

9.1 Result discussion

The results indicate that many people are in favour of drone companions and can imagine having a drone companion in their home. The idea of appearance is divided in the countries, but participants from both Sweden and Japan indicated that they would like to have some kind of face and machine-like features in a drone companion. Implementing anthropomorphistic features in a drone was also divided within the countries, but the result shows that they would like it to have arms and at least eyes. In Dautenhahn et. al.'s (2005) paper *What is a robot companion-friend, assistant or butler?*, they argue that people in their study saw the robot as an assistant, which we also found in our research, and that shows that the medium of the robot does not seem to affect what kind of social role the users see in robots.

Our study was designed and conducted with inspiration from amongst others, Dautenhahn et. al. (2005) and Cogniron Project (2004), where from many of the questionnaires and basis for the user study were derived. There are some similarities between the studies, both in how the studies were carried out regarding questionnaires that were used and that the user study was mimicking a home environment. Differences were that our study focused on companion drones instead of traditional robots and that we chose to implement VR technology in our user study. The context in the user study was modified to better suit the desired tasks that were elicited from the participants of the questionnaire study, with the exception that there was a need to choose tasks which were realistic to implement in the VR study due to limitations in our knowledge in VR design and programming. We believe that sufficient data from the study was received, and we can also note that doing user testing with the help of VR worked well in this study.

For the workshop, the four themes that are described by Lee et. al. (2012) worked as a foundation on which the participants of the study created designs of drones and they also worked as basis for the following discussions at the workshop. The themes by Lee et. al. (2012); Look and Feel, Interaction Mode, Social Features and Desired Tasks helped to describe key aspects of the drone prototypes that were designed. The similarities between the studies are that both studies are comparative in nature and compares cultural differences relating to robot technology in two countries, the difference is that our study focuses on drones and are more explorative than comparative. The workshop technique was also similar in some ways, for example where participants draw their own interpretations of drone companions, however we did modify the workshop to incorporate practical

prototyping as well. We think prototyping is a good way of conveying ideas to designers, and which also is a way to involve users in design as mentioned by LUMA Institute (2012).

The prototypes that were created according to the results from the workshops looked a bit different depending on if it was a Swedish or Japanese design, which is further described in chapter 7.2.5.

The prototypes that were created according to the results from the workshops looked a bit different depending on if it was a Swedish or Japanese design, which is further described in chapter 7.2.5. The Both Swedish and Japanese participants seemed to like a more machine-like drone, however the Swedish participants wanted a rounder shape. The participants from Sweden did like the drone to have more of emotional traits than the Japanese.

The expected contributions we envisioned our study to fulfil (see chapter 1.2) have been largely met. If summarized, we have identified a possible domain for use of a drone companion as being in a home environment (see C1, chapter 1.2). This was elicited through a pre-study with 14 participants done at Uppsala University. The majority envisioned the drone to be used in a home environment. There were also considerations taken regarding the plausibility to perform a study in different environments, and if the study would have been conducted in real public environments there would have been necessary to consider regulations concerning the operation of drones. However, since we opted to use VR technology this was not deemed any issue.

As previously discussed, important attributes (see C2, chapter 1.2) were elicited through the extensive use of different questionnaires, the execution of workshops and user studies, which helped us gain a clearer picture of what is preferred in a drone companion. The elicited domain (see C3, chapter 1.2), which in our study was a home environment, did have an impact on which tasks would be more suited to that area of use. Some of the different suggestions of tasks were elicited through related work, such as Dautenhahn et. al. (2005) and Cogniron project (2004), and own interpretations of which kind of tasks would suit a drone companion. In chapter 8 we present design implications (see C4, chapter 1.2) that have been elicited with help of the study results, these implications are meant to serve as help in which considerations to be aware for future work in the research area of drone companions.

9.1.1 Cultural Impact

Since one of this thesis aims was to research the possible cultural differences in attitudes and preferences about drone companions, it also is relevant to discuss what possible impact the culture can have had on the results. There are some differences between Sweden and Japan regarding preferences in a drone companion, however generally many of the results are quite alike. One of the most prominent differences is that Swedish participants tended to see the drone more as a tool, while the Japanese participants saw the drone as a companion (further elaborated in chapter 7, 8).

Another interesting difference was how Japanese participants seemed to want the drone companion to have no emotions. McDorman et. al. (2008) indicates that Japanese people are concerned about how robots can affect the society and the emotional aspects when interacting with robots. Our result shows that Japanese people seems to think, before interacting with the two drones, that robots should not express feelings and should only be machines. As McDorman et. al. (2008) explains, this could be due to the familiarity level of robots, and the less familiar the person is to robots, the more positive he or she is. Also, having participants with minimal experience with robots are more likely to treat them as social beings than machines. The majority of the participants in our study in Japan had a background in computer engineering, information science and technology or engineering, and this

could be the reason why the majority of the participants of both requirement elicitation questionnaire and workshop was not in favour of a face or emotions in the drone companion.

When conducting studies in other countries there are also some other cultural aspects that may have an impact on the results. A practical issue that came up was when conducting the study in Japan was the language difference, all materials for the requirement elicitation questionnaires, the workshop and user study needed to be translated from English to Japanese, also the execution of the workshop and the user study necessitated the use of a translator to be present during the procedure. Due to this, there was some difference in the amount of data that was attained. The possibility to ask spontaneous questions during the workshop was limited due to the need to translate what was communicated in real time, with nine participants this would have been too tedious and time consuming for it to be a realistic option, also considering the time plan.

9.2 Process discussion

By using the five steps that our study's process consisted of (see Figure 6.1), enough data was collected and analysed in order to find design implications. The literature phase was useful in order to get an understanding of the recent research and how similar work was carried out with traditional robots. The pre-study helped to understand in which context the users would like to have the drone companion. If this step would be neglected, the outcome could be different and would maybe not match the user's requirements. Also, by narrowing down the scope of the use context the project was more manageable and feasible to conduct.

The aim of the requirement elicitation questionnaire was to collect as much data about the user's preferences and attitudes as possible and have the information as a foundation for the workshop. Without the requirement elicitation questionnaire it would have been much more difficult to create a realistic scenario to describe the conditions of the drone.

The workshops made it possible to understand what the users think about the drone's appearance and let them be a part of the design process. If the participants would only be asked to imagine how the drone could look like compared to hands on prototyping, the drones would probably look different. We believe that by using both sketching techniques and low fidelity prototyping, the results were more elaborated and that it can sometimes be easier to imagine which type of use the drones can have if the participants actually can have the opportunity to build a physical representation. This type of methodology is also described by LUMA Institute (2012) as a way to incorporate users in a participatory design.

Using a VR prototype instead of the initial idea of using a real drone did probably have a great impact on the outcome we believe. If an ordinary drone would be used, physical limitations would emerge and the appearance of the drone would be more difficult to modify. By having a VR prototype the user could be set in a home environment, interact with a drone that match the requirements and experience as close as the actual interaction as possible. The possibility to replicate the environment, in which the user study was conducted, was thanks to VR fully possible even though the study was performed in both Japan and Sweden. We believe that thanks to the VR technology the comparison of cultural differences elicited by the user study were more easily done. VR technology has also been proven to function well as substitute for real world testing, as described by Jasinevicius et. al. (2004).

Throughout the whole process of the study, a user centered design approach has been implemented which has meant that users has been an integral part of the research. The user's goals and wishes have been taken into account as much as possible and this has been possible since every step of the process has involved the active use of direct feedback from potential users, this was done through

different questionnaires, the workshops and the user study. We believe this is in line with what Preece et. al. (2011) describes being important factors for a successful user centered design process.

If however we would not have implemented a user centered approach, and would not have involved users in the design process, the likelihood is that we would have ended up with drone designs that do not correspond to users expectations. This since the area of research is that novel and there are not many sources to this date that presents proven concepts on how to design a satisfying companion drone. What we refer to is that by using a user centered design approach we believe that the probability of success is greater since the direct input from potential users is valuable.

However, in some aspects there also is a need to test a new design further with potential users to really get information on how well the design actually works. Through the implementation of a user study where users did try out functioning drones in a 'real' environment, we think that even more valuable data were obtained, and these tests also could confirm or reject the designs. According to Nielsen (2001), it is a good way to get preference data after the users have interacted with the product. We believe a need for trying out designs that might not be exactly what the initial requirement elicitation questionnaires results fully described, this to see whether users would like design elements even though they did not explicitly request for them, the approach is sometimes described as: "*Users do not know what they want*" (Nielsen, 2001).

An example of this would be when the designs of the drones for the user study were created, the decision was made that we would try out a hypothesis which was to test if a certain drone design with anthropomorphistic features would be preferred by the users over a more neutral looking design. When we introduced anthropomorphistic features in a drone companion we proved that our hypothesis was right, participants did favour the anthropomorphistic drone over the drone which did not have such features.

9.3 Ethical issues

There are some ethical issues that could have affected the research. One of these issues would emerge if we would fly a drone outdoors. Video recording or photography with a drone outdoors can conflict with people's privacy. Also there are laws in place in Sweden which prohibits the use of cameras on drones at public places (Datainspektionen, 2016). Other ethical issues that should be considered is that the purpose of the drone should not be to harm humans or animals, i.e. it should not be used as a weapon. Realistically this is not an issue in our research, however since there are drones with these purposes available we think it is important to mention. Safety issues with the drones need also be considered since they are complex machines that consist of moving parts, such as propellers which may cause damage, in some cases even the drone itself may cause harm if a collision with a person occurs. Since the interaction in this study is done in a VR environment, we have mitigated the mentioned issues in a satisfactory manner. However, if future research will be conducted with physical drones there needs to be consideration taken to these issues.

Another ethical consideration that is needed to address is the need for a consent form to be signed by the participants of our study, this to ensure that eventual video, voice recordings or photographs taken during test sessions are made and processed with privacy concerns in mind.

9.4 Future work

This study focused on finding cultural differences between Sweden and Japan. In the future, researchers could expand the study and include more countries in the culture comparison. Another cultural comparison is to compare South American or African culture to Western or Asian culture.

In this study, the tasks which the drone performed were limited to bringing things and giving updates of social media. Other future research the study could be expanded and including other tasks that were prominent in our study such as cleaning and cooking.

Since the participants of our study in Japan were recruited from the general student population at Osaka University, it might be that the backgrounds and occupations were not that diverse as we had wanted. So for future research we suggest that study participants should be more diverse, in order to reconfirm if there would be differences in preferences about emotions in a drone companion if the backgrounds of the participants would be different.

10

Conclusions

The purpose of the project was to find different design implications, investigate cultural differences and start a discussion around having a drone companion in a home environment. By using requirement elicitation questionnaires, workshops and user studies much data was collected that has been useful in this study. We had three research questions that we wanted to answer;

- *"How do people respond to having a drone as a companion?"*
- *"How can a drone be used as a companion instead of a tool?"*
- *"What kind of cultural differences are there between Sweden and Japan when it comes to drone companions?"*

When coming back to the research challenge stated in the beginning of our thesis, also as mentioned above, we have found that both Japanese and Swedish people are in favour of having a drone companion in the home and there was no big difference between the both countries. When it comes to what kind of social role the participants saw in the drone companion, both countries saw the drone as an assistant. The most prominent tasks that both countries wanted the drone to do was to bring things and clean for the user.

Even though there are a lot of common ideas and preferences in both countries, there are some preferred features which separated the two countries. Having emotions in a drone seemed to be more favoured in Sweden than in Japan. In Sweden they say that the drone could have small amount of emotions because it would be nice or helpful. However, in Japan the idea of having a drone with emotions was not preferable because it would be scary, annoying, not necessary or something only living things should have. The idea of the drone's appearance was also divided where in Sweden they wanted a round drone while in Japan they seem to want a more machine-like drone.

After interacting with both drone A and drone B, both countries were considerably more in favour of a drone with a face. This shows that our hypothesis was right and people do want drones with anthropomorphistic features after they have seen and interacted with one. In Sweden the participants saw drone A as a tool and in Japan they saw it as a companion while the majority in both countries saw drone B as a tool. This shows that even though Japanese people sees a drone with anthropomorphistic features as a companion, Swedes have difficulties with seeing robots or other dead objects as companions and rather see them as tools.

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Appendix

A

Pre-study: Environment of drone companion usage

Consent:

This pre-study questionnaire is about “Human Drone Interaction”, and the aim is to understand in which context of use you perceive the drone to be used. The study is anonymous and will not show your personal data in any way that would be intrusive to your privacy.
Your participation in this study is voluntary. The data collected will be used as a part of a Master thesis, but is anonymized during the whole process and publication.
By signing this form, you agree to participate by answering this questionnaire and you consent to the publication of the results according to the above mentioned terms. Your name will not be published.

Name:_____ (Print)

Signature:_____ Date:_____

The study is conducted by: Anna Romell (annarom@student.chalmers.se), Kari Karjalainen (karik@student.chalmers.se), Mohammad Obaid (mohammad.obaid@it.uu.se), please feel free to contact us if you have any questions.

Companion: Spends time with the person, do activities together and maintain a relationship with the person.

1. **Age:** _____
2. **Gender:** Male ☐ Female ☐
3. **In which environment do you want to use a drone companion?**

_____

_____

_____

4. **What role do you think a drone companion should have (tick as many options as appropriate)**

Assistant ☐ Butler ☐ Device/Computer ☐

Friend ☐ Pet ☐ Toy ☐

Other: _____

B

Drone as a companion questionnaire

Drones as companions

This is a study where we investigate people's perception and attitudes against drones as companion. Now we want to know your thoughts about having a drone as a companion.

You are invited to participate in an online study on "Human Drone Interaction". The aim of this study is to investigate your perception towards drones.

Your participation in this study is voluntary. You are free to choose whether or not you will take part in the study. The study is anonymous and will not show your personal data in any way that would be intrusive to your privacy.

The data collected will be used as a part of a Master's thesis project. By agreeing to participant, you consent to publication of the results of the study with the understanding that anonymity will be preserved.

The study is being carried out by: Anna Romell and Kari Karjalainen

They can be contacted via email: annarom@student.chalmers.se , karik@student.chalmers.se

*Obligatorisk

1. **Do you agree?** *
   Markera alla som gäller.

   ☐ Yes, I agree

Demography

2. **Age** *

3. **Gender**
Markera endast en oval.

- ◯ Male
- ◯ Female

4. **Education** *

5. **Occupation** *

Please read the information

Drones come in many forms and sizes, and can be described as a flying robot. They usually consist of four propellars and can either be controlled by a user or be autonomous.

Companion: Spends time with the person, do activities together and maintain a relationship with the person.

6. **What role do you think a future drone companion should have (tick as many options as appropriate)?**
Markera alla som gäller.

- ☐ Assistant
- ☐ Butler
- ☐ Device / computer
- ☐ Friend
- ☐ Pet
- ☐ Toy
- ☐ Övrigt:

7. **Would you like to have a drone as a companion? Why/ Why not?** *

Drone companion tasks in Home environment

8. **What kind of tasks would you like your future drone companion to do at home?**
Markera alla som gäller.

- [ ] Bring stuff to you
- [ ] Clean after you
- [ ] Cook for you
- [ ] Follow you around
- [ ] Give you company
- [ ] Give you daily updates about certain things (eg weather forecast, Social media updates etc.)
- [ ] Have conversations with you
- [ ] Help you in your daily life
- [ ] Help with work / home work
- [ ] Play games with you
- [ ] Play with you (eg fetch, hide and seek etc.)
- [ ] Talk to you

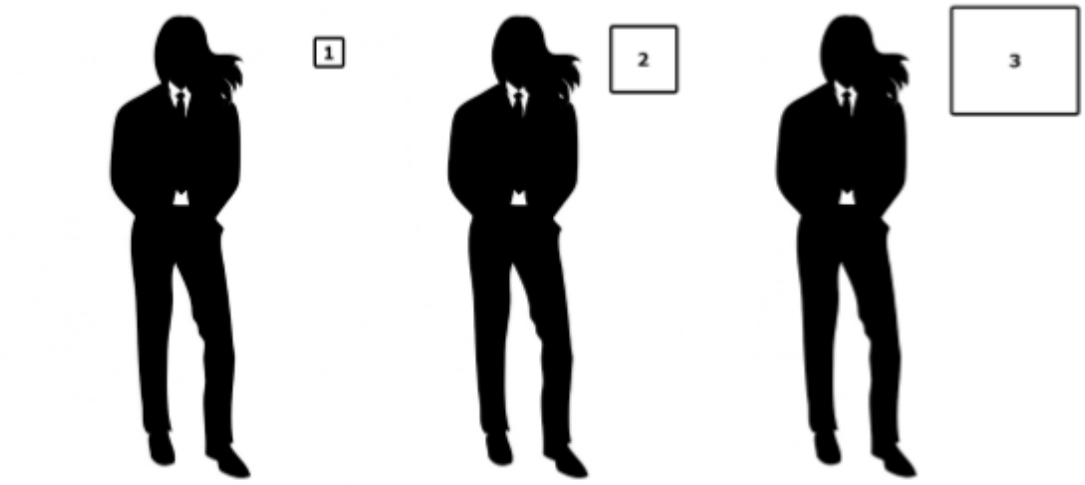
9. **Are there tasks or functions that is not listed above?**

10. **Of the tasks that you have chosen, which ones are the most important?** *

11. **Why do you consider the tasks mentioned above being most interesting?** *

Size of the drone companion

12. **What size do you think a drone companion should have?**



Markera endast en oval.

- ◯ Option 1
- ◯ Option 2
- ◯ Option 3

Drone companion appearance

13. **How human-like should the drone companion's appearance be?**
Markera endast en oval.

	1	2	3	4	5	
Not human-like at all	◯	◯	◯	◯	◯	Very human like

14. **How would you like your drone companion to look?** *
With this we mean the drone's appearance. Should it look like an animal, human or like a machine? Or something different? Please specify!
Markera endast en oval.

- ◯ Like a Human
- ◯ Like an Animal
- ◯ Like a Machine
- ◯ Some Human-like traits
- ◯ Some Animal-like traits
- ◯ Some Machine-like traits
- ◯ Övrigt: _____

Interaction with the drone companion

15. **Do you want the drone to follow you around? Why/ Why not?** *

16. **How would you like to interact with your drone companion?**
Markera alla som gäller.

- [ ] By a device
- [ ] By gestures
- [ ] By hands on interaction
- [ ] By speech
- [ ] Övrigt: _____

17. **Would you like a future drone companion to have different emotions? Why / Why not?** *
By emotions we mean if the drone should show different feelings in terms of e.g. happy when useful, tired when low battery, sad when not needed etc.

C

Workshop questionnaires

Consent:

This workshop is about “Human-Drone Interaction”, and the aim is to find different design solutions/ideas of a drone companion’s appearance and additional functions. The study is anonymous and will not show your personal data in any way that would be intrusive to your privacy.
Your participation in this study is voluntary. The data collected will be used as a part of a Master thesis, but is anonymized during the whole process and publication. As a method of collecting data, the use of audio recording devices will be used, and also some photography will occur. If you do not wish to be seen in photographs, please let the facilitators know, and your face will be blurred out in eventual photographs taken.
By signing this form, you agree to participate by answering this questionnaire and you consent to the publication of the results according to the above mentioned terms. Your name will not be published.

Name:_____ (Print)

Signature:_____ Date:_____

The study is conducted by: Anna Romell (annarom@student.chalmers.se), Kari Karjalainen (karik@student.chalmers.se), please feel free to contact us if you have any questions.

Workshop Questionnaire

Demographics:

Age:_____

Gender: _____

Education:_____

Occupation:_____

Drone experience:

Do you have any previous experience with drones? Yes/No? _____

If Yes, what kind of experience?, please elaborate!

_____

_____

D

User study: Introduction questionnaire

Introduction questionnaire

This User study is about "Human-Drone Interaction", and the aim is to evaluate solutions/ideas of a drone companion's appearance and additional functions. The study is anonymous and will not show your personal data in any way that would be intrusive to your privacy. Your participation in this study is voluntary. The data collected will be used as a part of a Master thesis, but is anonymized during the whole process and publication. As a method of collecting data, some photography will occur. If you do not wish to be seen in photographs, please let the facilitators know, and your face will be blurred out in eventual photographs taken.By signing this form, you agree to participate by answering this questionnaire and you consent to the publication of the results according to the above mentioned terms. Your name will not be published.

The study is being carried out by: Anna Romell and Kari Karjalainen

They can be contacted via email: annarom@student.chalmers.se , karik@student.chalmers.se

*Obligatorisk

1. **Do you agree?** *
   Markera alla som gäller.

   ☐ Yes, I agree

Personal details

2. **Gender**
   Markera endast en oval.

   - ◯ Male
   - ◯ Female
   - ◯ Övrigt: _____

3. **Age**

   _____

4. **Occupation**

   _____

5. **Do you have any experience with drones?**
   Markera endast en oval.

   - ◯ Yes
   - ◯ No

6. **If yes, what type(s) of experience(s)?**
   Markera alla som gäller.

   - ☐ At work
   - ☐ As toys
   - ☐ In movies/books
   - ☐ In TV shows
   - ☐ In museums/shows
   - ☐ School
   - ☐ Övrigt: _____

7. **Your technical knowledge of drones**
   Markera endast en oval.

	1	2	3	4	5	
Limited knowledge	◯	◯	◯	◯	◯	Extensive knowledge

8. **What role do you think a drone companion should have?**

Companion: Spends time with the person, do activities together and maintain a relationship with the person.

Markera alla som gäller.

- [ ] Assistant
- [ ] Butler
- [ ] Device/computer
- [ ] Friend
- [ ] Pet
- [ ] Toy
- [ ] Övrigt: _____

E

User study: Drone A and B questionnaire

Questionnaire

1. **What was your first impressions of the drone?**

2. **Did the drone perform the tasks according to your wishes?**
   Markera endast en oval.

	1	2	3	4	5	
It did not perform as I wanted	◯	◯	◯	◯	◯	Yes, it did perform tasks as I expected

3. **Did you like the way you interacted with the drone?**
Markera endast en oval.

- Yes
- No

4. **Please explain!**

5. **Did you experience that the drone had emotions?**
Markera endast en oval.

- Yes
- No

6. **If yes, which emotions did you notice?**

7. **Was there any Human-like features with the drone?**
Markera endast en oval.

- Yes
- No

8. **If yes, which features did you notice?**

9. **What did you think about the drone's appearance?**

10. **Do you see this drone as a companion or as a tool?**
Markera endast en oval.

- ◯ Companion
- ◯ Tool

11. **Why?**

F

User study: Final Questionnaire

Final questionnaire

1. **Do you like computers/ computer technology as a part of your home environment?**
   Markera endast en oval.

	1	2	3	4	5	
Don't like it at all	◯	◯	◯	◯	◯	Like it very much

2. **Do you like the idea of having a drone as a companion in the home?**
   Markera endast en oval.

	1	2	3	4	5	
Don't like it at all	◯	◯	◯	◯	◯	Like it very much

3. **After interacting with both drone companions, what kind of roles do you think a drone companion should have?**
   Markera alla som gäller.

- [ ] Assistant
- [ ] Butler
- [ ] Device/ Computer
- [ ] Friend
- [ ] Pet
- [ ] Toy
- [ ] Övrigt: _____

4. **What task(s) would you like the future drone be able to do?**
Markera alla som gäller.

- [ ] Bring stuff
- [ ] Clean after you
- [ ] Cook for you
- [ ] Follow you around
- [ ] Give you company
- [ ] Give you daily updates about certain things (eg weather forecast, Social media updates etc.)
- [ ] Have conversations with you
- [ ] Help you in your daily life
- [ ] Help with work / home work
- [ ] Play games with you
- [ ] Play with you (eg fetch, hide and seek etc.)
- [ ] Talk to you
- [ ] Övrigt: _____

5. **How animal-like should the future drone companion look?**
Markera endast en oval.

	1	2	3	4	5	
Not animal-like at all	◯	◯	◯	◯	◯	Very animal-like

6. **Why?**

_____

_____

_____

_____

_____

7. **How machine-like should the future drone companion look?**
Markera endast en oval.

	1	2	3	4	5	
Not machine-like at all	◯	◯	◯	◯	◯	Very machine-like

8. **Why?**

_____

_____

_____

_____

_____

9. **How human-like should the future drone companion behave?**
Markera endast en oval.

	1	2	3	4	5	
Not human-like at all	◯	◯	◯	◯	◯	Very human-like

10. **Why?**

_____

_____

_____

_____

_____

11. **How animal-like should the future drone companion behave?**
Markera endast en oval.

	1	2	3	4	5	
Not animal-like at all	◯	◯	◯	◯	◯	Very animal-like

12. **Why?**

13. **How machine-like should the future drone companion behave?**
Markera endast en oval.

	1	2	3	4	5	
Not machine-like at all	◯	◯	◯	◯	◯	Very machine-like

14. **Why?**

Your feelings after the session

15. **What did you find most interesting about the drones during the experiment?**

16. **What did you find most annoying about the drones during the experiment?**

17. **Did your feelings against a drone companion change after interacting with both of the drones? Why?**

18. **What do you think about having a face on the drone companion?**

19. **What do you think of having emotions in a drone companion?**

20. **Which of the drones did you like the best?**
Markera endast en oval.

- Drone A
- Drone B

21. **Why did you like that drone the best?**

22. **Do you think anything should be changed to that drone?**