# Designing for Trust in Domestic Robots

## Understanding how Design Affects Users' Trust in Robotic Vacuum Cleaners

Master's Thesis in Interaction Design and Technologies

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CHALMERS UNIVERSITY OF TECHNOLOGY
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# Abstract

The amount of robots that humans can be expected to interact with in their everyday life is steadily increasing. In order to facilitate the best interactions with these robots the human must have an appropriate amount of trust in the robot. This Master Thesis explores the aspect of trust that users have in domestic robots, focusing especially on the Robotic Vacuum Cleaner (RVC). This was done through a literature study supported by a subject expert inquiry interview which resulted in a relationship map over the factors that affect trust in RVCs. This was then followed up by creating a prototype which was used to test and dig deeper into how transparency factors into trust. At the same time user studies in the form of interviewing owners of RVCs were carried out in order to support the results from the literature study.

Keywords: Interaction design, human-robot interaction, trust, domestic robots.

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Björn Bergqvist, Hampus Rönström, Gothenburg, June 2020

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# 1
# Introduction

Human-Robot Interaction (HRI) is a field closely linked to Interaction Design which is becoming more important in recent days as robot technologies are finding its way into people's everyday life. Domestic robots such as automated lawnmowers and vacuum cleaners are example of automated robots that humans need to interact with. The way in which the robots are designed affects what mental model users have of them and what feelings the robots invoke. It is important to endues the appropriate amount of trust humans have in automated machines, in order to avoid the negative consequences of too little, or too much, trust (Hoff & Bashir, 2015).

As most research done has been focused on military, automotive and industrial robots or in robotics as a general field (e.g. Wang, Pynadath, & Hill, 2016; Verberne, Ham, & Midden, 2012; Balazs, Trygve, & Peter, 2013), there currently exists a research gap when it comes to trust research in domestic robots. It has been identified that in order to get a more holistic understanding of trust it is important to focus on a wide range of automated products. As such we deemed that trust in domestic robot would be an interesting field to explore deeper.

## 1.1 Aim

The project aim is to find a way to create domestic robots in which users put an appropriate level of trust. In order to do this we want to help create an understanding for what affects a humans trust in domestic robots, such as robotic vacuum cleaners, as well as how to design for appropriate amounts of trust. This understanding would help create robots with a more appropriate and well thought-out level of trust. During the project the goal is to develop a model for understanding what affects trust in RVCs and what is deemed an appropriate level of trust in them. A further goal is to develop a concept based on this model. The concept should take the form of a prototype or a design. The purpose of the concept is to present a way in which the model can be used when designing RVCs.

## 1.2 Research Problem

The research problem addressed in this thesis is to find out what an appropriate level of trust in an RVC is, and how one can design an RVC to achieve that level of trust. This also means that what factors affect trust in domestic robots, and specifically RVC must be investigate and presented.

### 1.2.1 Research Questions

- What affects users' trust in domestic robots, specifically robotic vacuum cleaners?
- How can design facilitate an appropriate level of trust?

## 1.3 Delimitations

There are many different automated robots a human may interact with, but for this project the focus will be on robotic vacuum cleaners. The literature studies will however be carried out on literature concerning different robots and with a focus on trust with the intention of applying the appropriate findings on domestic robots, but mainly robotic vacuum cleaners. Robotic vacuum cleaners has been chosen because they are a current piece of automated robot technology that exist in relatively many people's lives while expected to become increasingly more common in the not so far future. The technology is at the same time being continuously innovated with new designs, functionality, and better reliability for each iteration of the major providers flagship models.

## 1.4 Ethical Considerations

The main ethical considerations that needs to be taken during the writing of this thesis is how to handle personal information of the participants of the user studies and interviews that will be conducted. This should be done with care so that information that is not directly relevant to the study or that handles sensitive information about the persons involved in the studies is not collected. It is also important for us to know in what extent the General Data Protection Regulation (GDPR) affect us and the data we gather, and adhere to the rules of GDPR.

# 2
# Theory

Having automated systems in different parts of society is not necessarily new. Automation has been existent in various industries since 1961, when the first Unimate robot was used at the General Motors Plant in Turnstedt (Henderson, 2006). In order to provide sufficient background information for reading this report, this chapter will expand on information about robots, automation, and trust, as well as some general theory of Interaction Design.

## 2.1 Robots

Most people probably have an idea of what a robot is, but for the sake of creating a common understanding between the reader and the authors, the term robot will be explained. The word robot has origins in the Czech language, where the word *robota* means *compulsoury labor*, and is defined by Merriam-Webster as "*a machine that resembles a living creature in being capable of moving independently (as by walking or rolling on wheels) and performing complex actions (such as grasping and moving objects)*", "*a device that automatically performs complicated, often repetitive tasks (as in an industrial assembly line)*", or "*a mechanism guided by automatic controls*" (Merriam-Webster, 2019). In this report the word robot will be used in accordance with all of these definitions with the main aspect being that the robots are automated.

### 2.1.1 Automation

In order for robots to function, they need to have some form of automation. The automation can be described as a pre-programmed behaviour suitable for the robots specific task, but automation can also be artificial intelligence, or AI. While also being pre-programmed, AI gives the robot a way of deciding which actions to perform when and how. Common examples of automation that has been used for a long time in technology are industrial robots manufacturing products in an assembly line, automated telephone switchboards, analytics, and ship controls, to name a few of many. Today, however, both automation and automated robots are swiftly moving into everyday life of people. Voice controlled assistants (Juniper Research, 2018), like Alexa or Google Assistant, commercial cars with automated driving and driver-assistance (Strategy&, 2017), like Tesla, and automated lawn mowers and vacuum cleaners (Statista, 2017) are all becoming increasingly more popular.

### 2.1.2 Domestic Robots

In this project we will focus on domestic robots, and more prominently robotic vacuum cleaners. Domestic robots are automated robots which operate in or around the home, for example robotic vacuum cleaners, robotic lawn mowers, and ironing robots. The purpose of these robots are generally to do things around the home which otherwise humans would do. Because of this, the human should be able to trust the robot to do a good job so that the human does not have to do it themselves, as that would render the robot useless. A failure in a domestic robot is unlikely to result in harm or immediate danger for the human, and a catastrophic failure would in a worst case scenario result in a destroyed piece of clothing (ironing robot) or a floor smeared with dog faeces (vacuum cleaner). Thus, the risks involved are not as high as with for example industrial robots or autonomous vehicles.

## 2.2 Trust in Automated Technology

The aim of this project is related to the trust humans have for automated robots and this section explains what is meant with trust and why it is an important factor when design automated robots.

During this thesis there was a need for a definition of trust between humans, to serve as basis for a definition of trust between human and robot. Creating this was done by analysing different previous definitions of trust by other researchers such as Mayer, Davis, & Schoorman, who defined trust as "*the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.*" (Mayer, Davis, & Schoorman, 1995). From this, a definition of trust between humans was formulated as one individuals inclination to believe in another individual, or group of individuals, to behave and act as expected. In this report however, *trust* will be used to describe *the feeling a human user have towards a robot in terms of the robot doing its intended job in a desired manner and without fail.* The operative word in that definition being feeling, as it is the emotions of the human we are focusing on, rather than the correctness of their perception of the robot's reliability.

There are of course different things which affect the trust a human feel in a robot. Michael Lewis (2018) mentions different properties of the automated system and the operator which affects trust. These properties are system reliability, system faults, system predictability, system intelligibility and transparency, and levels of automation for the system and propensity to trust, self confidence, and individual differences and culture for the operator. Further, he also mentions that some environmental factors play in, with risk seemingly being the biggest factor.

In a 2015 paper, Hoff and Bashir (2015) explains that many different factors affect the trust between what they call the truster and the trustee, where the trust is built upon the truster's receptiveness to rely on the actions of the trustee, which in this case would be a Human and a Robot. For example, they claim that it is not only the robots AI and actions which might negatively or positively affect the trust, but also the outcome of a scenario when the robot or automated system has been misused as a result of the truster's, i.e. the user's, lacking trust or over-trust in the trustee, i.e. the robot.

### 2.2.1 Insufficient Trust

A user not having enough trust in an automated system or robot can lead to a failed result. If, for example, an automated system in a production line of a factory warns that something is wrong and the operator dismisses the warning, thinking it is a false alarm, the production line could potentially stop because of a fault in the automated system which could have been prevented if the operator had had trust in the automated system. In this case, it would have been better for the user to trust in the automated system.

### 2.2.2 Over-Trust

As opposed to not having sufficient trust in an automated system, a user can have too much trust in the system, which in turn can also lead to a failed result. In 2016 the first recorded fatal crash involving a Tesla using autopilot occurred. The National Highway Traffic Safety Administration (NHTSA), a child agency of the United States Department of Transportation, created a report in which information about the crash can be found. NHTSA (2018) describes how the accident occurred as the Tesla was travelling on the highway, crashing into the trailer of a truck which was making a turn across the cars' lane, while the car's autopilot was in control. According to the report Tesla's autopilot is an autonomous driver assistance tool for controlling the car during highway travel by keeping it in a lane and keeping the driver safe, but is not meant to be viewed or used as complete autonomy.

It was also reported that the driver had not been following the instructions for operating the vehicle during autopilot, which include keeping one's eyes on the road and being observant of the surroundings as well as keeping one's hands on the steering wheel. The system is designed to give audible and visible warnings to the driver when their hands are not on the steering wheel, but according to NHTSA (2018) the user had in this case ignored multiple warnings, both visual and auditory, before the crash. This, in combination with the fact that the driver had used the car for over 45 000 miles and posted positive comments about the car and autopilot on social media (Abrams & Kurtz, 2016), indicates that he trusted the car's autopilot, even when getting safety warnings, thus misusing the system by putting to much trust in it.

## 2.3 The Connection to Interaction Design

Interaciton Design is the process of designing the interaction between user and product. Preece, Rogers, and Sharp (2015) defines interaction design as "*designing interactive products to support the way people communicate and interact in their everyday and working lives*". As trust is developed through interactions it is important to incorporate design theory regarding how to design for interaction in order to be able to design for trust.

For example theory about how to evaluate a user's interaction with mobile phone application can be equally useful for looking at how another user interacts with an RVC. At least if focused upon things such as interview techniques, different ways of measuring user feedback, etc.

With more and more of interaction between user and RVC going through apps and smart home systems, rather than say a physical remote control, (e.g. Colon, 2020; Ansaldo, 2020) the process of designing such systems becomes a more important aspect of designing a good interaction with an RVC. As such it is important to look at the theory behind UI design in this thesis.

To use colours as an examples Cooper, Cronin, Noessel, and Reimann (2014) writes a lot of what to think about when using colours when designing an interface. Among those are how colour palettes should be used differently depending on the intended user. Cooper et al. (2014) states that the colour palette should be narrow and conservative when targeting intermediate users. They also write that accessibility is important when it comes to colours and interfaces should either be adapted for colourblind users or they should have an option to enable a separate colour palette that does, as well as colour should not be the only method used to convey meaning or importance. Furthermore they state that some colours comes with societal and cultural values. One of the examples they use is that in western societies the colour red is associated with stop signs and warnings, while in China it is linked to good luck.

Another thing to consider when designing with mobile applications in mind is the possibilities and limitations of the smart phone as a hardware. For example due to the small size of the screen and limitations programmed into the operating system of the majority of mobile devices most application should be made to use full-screen (Cooper et al., 2014). Moreover the screen of a smart phone is not only a way to displaying information, but also a method to input commands to the application. Different touch gestures needs to be considered when designing for mobile applications and the designer must also consider how the different gestures are usually used within the OS. For example the swipe function is used to navigate backwards and forwards in Apple's Safari browser, whereas in Google's Chrome it is used to delete browser tabs (Cooper et al., 2014)

# 3
# Methodology

This chapter deals with how the thesis was structured. It starts with an overview of the design process and the subsequent plan. From there on the chapter follows a pattern where it first describes the methods that were used and then in a later section how they were used specifically in this thesis. In the case a method was used in several different phases of this project (for example interviews) then that methodology will only be described once in the phase it was first encountered, whereas the execution of said method will be presented in every phase that it was used in.

## 3.1 Design Process and Planning

The Framework for Innovation, or the Double Diamond as it also is known as, is a model of a design process created by the Design Council (Design Council, 2019). The process contains four phases that are paired into two doubles, thus creating the double diamond shape the method is named after (see 3.1).

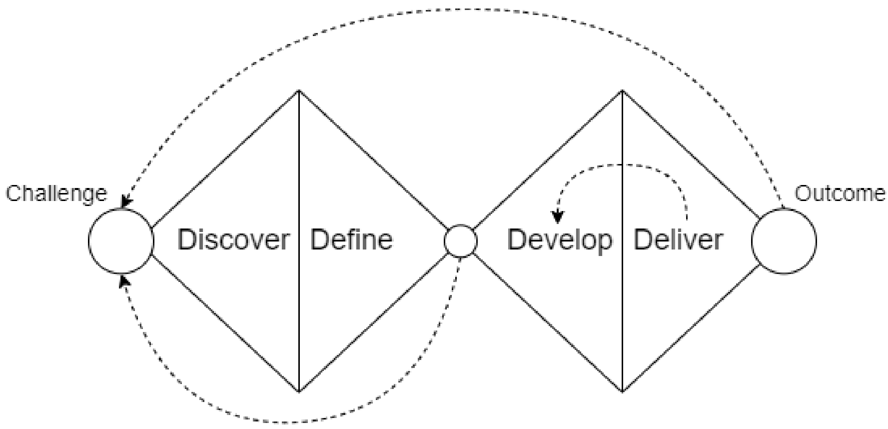



**Figure 3.1:** The Double Diamond, its four phases and suggested places to iterate

1. The *Discover Phase* is about understanding what the challenge is about. It is about gathering information through other research and by different methods to understanding the users.
2. In the *Define Phase* the information from the Discover phase is processed and analysed.
3. During the *Develop Phase* ideas are developed and tested. This is the first phase where a product should be considered. Brainstorming methods, scenarios and prototyping takes place here.

4. At the *Deliver Phase* the solution to the challenge is tested, and the product is improved.

While the Double Diamond has a progression which starts with a challenge and then moves right through the different phases towards an outcome. However, users of it are encouraged to iterate and take steps back if needed. For example if during the Discover and Define Phases it was discovered that your view of the challenge needed to be updated it could be wise to move back and redo the Discover Phase with this new challenge in mind.

This thesis uses the Double Diamond design process as a way to structure how the design part of the project proceeds with a few minor exceptions. The main one being that the written thesis can be seen as a deliverable, but was continuously written during the entire project. Another deviation is that the literature study was both used as part of the design process and a project that can stand on its own. Therefore it uses different methodology specifically meant for literature studies (see 3.2), while it is also considered a part of of the Discover and Define Phases of the Double Diamond.

From that structure a time plan was created. The first two weeks were completely focused on doing a literature prestudy and writing the planning report. This was done at the beginning of the project and part of it was coming up with this plan, as such it was considered finished when a plan for the rest of the project had been created.

The rest of the project came to be divided into three different parts. The *Literature Study* uses the methods created by Wolfswinkel, Furtmueller, and Wilderom (2013), which includes the Preparatory Stages in which search criteria are defined and databases are searched for articles, the Reading Stages in which articles are read and analysed, and the Present Stage in which data is structured so it can be written about in the report. This was planned to be done between week three and 16 of the project. For a more detailed explanation of the literature study see section 3.2.

Then there is the *Design Process* in which the prototype or concept described in Aim (1.1) is developed. This was planned to be done in three phases and starts at week four. The first is the Discover Phase, which last for three weeks and deals with gathering data about human-robot interactions. This is considered complete when sufficient data about the RVCs and trust has been gathered. The second phase is the Define Phase in which said data is analysed and grouped. This was also scheduled to take three weeks, it was to be considered finished when the data from the previous phase has been analysed and processed in such a way that it can be presented in the thesis.

Last is the phase called Develop and Deliver in which a prototype or concept is developed and evaluated through several iterations. This combines the two last stages of the diamond as, at the time of writing, flexibility to divide time between the Develop and Deliver Phase was desired after the Define Phase was completed. This was planned to last until week 16 of the project. The Develop Phase was to be considered finished once an idea of how to test how trust in RVCs has been developed and the Deliver Phase is completed when said ideas has been tested and updated according to the tests.

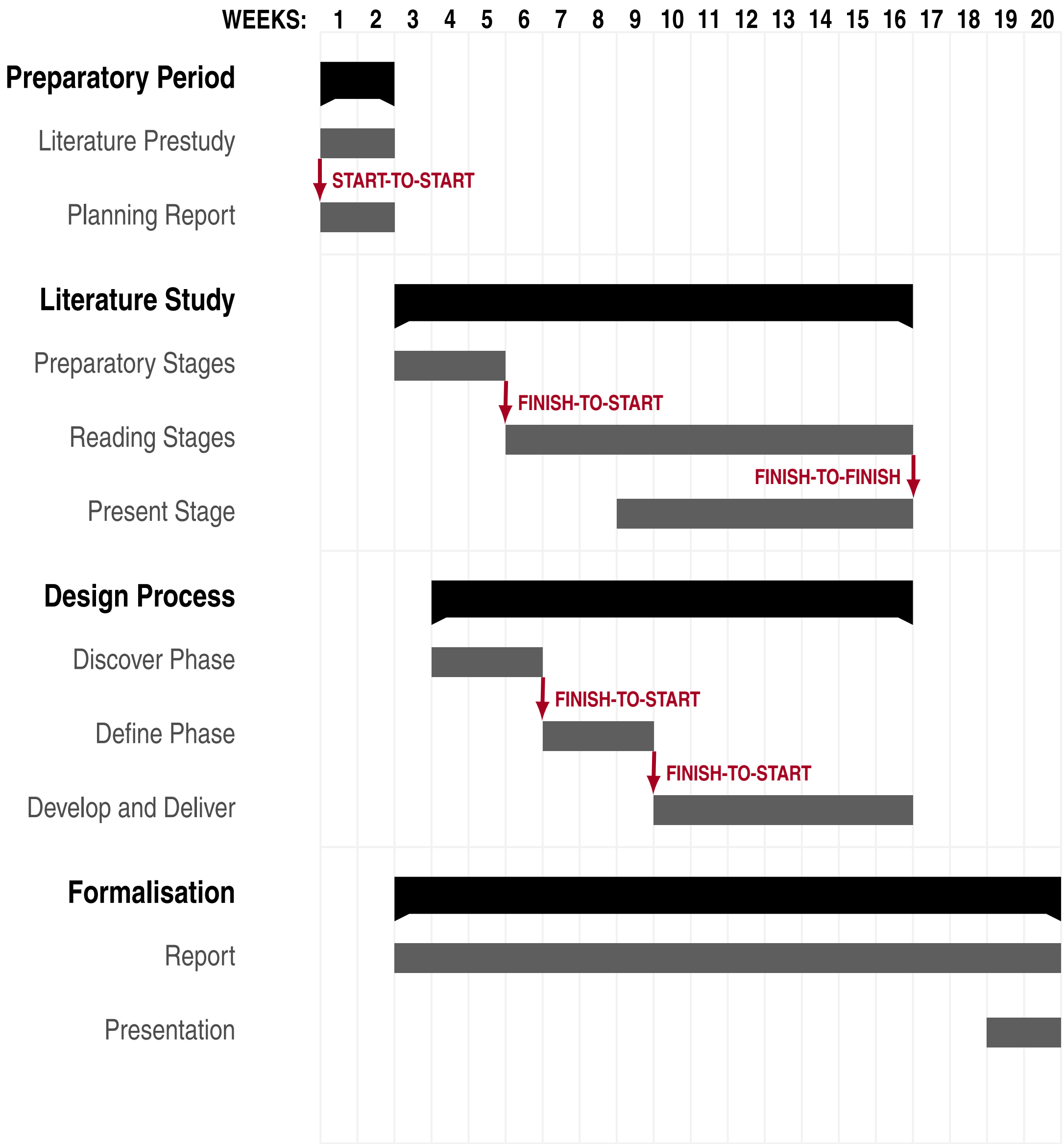



**Figure 3.2:** A Gantt Chart detailing the planned process for this project.

The last part is the *Formalisation* part, in which writing the report is the largest part. It was planned to start at week three and last until the end of the project at week 20. With week 17 and 18 solely focused on writing the report. During week 19 and 20 work on the presentation was planned to take place. Once the report has been handed in the project is considered to be completed. For a more graphical overview of the time plan see the accompanying Gantt Chart (Fig. 3.2).

## 3.2 Literature Study Methods

A large part of this thesis is the reviewing of literature and finding out what others have written about trust in robotics, and especially domestic robots like RVCs. As such a framework for how to methodically review literature is needed. Therefore, this thesis bases its literature study on the grounded theory for reviewing literature as described by Wolfswinkel et al. (2013), and recommendations for how to read studies by Booth, Colomb, Williams, Bizup, and FitzGerald (2016).

Wolfswinkel et al. (2013) describes a five-stage method for doing a literature study. The five stages are Define, Search, Select, Analyse and Present. This method is used to find and categorise sources, as well as presenting a large quantity of data gathered from said sources.

Booth et al. (2016) on the other hand deals more with how to read a source, in a more literal sense. The book deals with how to take notes, which part of an article to pay extra heed to as a reader and in what order one should read a source. As such both Wolfswinkel et al. (2013) and Booth et al. (2016) was selected as good instructions for how to conduct a well thought-out literature study.

### 3.2.1 Define Stage

The first part of the study is about defining criteria for the study. Wolfswinkel et al. (2013) has named this the *Define Stage* of the study. In this stage one should define different criteria for what to include and exclude in the study. Wolfswinkel et al. (2013) suggest to base these limitations on time of publication, publication outlet, fields of research and to try to find other criteria that are relevant to their study.

During this stage of the literature study it is important to start keeping notes of why certain decisions were taken, both in case something happens further into the study that makes one want to redefine some of the criteria and as an aid when presenting the results of the study. The last step of this stage is to define search terms according to Wolfswinkel et al. (2013). A table with these criteria along with the specified search terms can then be constructed (See Table 3.1 for an example).

| **Define** | | | |
|---|---|---|---|
| **Criteria for insertion/ exertion** | **Identify fields of research** | **Determine the appropriate sources** | **Decide on the specific search terms** |
| Criteria A | Field A | Database A | Search Term A |
| Criteria B | Field B | Database B | Search Term B |
| | | | Search Term C |

**Table 3.1:** A table of criteria used to define search terms in the study.

### 3.2.2 Defining the Literature Study

At the beginning of the Define Stage four steps were taken to find definitions for the literature study in accordance with Wolfswinkel et al. (2013). These steps were "*Define the criteria for insertion/exertion*", "*Identify fields of research*", "*Determine the appropriate sources*", and "*Decide on the specific search terms*". For the first step the following criteria for articles to be include in the study were defined:

**Criteria**

1. Must contain at least one search term related to trust or similar and one search term related to technology
2. Search terms must be found in title, abstract or subject listing of the paper
3. Written in English
4. Filter out any mention of HRIS when searching for HRI

The first criteria was created to focus on the cross section between trust research and robotics research. The second criteria was there to help finding relevant articles and to save time. For the third criteria we discussed including papers written in Swedish too, but decided against that due to the limited selection of research done in Swedish as well as us writing in English we figured the sources used in the literature study should be able to be checked by anyone who speaks English regardless of whether they speak Swedish or not. The last criteria was created by necessity as a search for ”HRI” gives results for ”HRIS” (Human Resource Information System) and was considered irrelevant for our research.

Next step was to define which fields of research to include in our study:

**Fields of Research**

1. HRI
2. Robotics
3. AI
4. HCI
5. Cognitive Science

HRI and Robotics were our main fields that we expected most of our papers to come from. Whereas, AI, HCI and Cognitive Science were chosen so that papers that were specialised in a field of related to our subject could be included in our research, though we expected to have to do a deeper review to know whether to include papers from these fields in later steps.

It should also be stated that going into the research we expected that search engines and databases would have an option to filter for fields of research. It turned out that that was not the case and there was not any simple way of filtering articles by fields of research. Therefore, these criteria were not used to filter out results, but rather something taken into consideration when manually selecting articles as well as for creating the criteria to filter out HRIS.

Next we decided on which search engines and databases to use in our research:

**Search Engines / Databases**

1. Google Scholar
2. Chalmers Lib

Google Scholar is a big search engine that offered us access to many different databases. Chalmers Library (Lib) on the other hand is a collection of databases curated by Chalmers University. Scopus and IEEE was also considered at the beginning of the project, however, it turned out that the Chalmers Library had access to those databases and included them in their search result. Therefore, it was decided to not use them as a primary source for this study.

Finally the actual search terms were decided:

**Search Terms**

1. Trust
2. HRI
3. Robot(s)
4. Trustworthiness
5. Robotic Vacuum Cleaner

”Trust” was chosen as our initial search term to focus our research on trust, this was soon expanded to include ”Trustworthiness”. As some researchers define their trust research with that term and as such we needed to expand our definition in order to be able to include articles that were relevant to our study but did not satisfy Criteria 2.

”HRI”, ”Robot(s)” and ”Robotic Vacuum Cleaner” were included to satisfy Criteria 1. Here ”HRI” and ”Robot(s)” were broad terms that helped find research related to trust in robotics. Whereas we were a bit more lenient when it came to the very specific ”Robotic Vacuum Cleaner” term in terms of how well it satisfied Criteria 1.

The following search terms were considered, but ultimately not included in the study:

**Rejected Search Terms**

1. Automation
2. Automative System(s)
3. Smart Home
4. Behaviour
5. Acceptance
6. Overtrust
7. Undertrust

”Automation” and ”Automative System(s)” were considered to lean too much to the industrial side of robotics and a sufficient amount of articles were found using the other search terms that in the end they were not used in the study. For similar reasons while being in a domestic setting ”Smart Home” was not included because we thought it went to far away from the robotic aspect of this study.

”Behaviour” and ”Acceptance” were considered to be compliments to the ”Trust” search term and to be used to expand Criteria 1. However, as we at that point had not conducted the literature study we felt that it would lower the quality of the study to just propose that those terms had a relation to trust when it was that relation we were exploring. Thus it was decided to not include them in this study.

Last ”Overtrust” and ”Undertrust” were not included by the simple reason that there was a too big overlap between those terms and ”Trust” as a term. Both terms gave a small sample of papers and those papers had already been included in our study when using the ”Trust” term.

For the complete list of definitions used in this literature study looks see table 3.2

| Define | | | |
|---|---|---|---|
| **Criteria for insertion/ exertion** | **Identify fields of research** | **Determine the appropriate sources** | **Decide on the specific search terms** |
| One term of each type | HRI | Google Scholar | Trust |
| Where to find terms | Robotics | Chalmers Lib | HRI |
| Written in English | AI | | Robot(s) |
| Filter out HRIS | HCI | | Trustworthiness |
| | Cognitive Science | | Domestic Robot(s) |
| | | | RVC |

**Table 3.2:** A table of definitions used to search for papers relevant to the study.

### 3.2.3 Search Stage

The next stage is the *Search Stage*, in which Wolfswinkel et al. (2013) instructs the researcher to use the conditions defined in the previous stage to find articles relevant to the study. In this stage it is common for researcher to find things that requires them to reconsider the previous definitions. While this can be time consuming Wolfswinkel et al. (2013) recommends researcher to go back and revisit those definitions.

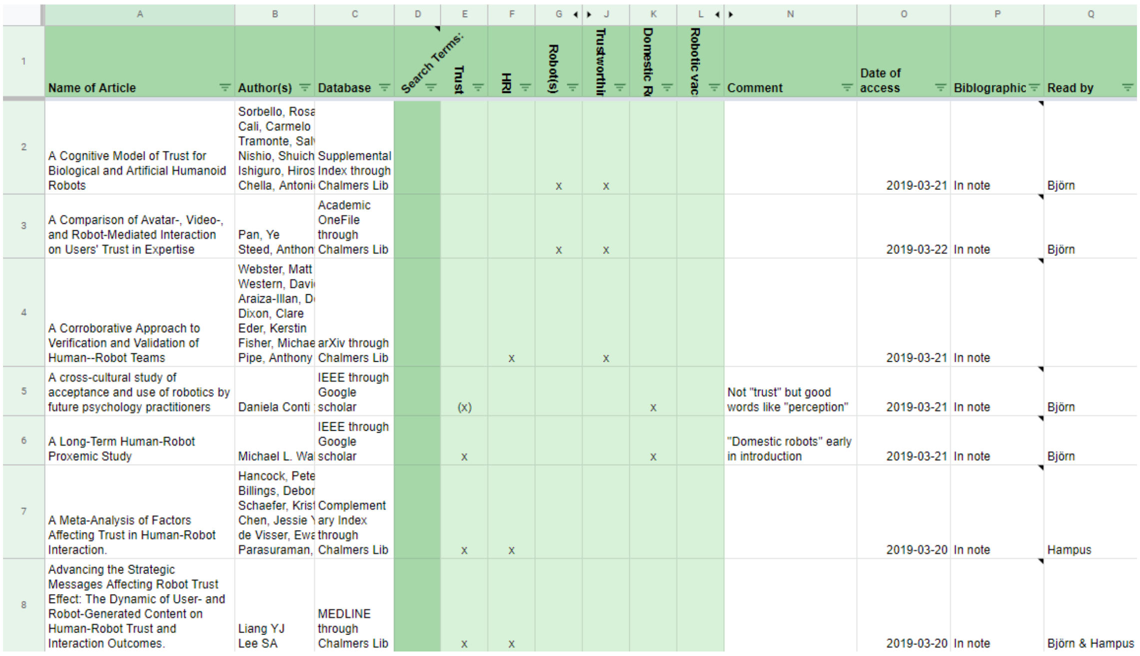
Another thing that they stress is the importance of documentation early in the study. Not only should one write down the bibliographic information in this stage, but also the search terms that helped the researchers find the article Wolfswinkel et al. (2013). Booth et al. (2016) also recommends that one writes down all bibliographic information before one starts reading the source.

### 3.2.4 Searching for Literature

With the criteria for inclusion to our literature study decided we started to search for articles to include in our study. Once an article had been found a pdf version of the article was downloaded and saved on Google Drive. To get an overview of the collection of papers we created a database in Google Sheets where we wrote down information about the paper, where and how it had been found, as well as who had read it (see figure 3.3). In total 70 papers were included into the database during the Search Stage of the literature study.

### 3.2.5 Reading Stages

Once the articles has been found they need to be filtered, Wolfswinkel et al. (2013) calls this the *Select Stage*. The researcher should be looking for doublets and articles that do not fit the research criteria. The filtering itself is done by reading the title and abstract, and sometimes more, of the papers. At this stage forward and backward citations should also be be checked to see if there are any other text that should be included in the study. The last step of this stage is to see if any new texts has been added to the sample size, and in that case the steps of the Select Stage need to be done again. Once this has been done it is possible to order the papers into different



| | Name of Article | Author(s) | Database | Search Terms: | Trust | HRI | Robot(s) | Trustworthi | Domestic R | Robotic vac | Comment | Date of access | Bibliographic | Read by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | A Cognitive Model of Trust for Biological and Artificial Humanoid Robots | Sorbello, Rosa Cali, Carmelo Tramonte, Sal Nishio, Shuich Ishiguro, Hiros Chella, Antoni | Supplemental Index through Chalmers Lib | | | | x | x | | | | 2019-03-21 | In note | Björn |
| 3 | A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Pan, Ye Steed, Anthon | Academic OneFile through Chalmers Lib | | | | x | x | | | | 2019-03-22 | In note | Björn |
| 4 | A Corroborative Approach to Verification and Validation of Human--Robot Teams | Webster, Matt Western, Davi Araiza-Illan, D Dixon, Clare Eder, Kerstin Fisher, Michae Pipe, Anthony | arXiv through Chalmers Lib | | | x | | x | | | | 2019-03-21 | In note | |
| 5 | A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Daniela Conti | IEEE through Google scholar | | (x) | | | | x | | Not "trust" but good words like "perception" | 2019-03-21 | In note | Björn |
| 6 | A Long-Term Human-Robot Proxemic Study | Michael L. Wa | IEEE through Google scholar | | x | | | | x | | "Domestic robots" early in introduction | 2019-03-21 | In note | Björn |
| 7 | A Meta-Analysis of Factors Affecting Trust in Human-Robot Interaction. | Hancock, Pete Billings, Debor Schaefer, Krist Chen, Jessie Y de Visser, Ewa Parasuraman, | Complementary Index through Chalmers Lib | | x | x | | | | | | 2019-03-20 | In note | Hampus |
| 8 | Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Liang YJ Lee SA | MEDLINE through Chalmers Lib | | x | x | | | | | | 2019-03-20 | In note | Björn & Hampus |

**Figure 3.3:** A screenshot of the database we used to organise papers during the literature study.

stacks, but Wolfswinkel et al. (2013) recommends caution when doing so, and brings up the examples of only doing when there are distinct disciplinary or stakeholder differences.

The next stage that Wolfswinkel et al. (2013) call the *Analyse Stage*, in it articles are read thoroughly and grounded theory is applied to the process. Three types of coding is done each article. First the articles are read and excerpts are created, the excerpt(s) is then reread and "concepts" are identified. Those concepts are put into "categories" and both the concepts and categories can be given "properties". This process is called open coding.

Next step is called axial coding, in which the relationships between categories are explored and subcategories can be created. Then the selective coding step main categories that relates closely to the research question(s) are identified and refined. In order to help with this stage Wolfswinkel et al. (2013) suggest using a tool called a concept matrix (table 3.3) to get an overhead view of the concepts that are being worked with. The columns of the matrix can be merged or split during the study as the researchers read more texts and gets a deeper understanding of how the concepts relate to each other. Wolfswinkel et al. (2013) also recommends researchers to read articles in a random order.

### 3.2.6 Reading and Making Observations

Out of the 70 papers found 46 papers were read, however it turned out that one of said papers were found out of scope as it had defined trustworthiness as a measurement of the accuracy of data. Also we had tried to divide the papers among us so that we could read as many as possible. As such only one paper was read by both

| Article | Concepts | | |
|---|---|---|---|
| | X | Y | Z |
| A | √ | √ | √ |
| B | √ | √ | |

**Table 3.3:** Concept matrix by Wolfswinkel et al. (2013)

of us, this was due to us picking the same paper at the same time.

To help organise our research during the Reading Stages of the literature study another database was constructed, once again in Google Sheet. This database included three columns; article name, the observation itself, and in the third column called "type" we used to divide different observations into different categories (see figure 3.4). When the Reading Stages were finished we had collected 357 different observations.

| | A | B | C |
|---|---|---|---|
| 1 | **Article** | **Observations** | **Type** |
| 2 | The future African workplace : the use of collaborative robots in manufacturing | Article brings up the fourth industrial revolution and the usage of smaller industrial robots. | Meta |
| 3 | The future African workplace : the use of collaborative robots in manufacturing | Trust determines acceptance - *"Human–robot trust determines a worker's acceptance of a Cobot in a collaborative work environment."* | Human |
| 4 | The future African workplace : the use of collaborative robots in manufacturing | *"Billings et al. (2012) indicates that human characteristics, environmental characteristics and robot characteristics influence human–robot trust. Additional factors include usability, social acceptance, user experience and societal impact (Weiss, Bernhaupt, Lankes & Tscheligi, 2009)."* | Meta |
| 5 | The future African workplace : the use of collaborative robots in manufacturing | *"The major challenges for South African and African businesses that introduce Cobots at the employee level are fear of redundancy, retrenchment and increased unemployment"* | Human |
| 6 | The future African workplace : the use of collaborative robots in manufacturing | *"The major training needs for the introduction of Cobots at employee level are greater technical training, trust and safety, understanding robotic functionality and employee loneliness"* | Human |
| 7 | The future African workplace : the use of collaborative robots in manufacturing | *"'In the long term there might be some emotional support needed as the job might become lonely without other humans in the proximity'"* | Human |
| 8 | The future African workplace : the use of collaborative robots in manufacturing | Feeling that the robot depend on the human leads to trust | Robot |
| 9 | The future African workplace : the use of collaborative robots in manufacturing | feeling that the human is in control leads to trust. | Human |
| 10 | The future African workplace : the use of collaborative robots in manufacturing | *"Interestingly, the automotive manufacturer respondents, some of whom have introduced Cobots, did not think 'culture' had a major impact on HRI"* | Enviroment |
| 11 | A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Robots are prefered to avatars when seeking advice. | Human |
| 12 | A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Physical presence leads to trust | Robot |
| 13 | A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Gender can influence trust in computer recommendation systems. | Robot |
| 14 | A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Respondent throught "Robots must be intelligent" (humanoid robot in this case) so they trusted them more. | Human |

**Figure 3.4:** A screenshot of the database we used to organise our observations during the literature study.

### 3.2.7 Present Stage

In the last stage, the *Present Stage*, the concepts developed in stage four and presenting them to a wider audience. Wolfswinkel et al. (2013) recommends that this is done through a two step approach. First one should structure the content in a way that is based on the findings and insights from the Analyse Stage. Then Wolfswinkel et al. (2013) encourages researchers to go deeper than just presenting the concepts in tables, but to also use graphical representations. They use an Euler diagram as a good example. The circles of the diagram represents concepts, and the size of them shows how many articles said concept has shown up in. The overlap between circles show an overlap between concepts in the articles.

In the final step Wolfswinkel et al. (2013) describes how to include one's findings into a research article and details how such an article should be written. This follows a rather standard layout, starting with an introduction. This is followed by a methodology chapter. Then a main section where the findings of the study is presented and discussed. The article is ended a discussion and/or conclusion.

### 3.2.8 Diverging from the Literature Study Methodology

At the start of the literature study it was carried out with strict adherence to methods written by Wolfswinkel et al. (2013). However as the study went forward it started to diverge from the theory and other methods were implemented. This means that the Preparatory stages were carried out in accordance with Wolfswinkel et al.

During the Reading stages this divergence started to happen. To begin with the Select and Analyse Stages were carried out simultaneously. Secondly after the excerpts were created we opted to stop using Wolfswinkel et al's methods and switched to using an Affinity Diagram instead (see 3.4). However, the recommendation about the Present Stage were still kept in mind when writing the chapter that presented results of the literature study.

## 3.3 Discover Phase

The first phase of the Double Diamond required methods aimed at understanding the different domains of the project. Whether from a user perspective, a product perspective, or a business perspective. As such different design methods that helped with creating such understanding needed to be selected. In this phase methods that Martin and Hanington (2012) has defined having the research facet of being 'exploratory' as well as one of 'participatory', 'observational', or 'self-reporting' was used as a base for finding methods.

The literature study that is being done along side the design part of this is going to double as a literature review as described by (Martin & Hanington, 2012), but the details of that is described above.

### 3.3.1 Interview Methodology

An interview can essentially be seen as asking questions and getting answers, and includes a multitude of from emailed questionnaires to telephone surveys, however the most common type of interviewing is the individual face-to-face verbal interchange (Fontana & Frey, 1994). Interviews can differ in structure, from the the strictly organised structured interview, in which the interviewee can only select from a limited set of responses, to the free form unstructured interviews which has a great breath (Fontana & Frey, 1994). Then there is the semi-structured format that allows for both standardised questions as well as letting the interviewee stir the conversation into unexpected directions (Preece et al., 2015). Group interviews such as focus groups are also under consideration for this project(Preece et al., 2015).

For this project interviews were used during different parts of the process, with different goals. Thus, the interviews took different forms. An expert in the area of robotic vacuum cleaners was interviewed with the purpose of finding out how designers and producers look at the trust aspect and in which ways the users interact with the robotic vacuum cleaners today as well as in the future. Some questions were prepared beforehand, but since the expert had extended knowledge that we did not possess the interviews was semi-structured, but leaning towards unstructured.

Interviews were also conducted with users of robotic vacuum cleaners. During these interviews the goals was to get information about how the robotic vacuum cleaners are used today and what the attitude towards the robotic vacuum cleaners are today, in regards to trust. In order to get results based on a common understanding of trust the term was explained and the interviewees were asked to relate to this explanation of trust. However, since different peoples definition of trust may be deeply rooted the interviews were more structured than that conducted with the expert and the questions were more specific, rather than broad. However they still had a few questions of the unstructured variety, thus making the interview as a whole semi-structured. The identities of all interviewees is kept anonymous for ethical reasons.

### 3.3.2 Subject Expert Inquiry

Because of a lack of articles that specifically focused on the trust in RVCs we decided to fill that gap in our research by interviewing a product owner at a large company that manufactures RVCs. The interview was conducted via a voice chat program that the expert's company provided us with.

In order to better structure we decided to write an interview guide. This guide contained both questions to ask and goals to consider during the interview, as well as some simple instruction on how we were to conduct it. For example we had a prewritten welcome and good bye script. The questions were divided into three categories. The first dealt with background questions for the interviewee, who he was, and what kind of experience he had. The second was exploring RVCs in regards to how the interviewee viewed them, especially in regards to trust. The last category of questions were about presenting our ideas and getting his input on those.

The goals were used to help us write questions before the interview as well to guide the conversation in case we were to go off script during it. This is the complete list of goals we had selected:

1. *Test how different types of methods of notifying the user affects trust.*
2. *Test how different responses by the robot and the relation with how it notifies the user about them affect trust.*
3. *What do I want to say about this interview afterwards?*

During the interview one of us asked questions, while the other transcribed what was being said. That script was then condensed into several notes that were put into the same analysis method as the observations from the literature study. However, to help us tell where the information was coming from observations from the interview was colour and shape coded differently from those from the literature study.

## 3.4 Define Phase

In the second phase of the project methods for processing and analysing the data collected in the first phase is needed. Martin and Hanington (2012) describes many of these. Among them is Affinity Diagramming, which is useful for concretising data and could be a very fitting method for the data gathered trough interviews during the Discover Phase. Martin and Hanington (2012) also describes the method Content Analysis. Content Analysis is also useful for the data that is produced from interviews, but may result in a deeper and more detailed analysis and uses the qualitative data to create quantitative data. Further, Affinity Diagramming can also be used to analyse the resulting themes that emerge from the Content Analysis.

### 3.4.1 Analysis

To help get an overview of our observations we used the affinity diagram method (Martin & Hanington, 2012). Due to a lack of a permanent workspace where we could physically store our work for an extended period of time, we opted to use a digital whiteboard instead of a physical one. We opted to use a platform called Stormboard (`www.Stormboard.com`) that offered both whiteboard's writing functionality and simulated sticky notes.

The actual affinity diagram was constructed by copying over our observations from a database (see 3.2.6) into the digital whiteboard. The colour coding was kept by selecting the same colour as the notes were flagged with for the the digital sticky notes. As we were copying over the observations we began to cluster the notes together if they shared some characteristic, which we labelled with a bigger white sticky note. The clusters started out rather organically with no predefined common denominator, but the characteristics gradually became more clear and defined. For example any note that mentioned trust was clustered together with other notes that mentioned trust.

When all observations had been copied over, we began to look at the bigger clusters and created smaller clusters within these clusters. Particularly big clusters where divided into smaller clusters. For example the cluster labelled "*Trust*" was turned into "*Trust Prediction*", "*What Affects Trust*", "*What Trust Affects*" and "*Designing for Trust*". Inside these clusters subclusters were also formed, these however were not labelled and only marked by being closer to to each other than to other notes on the whiteboard. For example all notes that said that trust leads to more use was put into one subcluster inside the "*What Trust Affects*" cluster. The final whiteboard is shown in figure 3.5.

In order to also get the information from the subject expert inquiry into the affinity diagram of the observations we applied a coding method inspired by the one used in content analysis. However, as keeping the information in qualitative form was still desired not all steps of the method was used. The coding was instead used to find out where on the existing affinity diagram these observations would fit.

From there on we started identify concepts highlighted by the clusters on our whiteboard and looked for relationships between those concepts. To help with this we used a free online diagram software called Draw.io (`www.draw.io`). The program

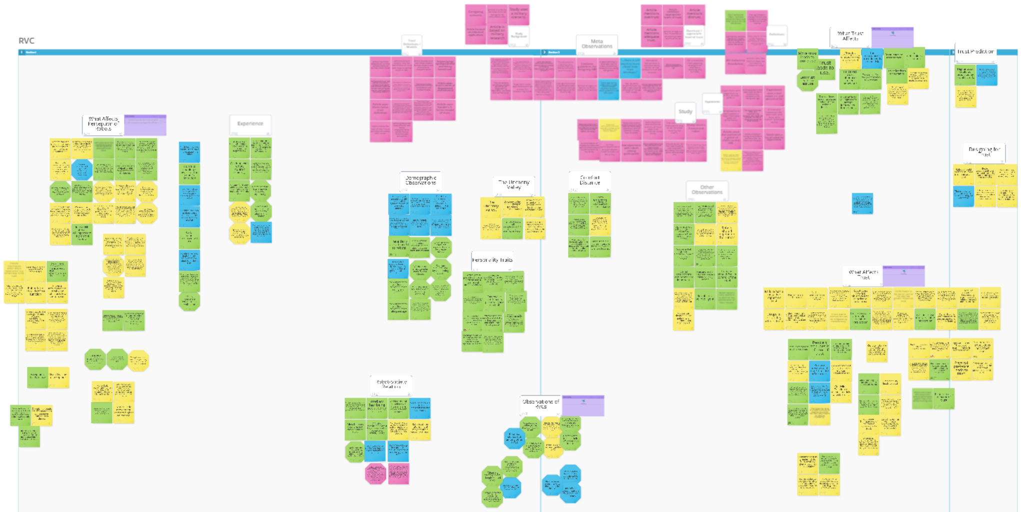


**Figure 3.5:** A screenshot of the digital whiteboard used during the thesis

allowed us to create geometrical shapes, write inside them and draw arrow between them. For example we had an observation that said "*trust leads to use*", which meant that we created two bubbles, one labelled trust and one labelled use, and drew an arrow between them (see 3.6).

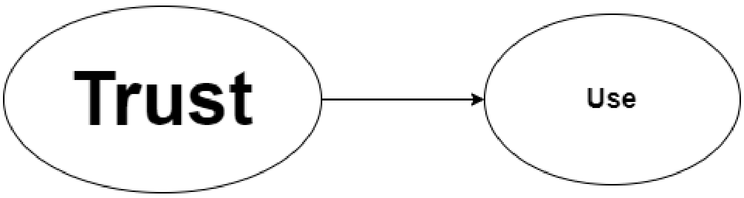



**Figure 3.6:** An example of how we represented the relationship between trust and use in Draw.io

This worked for most observations we found as they often were straight forward. However, we did get a more complex relationship in what we came to call the "*Mental Model*" (see 3.7). This category was centred around how people create a mental model of how a robot behaves that might not correspond to how it actually does behave in reality. We had relatively few observation that directly talked about the mental model of a robot or a user's perception of a robot, but many observations on things that affects said perception in a similar manner to each other. For example the effect of the perceived gender of the robot was brought up in a few of the articles, and it was stated that the perceived gender of the robot matched with what gender users expected it to have had an effect on both how positive the encounter was perceived and on trust. As we have many similar observations along that line and since we felt that exploring how they interacted with each other or which had primacy over the others was outside of our scope we created an overarching category for them and encourage future research to dig deeper into how perceptions of a robot affects trust.

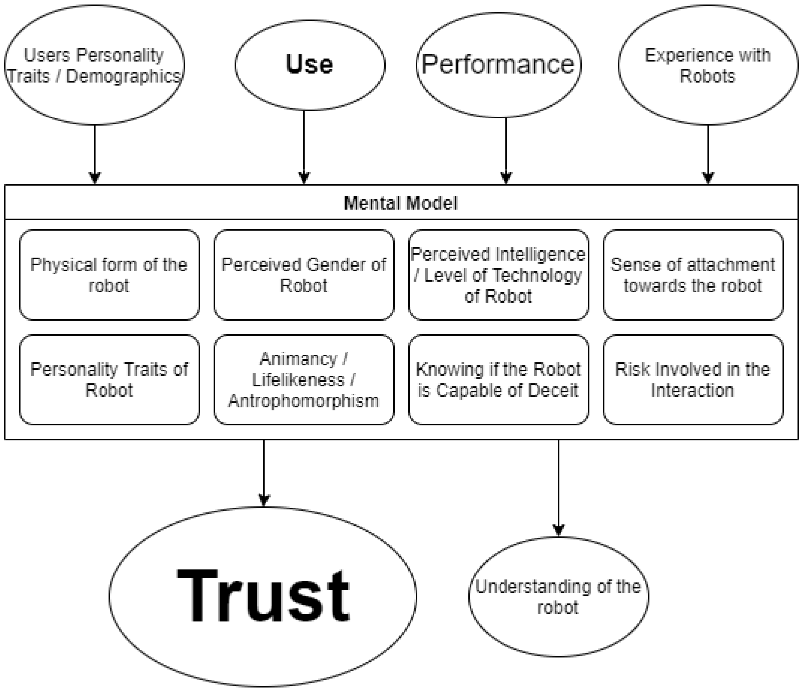



**Figure 3.7:** An example of what we came to call the Mental Model represented in Draw.io

## 3.5 Develop Phase

During the third phase of the design process methods for developing the concept was needed. The point was to come up with solutions to the problem found within the first diamond. As those solutions depended on what said problem was it was hard to decide upon what methods to use before coming to this step. Instead a lot of different methods were considered and ultimately a few were chosen that best suited the needs of this project. Those methods will be described below.

### 3.5.1 Concept Development and Ideation Methods

The concept started out with findings from the literature study and the Define Phase. Here we looked for points in the Trust Relationship Modelled that needed further investigations. The first method being used here was brainstorming with graphical organisation, this helped creating a visual structure to new ideas (Martin & Hanington, 2012). Another method used at this stage was sketching, were we would draw as a way to conveying our thoughts to the rest of the team as well as a tool to remember our ideas. After some discussion, both among ourselves and with our supervisor, we had identified we wanted to further investigate the link between transparency and trust. This triggered another round of brainstorming, sketching and discussions on how we could best develop tests and what role a prototype would have for said tests.

### 3.5.2 Prototyping Methodology

As the concept we had decided upon was focused on the how an RVC and its user interacted through the usage of smartphone applications methods for developing such a program needed to be used. The first method used was paper prototyping (Babich, 2018), this essentially meant that we added to the complexity of the sketches we had created in previous step and use the paper medium to explore possible versions of the app before moving into higher fidelity. These paper prototypes would then get turned into low-fi wireframes (Cao, 2018) once we started looking at how to implement what functionality we wanted the prototype to have. A method called storyboarding (Martin & Hanington, 2012) helped us explore the scenarios we wanted to put our app into and see what functionality it needed to have in order to handle them. Storyboarding was also used to develop the scenarios we wanted to test the prototype in as well. Once we were happy with our low-fi prototype we started to create higher fidelity prototype in a program called Adobe XD.

## 3.6 Prototype Development

After obtaining information through different methods and analysing the data we had created a grasp on the design of RVCs. The knowledge we now had was however rather broad and not always based on RVCs specifically, but design in automation and trust in general. Since a goal of the thesis has been to research how design choices affects trust in RVCs we wanted to investigate if some of these findings could be translated from automation in general, or automated robots, to specifically RVCs.

We decided to create a prototype of a smartphone app that would be used for controlling and getting information about an RVC. Creating and testing a prototype for specifically a mobile app was decided to be the most suitable approach. This was done because of our previous experience from creating similar prototypes, our interest and education in interaction design, the quick nature of prototyping a mobile app, as well as the presence of pre-existing mobile apps with the same purpose. App design is also easy to both test and modify, be it modifications based on test results or designing different variations from the beginning.

For the design of the prototype we focused on just one part of the Trust Relationship Model with the goal of gaining clarity as well as trying to adapt to the RVC context. Based on which findings we were most interested in, and to some extent uncertain of how they would translate, we decided that the focus should be on transparency and information presentation. Since the literature study had pointed towards a correlation between transparency and trust we more specifically wanted to investigate whether more transparency automatically lead to more trust, or if too much transparency amount to an excess in information. We suspected that too much information could hurt the usability, and therefor also affect trust negatively.

### 3.6.1 Test Hypothesis

In order to study transparency's effect on trust we proposed the following hypothesis:

**Hypothesis**: *More transparency and information leads to more trust.*
**Sub-hypothesis**: *An excess in the amount of transparency and information has a negative effect on trust.*

### 3.6.2 Designing the Prototype

Designing the prototype required a series of decisions about what we desired to achieve with the tests. We had some discussion and deliberation about in which degree we should focus on usability. The focus of the tests and the desired results were not immediately related to usability, but rather trust and perceived transparency. However, we had strong suspicions, based on previous experience and consulting with with our supervisor, that performing tests with a prototype of a mobile application would generate feedback mostly focused on usability if the usability was sub par. Because of this we gathered inspiration from existing mobile applications with similar functionality and tried to emulate the overall usability and design patterns, where applicable.

The process of creating the prototype took several steps. Starting out by using scenarios of what could go wrong while an RVC was running and using storyboards to anticipate how the user responds to that situation. These scenarios were created by brainstorming nine different events based on the results of the Discover Phase. The events were then ranked according to how much attention we expected said event would require from the user and how urgently the user would need to attend to them.

1. *Recharge* - the RVC needs to interrupt its program to recharge its batteries.
2. *Stairs* - the RVC has encountered a set of stairs.
3. *Expected Obstruction* - i.e. a user has told the RVC to not go into an area.
4. Dirt Event - the vacuums needs to run a spot an extra time or with increased suction to clean properly.
5. *Unexpected Obstruction* - something unexpected is blocking the RVC's path.
6. *Arena Unavailable* - Unexpected Obstruction that block entrance to a larger area, i.e. a worse version of the Unexpected Obstruction event.
7. *Sensory Event* - i.e. a failure to one of the RVC's sensory functions, e.g. something has been caught in the sweeps, a filter is blocked, or battery is approaching the end of it's lifespan and needs to be changed.
8. *Stuck* - the RVC is stuck somewhere.
9. *Catastrophic Failure* - by this we meant critical failures such as engine failures or or the RVC catching fire.

Out of these four events were selected to become scenarios, *Unexpected Obstruction*, *Sensory Event*, *Stuck* and *Area Obstruction*. These events were selected because they were deemed to have a good mix of severity while still being events that would reasonably commonly occur during daily activities of the RVC. The *Dirt Event* was also incorporated into all scenarios in order to create clutter that would increase transparency at the cost of worse User Experience.

At the same time rough sketches of the prototype were created to see what functionality was required in order for the user to be able to deal with the different scenarios. These rough sketches were then given higher fidelity and turned into pa-

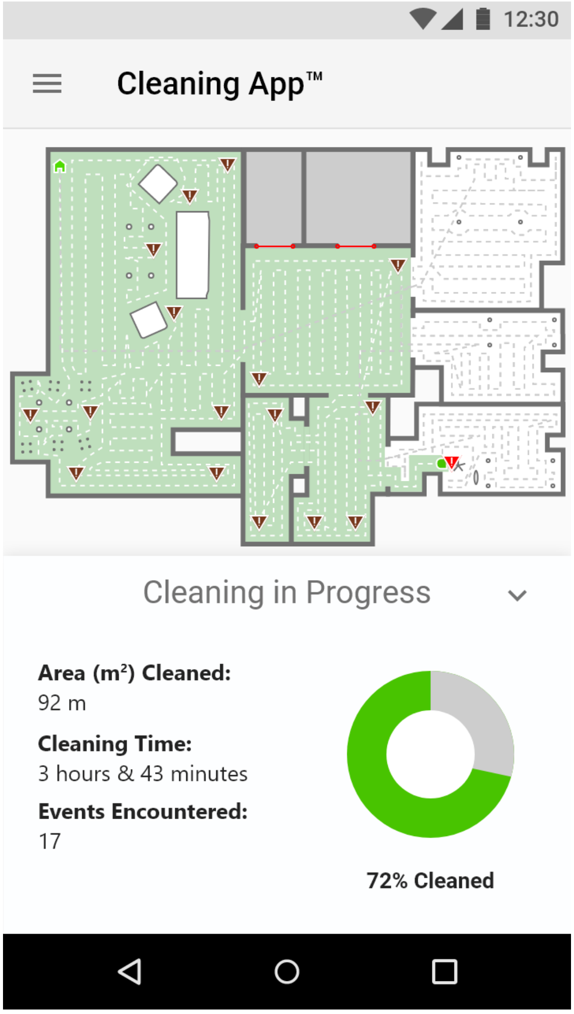



**Figure 3.8:** A screenshot of the the prototype version that displays an unexpected obstruction with a map.

per based wire-frames in order to support our discussions of what functionality we wanted to include in our prototype. Once we were happy with our paper versions we used a program called Adobe XD in order to create a prototype of the app which could be run on mobile phones and had enough functionality in order to carry out the tests. See figure 3.8 for an example of how the prototype looked in Adobe XD looked.

Since our goal was not to evaluate the usability of the prototype our focus when creating it instead was on the details in the way which information was presented. While the majority of the application was identical between the different variations of the prototype the key differences was in which way information was displayed and the amount of information given. The different variations in the prototype will be described in chapter 5.

## 3.7 Deliver Phase

In the last phase the Double Diamond the project is being prepared to be published. As such the tests on the prototype is going to be carried out and those tests are going to be analysed and evaluated.

### 3.7.1 Evaluation Methodology

User testing was used in order to evaluate the prototypes. The user testing was done using the Think-aloud Protocol (Martin & Hanington, 2012) and be combined with interviews. The tests were carried out on two different iterations of the prototypes, and in order to evaluate whether changes to the guidelines make for a better resulting prototype the method Experiments (Martin & Hanington, 2012) was used, by having the tests being as similar as possible with just small changes to the prototype. Afterwards the results of the Think-aloud and interviews were analysed using a Feedback capture grid (Dam & Teo, 2019).

### 3.7.2 Test Preparations

For the tests of the prototype, we wanted participants with some experience of RVCs. We partially wanted this because of the prototype being that of an app and we wanted the test participants to already have an understanding of what is possible to do with an RVC and thus be able to focus on results related to the app prototype and trust, rather than discovery or assumptions about RVCs. Further, we also desired to perform short interviews with the test participants. While we were doing tests of a prototype in order to determine the effect of transparency in trust, our Trust Relationship Model had many other claims about different aspects effect on trust. It was decided to not evaluate these claims further, due to the scope of the project, and instead let them remain as a summary and model of theory acquired from the literature study. To make up for not evaluating all claims the interviews were intended to also gain some broader understanding of the test participants general attitude and experience with RVCs. The interviews were also expected to let us acquire data on the trust actual real-life users have in RVCs and their experiences in general, with a relative low investment in time and other resources from us. This, however, proved to be a false assumption, as it was not as resource-light as anticipated.

A few requirements were set up in order to find the most suitable test participants for our tests. The test participants needed to have experience with RVCs, as previously stated. They also needed to be English or Swedish speaking, simply because those are the languages we ourselves speak. Another requirement was that the test participants ideally would not be our friends. The purpose of this requirement was mainly to reduce the risk of potential personal bias affecting the tests, but it also served the purpose of simulating how we except finding test participants is done in a professional environment.

A goal of finding roughly 20 testers was discussed. This goal was rationalized in discussion with the supervisor and was seen as the amount of testers that was desired in order to be able to recognise trends and draw strong conclusions from the tests. A more attainable goal of eight to ten testers was also discussed, which could also be a suitable goal depending on the format of the tests. Since the second goal was considered more reasonable within scope of this thesis the tests were designed in order to accommodate for eight to ten testers.

We proceeded by ideating methods for finding test participants. Methods that were considered included flyers, posting on bulletin boards, asking people on the street in both random locations and relevant selected locations, and even contacting online survey services. The last option, online survey services, was quickly ruled out because of budget restrictions. Other methods that were not initially considered were asking friends, family, and classmates and posting on social media, since these methods were deemed to not be fitting for finding the target audience . Since we were not very satisfied or confident with the different methods we currently had we decided the next step would be to ask our peers for advice. We posted in a group on social media for interaction design students at Chalmers and asked if anyone could recommend any other method for finding suitable test participants. The result from querying the interaction design students were one suggestion of asking family (a method we already had discarded) and multiple cases of people volunteering as potential test subjects.

At this stage, we decided that the most fitting method for finding test participants in our target demographic was to post on public bulletin boards around the campus of Chalmers University of Technology and public libraries as well as at workplaces of people we knew. We decided not to use flyers as it is more difficult to control them and analyse their effect, and we also feared the flyers circulating far longer than intended. Asking people in the street was also decided against. This decision was based on the assumption that the chances of actually getting a person to stop and talk, while this person also has experience with RVCs were slim. The assumption was also that very few people would be willing to stop and talk for approximately 30-45 minutes, which is how much time the test and interview was estimated to take. This meant that a potential test participant approached on the street would have to be persuaded into scheduling another date and place for the test. We found this to be a not only rather unlikely scenario, but also a very time consuming method, something we were trying to avoid.

After three weeks of not getting any positive results on our attempts of gathering test participants the decision was made to consider this a learning experience and remove the restriction of not allowing test participants with whom we had personal relations. This meant that we could ask people we knew, and people who had already volunteered. However, since we were already far behind on our schedule we decided on going with the minimal amount of testers in order to test all scenarios created for our prototype. This meant getting only four testers. To make up for a lack of participants we tried to get as mixed backgrounds as we could given our limited pool to choose from. As such we got two men and two women, all our testers were in relationships, two of our testers had children, and two of them had pets. All test participants had some form of higher education, and above average technological knowledge and familiarity.

### 3.7.3 Test Execution

When it came to actual tests they were divided into two parts. The first part was an interview with the tester, which focused on their background in regards to RVCs. Whereas the second part was focused on our prototype and the relationship between trust and transparency.

When setting up a time and place for the test we gave the participants the option of doing the test with us in their home, if they would be comfortable with it. Our reasoning was not strictly related to the test, but rather the accompanying interview. In discussion with our supervisor we had reasoned that this could prove useful in triggering memories of certain events and feelings related to the RVC, which might be overlooked in a more neutral and sterile environment like the school group rooms we otherwise used. None of the test participants did however choose to perform the test in their own home.

For each test participant a time period of 45 minutes were allocated. This time was divided between an interview part and a test part. The interview was conducted by one project group member by following a planned script, while the other were taking notes. It was also recorded on a laptop for clarity and accuracy. Before the interview, test participants were offered cookies and coffee, as earlier promised, as they were being informed that they would be anonymous in the report and that we wished to record the interview as well as take notes. Test participants were asked to read and sign a form which described the purpose of the interview as well as addressed privacy concerns and explained how personal information and recordings from the interview and test would be handled in order to adhere to the GDPR. The form also asked for the participants consent to being recorded. The interview was performed in a semi-structured manner.

The questions in the interview were ordered in a way so that the first part of the interview focused on getting information about the test participants experience with RVCs and automation in general and their background. The questions in the second part of the interview were instead focused on trust in RVCs, AI, and automation. Before these questions however, the test conductor read aloud the definition of trust that have been used in this project. The test participant was asked to answer the following questions with this definition in mind. In the literature study it became apparent that the definition of trust vary greatly between different people and even between different areas. For the result of the interviews to be comparable we wanted for the participants to have a common definition of trust. The exact questions written in the script can be found in appendix B.

Testing was done on two variations of the prototype for each test participant. The variations used was pre-determined for each test in order to ensure that all different combinations (of using a list or using a map with displaying much information or less information) were tested, given the low amount of test participants. The test participants were presented with one of four scenarios and were asked to identify what they saw on the screen. They were then asked to describe what their initial thoughts were about what was going on in the specific scenario. After they had explained their thoughts, we asked them about their feeling of urgency towards the scenario. At this stage they did not have any confirmation of what scenario we had intended to convey. This was done in order to find out what level of risk the test participants felt when involved with RVCs, since this was an area of interest which arose during the thesis. Following this, the actual intended scenario was explained and the test participants were asked if this new information changed their previously stated sense of urgency towards the scenario. The intention of performing the test in this way was to get some understanding of how well the design choices managed to correctly portray events and convening a suitable level of urgency. Test participants were also asked about the amount and quality of the information provided from the prototype. Following this, a piece of paper was presented and the test participants were asked to mark a point on a seven point Likert scale, answering the level of trust they felt in the fictive RVC, for which the app prototype was intended. The whole test was then done again with another variation of the prototype before test participants were asked to compare the two prototypes, explaining why they trusted one more than the other etc.

### 3.7.4 Test Analysis

In order to work the data into an analysable and organised state the test notes were combined with transcriptions of the audio recordings. The data was then traversed in order to find feedback suitable for putting in a Feedback capture grid. Observations and answers which had anything to do with either *likes*, *criticism*, *questions*, or *ideas* related to the prototype were written in their corresponding quadrant on a whiteboard. In order to not mix-up feedback for the different variants of the prototype the notes were colour coded and marked with letters. With the feedback in a organised and comprehensible structure it was easier to analyse it and summarise some key points through open discussion.

# 4

# Trust Relationship Model

In the following text the results of the literature study and the interview with the subject matter expert will be presented on a overarching level. This Trust Relationship Model will be presented as a relationship map (see figure 4.1) as well as been given in a text which deeper explains how we have defined our findings. This includes everything related to design of trust in RVCs, and consists of what can be considered factors of the robot, the users, how to design around those factors, and what design patterns that affect trust.

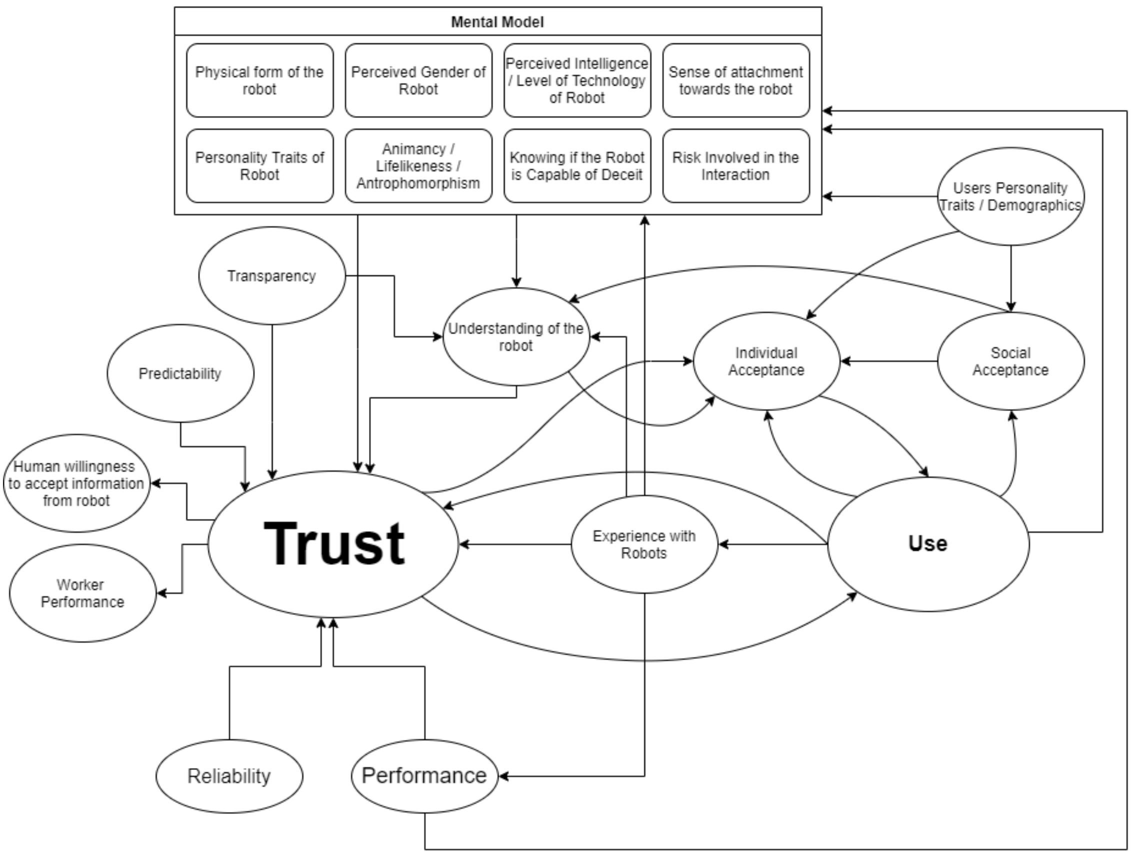



**Figure 4.1:** A graphical representation of the relationship between different factors of trust.

## 4.1 Reliability

Defined as doing what the robot is supposed to do. It has a positive correlation with trust. The rarer it is for the robot to have errors the higher the trust the user is going to have in the robot. Studies show that there exists a correlation between interactions of different degrees of reliability and increase or decrease in trust (Rossi, Dautenhahn, Koay Kheng, & Walters Michael, 2018). Interactions with less reliability has been shown to lead to less trust, while interactions with high reliability leads to more trust(Hancock, Billings, & Schaefer, 2011). It has also been shown that a growing amount of smaller errors has a bigger negative impact on trust than one big error (Sarkar, Araiza-Illan, & Eder, 2017; Salem, Lakatos, Amirabdollahian, & Dautenhahn, 2015). The severity of the error also has an impact on the loss in trust, as more severe errors leads to more distrust (Rossi et al., 2018). While errors have a negative impact on trust, they can be mitigated by transparency (Desai et al., 2012).
In order to build up trust using the perceived reliability of a robot the robot could perform low risk actions that are certain not to fail during the crucial early parts of interaction.

## 4.2 Performance

How well the robot performs. Better performance is going to create higher trust (Hancock et al., 2011). Performance has a great impact on trust in the early stages of interaction and issues with performance in these initial stages has a severe negative impact on trust. There are also indications that drops in performance takes a bit of time before it has an impact on trust (Desai et al., 2012).

## 4.3 Transparency

Transparency is how well the robot communicates its actions to the user. Transparency generates trust (Balazs et al., 2013). Good transparency can mitigate the negative impact of errors by informing the user of why they happened (Desai et al., 2012), as well as lessen the risk of overtrust by giving the user a better understanding of the robots limits (Wang et al., 2016). Transparency can also be helpful in creating a better understanding of the robot (Wang et al., 2016), which was also found to affect trust (see 4.6). Overall, transparency can be a good way to combat both over- and undertrust (Wang et al., 2016).

## 4.4 Use

Use creates experience, it leads to acceptance (Sheba, Mohan, & Martínez García, 2012), and it influences trust and the mental model. The relationships with acceptance and trust goes two ways as higher trust and acceptance leads to more use (Wang et al., 2016; Schaefer, Sanders, Yordon, Billings, & Hancock, 2012). Use does most often affect trust in combination with something else, like for example reliability (Desai et al., 2012).

## 4.5 Experience with Robots

This is how much experience a user has with robots. It is influenced by use, and affects trust, performance, understanding, and the user's mental model of the robot (Sarkar et al., 2017). Further division might be done between the user's experience with robotics in general and with one particular robot.

## 4.6 Understanding the Robot

Understanding of how a robot works and what it does creates trust and, in turn, willingness to use (Wang et al., 2016). There are different ways of catering for the creation of understanding. Clear information is presented as one way of assisting the user in understanding what a robot does and how it works (Balazs et al., 2013). Providing clean information does not necessarily mean you should provide an extensive amount of information. It is more important how the information is presented. Too much information, presented in the wrong way, may rather create confusion and overload the users mind.

For example, in human-robot cooperative teams within the military the robot may limit the amount of information the user receives in order to let the user focus on the essential information needed to perform the critical task of decision making, without having to filter out unnecessary information (Wang et al., 2016). While RVCs are not as critical or high-risk as the interaction within military human-robot teams, information overload is advised against when aiming to create understanding of the robot. Different ways this information can be presented could for example be a quick video with explanation, an app with real time explanations, a booklet with text, the robot talking about their actions, an app with a map of the RVCs activity and an activity feed, or something else.

## 4.7 Predictability

The effect predictability has on trust is a combination of the robot behaving in a way which correlates with the expectation of the human user, but also the robots ability to convey what it is going to do and influence the users expectation for it to more closely resemble the robots actions (Lazanyi & Maraczi, 2017). Predictability is closely linked with "Understanding the Robot" and "Transparency".

## 4.8 Mental Model

The mental model is the way users perceive the robot, how it works and how it thinks. This is not necessarily the same as how it actually operates. This has an affect on trust and the users' understanding of the robot. The users' mental model is affected by use, the level of prior experience the user has with robots , and robot performance, as well as physical and behavioural characteristics of the robot:

### 4.8.1 Look and Feel

Look and feel of the robot deals with appearance, behaviour and other thing that might trigger biases towards the robot.

1. Physical form of robot (Sarkar et al., 2017)
2. Animancy / lifelikeness / anthropomorphism (Castro-González, Scassellati, & Admoni, 2016)
3. Perceived gender of the robot (Tay, Jung, & Park, 2014; Fink, Bauwens, Kaplan, & Dillenbourg, 2013)
4. Perceived intelligence / Level of technology of robot (Sarkar et al., 2017)
5. Personality traits of the robot (Tay et al., 2014)

### 4.8.2 Sense of Attachment

The sense of attachment a user develops towards their particular unit is something that designers need to be mindful of (Fink et al., 2013). According to the subject expert inquiry, many users create a strong sense of attachment towards their robot, and in case it breaks down they strongly prefer to get their unit fixed, rather than getting a new one (see 3.3.2)

### 4.8.3 Knowing if the Robot is Capable of Deceit

Most people will assume that domestic robots are advanced tools incapable of deceiving its user (Chen, Nikolaidis, Soh, Hsu, & Srinivasa, 2018). This affects trust as it limits what type of definition of trust a designer can work with while designing RVCs. There are however cases where deceit can be used in the design, in order to increase the effectiveness in Human-Robot teams or in order to direct the amount of trust in a direction. Should the user find out the robot is using deceit, it could negatively impact their trust in the robot (Hancock et al., 2011).

### 4.8.4 Risk Involved in the Interaction

How much risk a user perceives in an interaction moderates how much trust matters to usage of a robot (Chen et al., 2018). In the case of RVC users often perceives it as a low risk interaction, and a boring one at that, which means that they are more likely to want to use a RVC even if they have low trust in it (Lazanyi & Maraczi, 2017).

## 4.9 Indirect Factors

This category consists of different factors that do not directly influence trust, but does have a significant impact on other factors that do. Acceptance of robotics is an important factor to trust as it affects human expectations of robots. The overarching category of acceptance can further be divided into individual and societal acceptance. Few of the text included in the literature study actually made a distinction between individual and societal acceptance, but used the term acceptance to refer to one or the other.

### 4.9.1 Individual Acceptance

How much a single person accepts robots. Higher trust leads to higher acceptance, whereas higher acceptance leads to more use, which in turn is essential to generating more trust (Sheba et al., 2012).

### 4.9.2 Societal Acceptance

How much society as a whole accepts robots. Use creates this acceptances, and in turn it influences individual acceptance as well as people's understanding of robots (Poisat, Calitz Andre, & Cullen, 2017). This is an overarching factor that is hard to influence with a single product.

### 4.9.3 User Personality Traits / Demographics

Who the user is also has an indirect effect on how trust is formed. Several articles in the literature study found that demographics influences acceptance and users' the mental model (Conti, Cattani, Di Nuovo, & Di Nuovo, 2015; Fink et al., 2013; Salem et al., 2015). Furthermore certain personality traits also had similar connection. For example users who were extroverted tended to anthropomorphize robots more and were quicker to accept them (Salem et al., 2015). This is something that designers need to know and adapt their product to, but not something that can be changed through interaction with the robot.

# 5

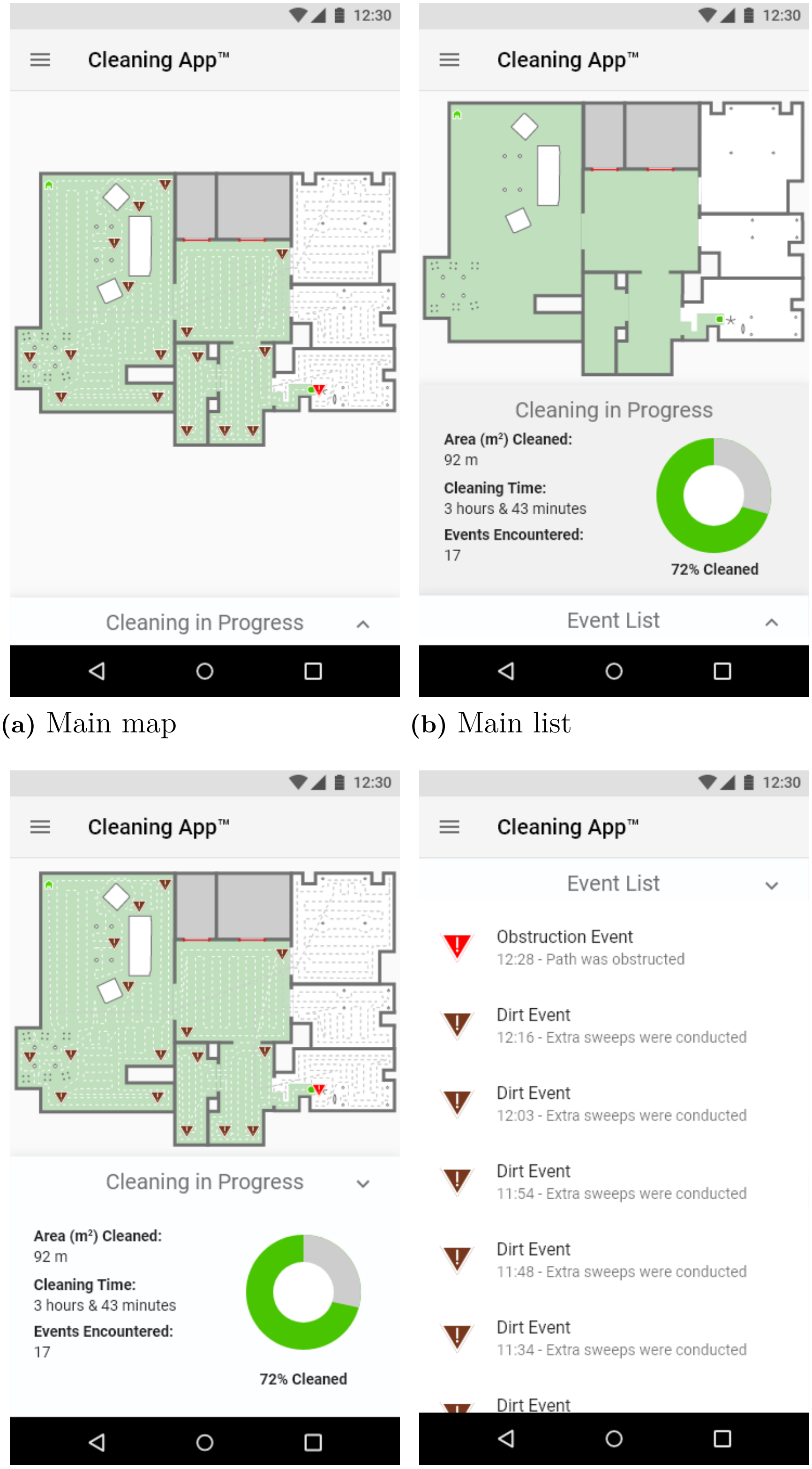
# The Prototype

For the purpose of testing the effect of transparency on trust in RVCs a prototype of an app user interface for an RVC was created. This prototype was altered into two different aspects in order to be able to compare how these differences affected the user's perceptions of transparency and trustworthiness, as well as to see which type they preferred over all. The first aspect was the way in which the information about warnings and notifications were displayed. The two different variations that were decided on was displaying notifications in a list and displaying notifications directly on a map of the vacuumed area (see figure 5.1). The other aspect was the amount of information, the two options decided on being just the essential information and as much information as possible.

## 5.1 List and Map Variations

The decision of using a list as one of the information displays was based on the usability aspects of a list. It can easily be sorted or designed in a way so that the most relevant and pressing information is displayed in a more prominent way than other information, while still allowing for a lot of information to be displayed. Important notifications can be highlighted or displayed using an icon of a different colour or shape in order to stand out or the list could be able to be sorted in order to accommodate the user's need e.g. by time of the notification or by order of severity (see figure 5.2).

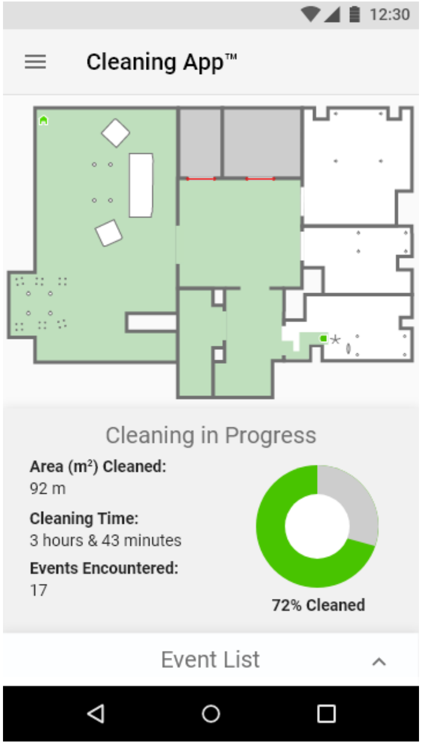
The reasoning for the opposite way of displaying this information, being directly on the map, was that all warnings and notifications could be displayed at the same time and the most relevant and pressing information could be more prominent by using icons of a different colour or shape. When displaying this information on a map it will be immediately apparent where in a room the problem has occurred (see figure 5.3). The drawbacks of using this information display would be that notifications may become hard to distinguish when the number of notifications increase. The amount of information immediately displayed would also be restricted and the nature of a notification could be a mystery to the user unless they for example learn to recognise different icons, until they choose a notification to display extended information. A notification icon may be a warning triangle, making the user feel as something has gone horribly wrong, while in reality it could be a less severe problem than anticipated (e.g. the RVC running out of batteries and needing to go back and recharge). Being exposed to a false alarm in this way leaves users feeling deceived, thus lowering their trust in the robot.



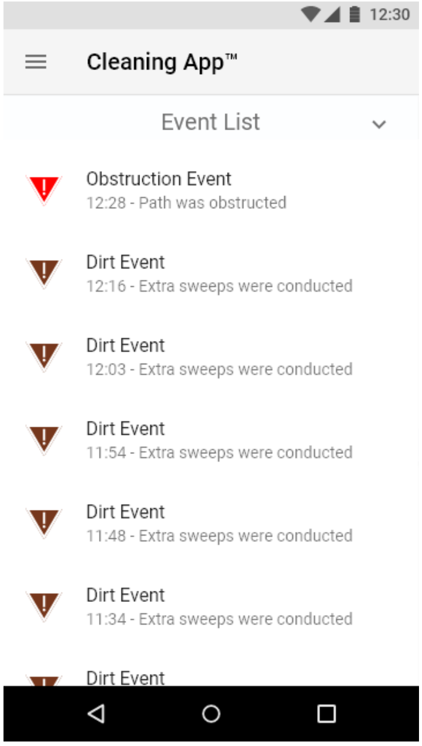

(a) Main map (b) Main list

(c) Map expanded (d) List expanded

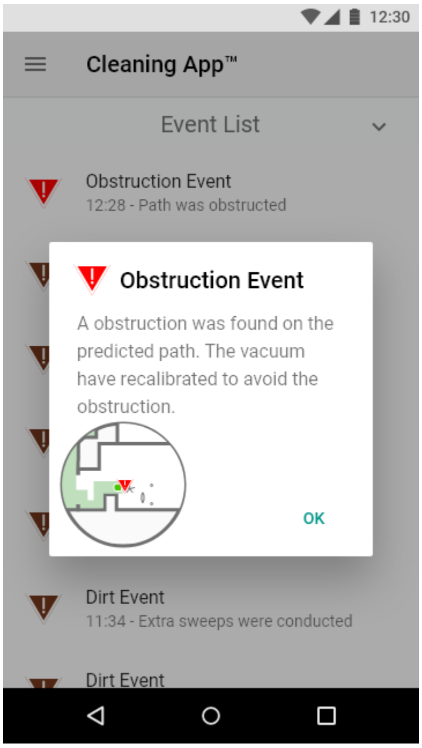
**Figure 5.1:** Side by side of the main view and the expanded view of the unexpected obstruction event. Showing both the list and the map version.



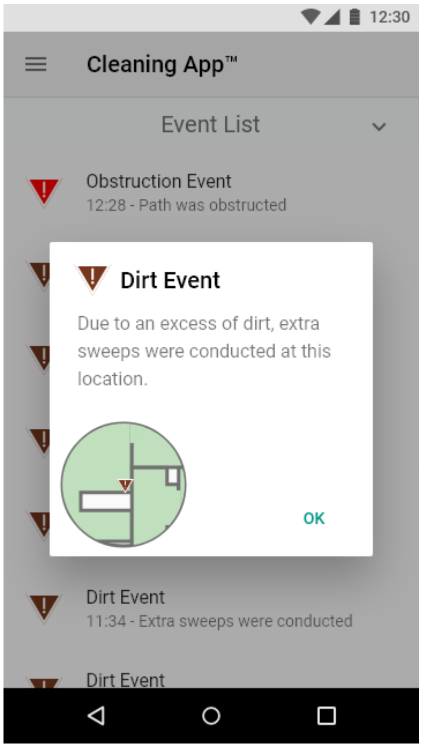

(a) Main list




(b) List expanded




(c) Obstruction event box




(d) Dirt event box

**Figure 5.2:** The four different view of the list version of the unexpected obstruction event.

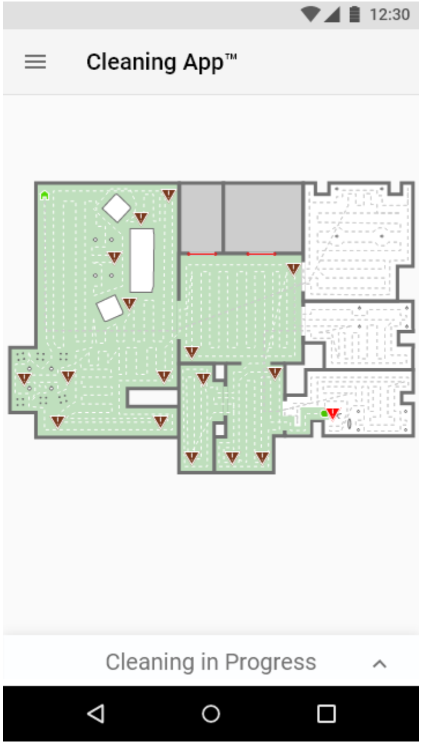
This potential problem could be avoided in a list since the available space for information would fit an explanatory title or something corresponding. The map also has the added benefit of displaying location data for the RVC, theoretically both the travelled path and a projected path, as well as the current position of the RVC.

## 5.2 Focusing on Transparency

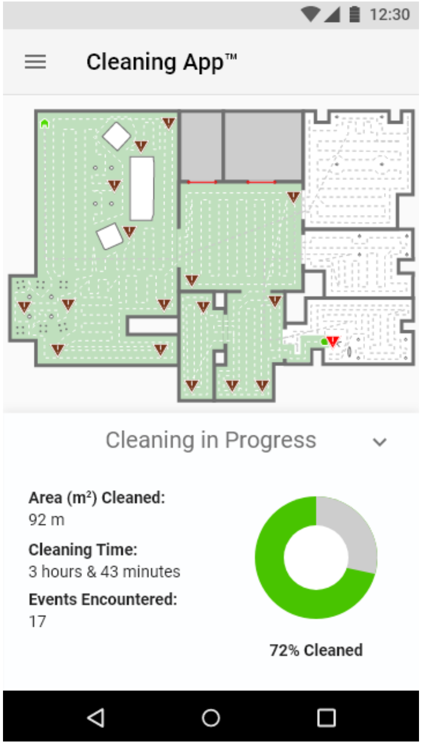
With the hypothesis (see 3.6.1) of the user tests being that "*More transparency and information leads to more trust*" and using the definition of transparency being *providing information with openness and without censorship* it was decided that transparency should be expressed by providing the testers with large amounts of data. The data consisted of different levels of status updates and warnings in the form of notifications. This data was not collected by a real life agent, but instead mock data was used to create a realistic test environment without risking to violate anyone's integrity The detailed data was excepted to be aiding the perceived sense of transparency, and further, trust. Displaying all available data would also, in theory, have the data readily available to the user and not hidden in some kind of interface navigation hierarchy.

As a way of controlling whether the amount of data affected the testers' sense of transparency and trust, the opposite of this aspect was to provide data which was deemed to be only essential. By doing this, the designers took on the role of what would otherwise be a software which would be making decisions on which data to filter out in a real world scenario. Displaying the limited data was suspected to create a lesser sense of transparency compared to displaying more data. It was at the same time predicted that this could lead to a more pleasant user experience, since less information would lead to important notifications could be made even more prominent. It was acknowledged that this could affect the overall results of the tests while not necessarily giving a definitive answer to the hypothesis, but rather give an indication to the degree of which trust in an RVC matter versus usability of its app.

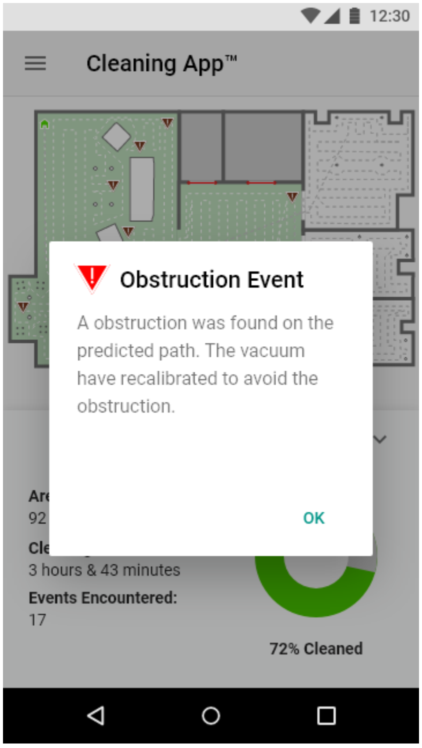
Another way we tried to focus the test on transparency was through the usage of four different scenarios, *Unexpected Obstruction*, *Sensory Event*, *Stuck* and *Area Obstruction*. Each of these needed two different versions of the prototype, one for the map and one for the list. A comparison between the map version of the four scenarios can be seen in figure 5.4. The differences between these events were the information and position displayed on the map and the describing text of the event. In the case of the list version the position of the event in the list also differed.



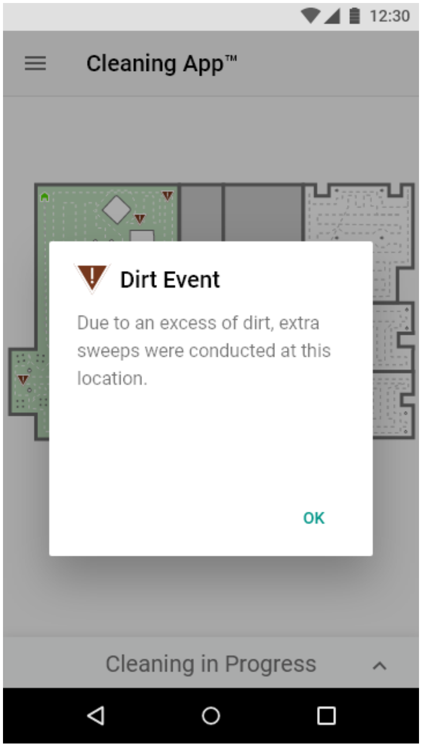

(a) Main map




(b) Map expanded




(c) Obstruction event box




(d) Dirt event box

**Figure 5.3:** The four different view of the map version of the unexpected obstruction event.


(a) Unexpected Obstruction (b) Sensory Event

(c) Stuck (d) Area Obstruction

**Figure 5.4:** Side by side comparison of the four event chosen for the test.

# 6
# User Studies

This chapter presents the results of the user studies conducted during this thesis. Tests were carried out with with owners of RVCs. Each of these test sessions were organised into two parts. The first was a pure interview which focused on the users background in regards to RVCs and we came to refer to that as the interview part of the user study. Whereas the second part of the user studies was a test focused on our prototype, as such we came to refer to that as the test of the prototype. Both of these are detailed below.

## 6.1 Interview Results

These are the results of the interviews we conducted before the user tests of the app prototype. The results from the structured part of the interview can be seen in table 6.1.

An interesting correlation to highlight is the relationship between the perceived intelligence of the RVC, if the RVC behaves in a predictable manner and the desire of users to have it act more predictable. Essentially this seem to indicate that if users think it is more predictable they will see it as smarter and trust it more. However, this would require further investigation with a larger sample size over a longer period of time.

As for the unstructured part of the interviews the most important findings were what the people we interviewed saw as the greatest problems with their current RVCs and what risks involved with RVCs over all that they had identified.

Our users had had problems mostly todo with hardware with the RVC, the machines had broken down. The charging station was not always working which had resulted in the RVC running out of batteries in the middle of cleaning. On the software side of things several of our users had had problems with their RVC getting stuck.

As for the risks that they identified. Some of our users were worried that they would accidentally drop objects on the floor and the RVC would vacuum said objects without the user noticing it. This would lead to valuable things getting lost. Another risk identified by several users were the fact that there are plenty of areas in the house that a normal vacuum cleaner can reach that an RVC won't, for example mouldings or underneath certain furniture. One user also said that they were worried about this might lead to more issues with allergies than a normal vacuum cleaner. Lastly, a user pointed out that if the stair sensor of an RVC does not work all of the time it might risk the RVC tumbling down the stairs and potentially breaking, and this

| Question | Tester 1 | Tester 2 | Tester 3 | Tester 4 |
|---|---|---|---|---|
| Do you take part in cleaning in your household? | Yes | Yes | Yes | Yes |
| What's your experience with robotic vacuum cleaners? | Owner | Owner | Owner | Owner |
| Do you have any other experience with robots or AI? | Owns robotic lawnmower | Academic | Academic | Limited |
| How do you live? | House | Apartment | House | Apartment |
| Do you trust your RVC? | No | Yes | Yes | Cautious |
| Do you think the robot is smart? | No | Yes | Uncertain | Uncertain |
| Do you trust robots in general? | Yes. | Yes | Yes | Yes. |
| Would you say that you understand what is happening when your RVC is running? | Yes. | Yes | Yes | Yes |
| Do you feel the information you receive from the robot is sufficient? | No | Yes | Yes | No |
| Is the RVC predictable or is it more random? | Predictable | Predictable | Random | Random |
| Would you trust it more if it was more predictable? | Yes | Not relevant | Yes. | Yes. |

**Table 6.1:** A table with the results of the structured part of the interview.

only need to happen rarely in order to be a big problem for the user.

## 6.2 Results of the Test with the Prototype

The prototypes were received well by the people partaking in our test, especially among the those who whose RVC did not come with an app. In the test a score of 7 was labelled as complete trust, 4 as adequate trust, and 1 as no trust. As for the different versions of the apps, both scored highly in trust on our test with most people preferring version A, the one which had an overflow of information in the map. One person preferred version B, which had the overflow of information in the list. And one person said the trusted both versions completely (see table 6.2 and figure 6.1).

| | Test A - Maps | Score A | Test B - Lists | Score B |
|---|---|---|---|---|
| **Tester 1** | Area Obstruction | 7 / 7 | Stuck | 6 / 7 |
| **Tester 2** | Obstruction | 7 / 7 | Area Obstruction | 6 / 7 |
| **Tester 3** | Sensory Event | 7 / 7 | Obstruction | 7 / 7 |
| **Tester 4** | Stuck | 5 / 7 | Sensory Event | 7 / 7 |

**Table 6.2:** A table with the results of the Likert scales measuring trust in our prototypes from 1 meaning no trust to 7 meaning complete trust.

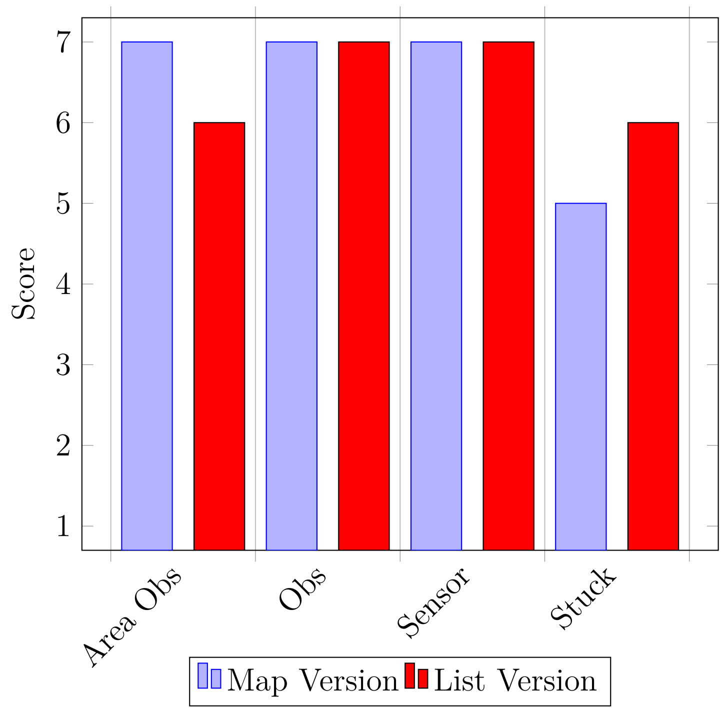



**Figure 6.1:** The data from table 6.2 presented as a bar chart. All tests are displayed as Likert scales measuring trust in our prototypes from 1 meaning no trust to 7 meaning complete trust

To summarise the comments we got on our two different prototypes. Our testers felt that prototype A gave greater understanding and that it presented lots of information, however some users found this to be a bit too much information. In regards of prototype B our testers thought the interface was cleaner, but a few testers failed to find all relevant information. There was also mixed opinions on whether it displayed the right amount of information.

Even when our testers had issues with finding the correct information or they had stated that they found the app to display too much information, regardless of which version they tested, our testers stated that they trusted our prototypes. This seems to indicate that information creates more trust, even in situations when the presentation of said information leads to a worse user experience.

This means that the result of the literature study need an addendum for its definition of transparency (see 4.3), which can be found below (with the changed parts marked in bold):

## 6.3 Updated Transparency

Transparency is how much of the robots actions are communicated to the user. Transparency generates trust (Balazs et al., 2013). Transparency can mitigate the negative impact of errors by informing the user of why they happened (Desai et al., 2012). Transparency can also be helpful in creating a better understanding of the robot, which was also found to affect trust (see 4.6). **However, too much transparency might lead the user to feel overwhelmed by amount of information given by the robot which in turn leads to a worse user experience. Our findings suggests that even when that is the case, the positive effect on trust created by the transparency outweighs the negative effects of worse user experience leading to an over all increase of trust.**

# 7

# Discussion

While writing this thesis there have been certain topics that we have discussed among ourselves that we would like to bring to attention of the reader, as well as giving more context to decisions that we took during it. All such things can be found here in the discussion chapter.

## 7.1 Lack of Over-Trust Research

Only four of the 44 the articles in our study made clear references to over-trust or appropriate levels of trust and none of those articles were writing directly about RVCs. This meant that a majority of the articles we read, and all articles we read about RVCs, saw increased trust as something that should only be viewed as positive. These results can be interpreted in two different ways; either optimistically as they indicate that the risks involved with RVCs and most domestic robots are so small that placing too much trust in those kinds of robots are harmless and as such it is more important to allocate resources to researching how to increase trust. This seems to be the stance that the industry is taking judging from the interview we had with the subject expert. The other interpretation is to admit that there is a lack of research in this area and that more research needs to be done into the more narrow category of over-trust in RVCs.

Because of the lack of research we often discussed among ourselves whether or not over-trust was a problem for RVCs. Compared to say a self-driving car where over-trust may have fatal consequences (NHTSA, 2018), our research indicated that the risk trusting RVCs too much is about damage or loss of valuable possessions. From a purely academic point of view it could be an interesting topic to cover, but in the commercial sector seems solely focused on creating more trust. For example the subject expert that we interviewed only spoke about how to create more trust and creating products that his customers would trust more.

## 7.2 Traditional Robots and RVCs

During the literature study we made the assumption that research done on any robot that fits in a domestic setting or research done on general robotics are applicable to the setting of RVCs. This was done due to a lack of research being done on RVCs in particular so a more general approach was required. This does mean that as more research on robotics in a domestic setting in general, and on RVCs in particular, is being done the findings of this thesis might need to be revisited.

However, that brings us to the question of how similar an RVC is to other kinds of robots. As previously stated the risks involved with RVCs are relatively small. For example a common household robot that in both appearance and behaviour is similar to an RVC is the robotic lawn mower (RLM). The RLM does however come equipped with blades, and thus poses some kind of bodily hazard to humans and animals in a way that RVCs do not. Thus designing trust in an RLM requires taking safety into account in a way that we could simply ignore in our research.

## 7.3 The Effect of Usability on Test Results

During the final part of the thesis we did tests on the effect of transparency by trying to give too much information to the tester in different ways. This attempt of overload of information did not only affect transparency however as it also had a significant impact on usability. While we can see some of the effects of this change in usability can be seen in the results we got from the interviews, it is not completely clear to what degree our results are affected.

To mitigate this uncertainty we should have measured how user-friendly as well as how transparent the testers found the prototype in a quantitative manner, as neither of these things were specifically measured during the tests. From there open questions could have been asked in order to gauge how trust scores given by the users were affected by usability. Instead, the whole focus of the tests were on how the users perceived trust in the prototypes. Our suggestion to future researchers of this topic is to make a more specialised test that tries to keep the usability aspect of comparable prototypes as similar as possible while varying the level of transparency.

Usability does not only affect the results of tests, but it also affects trust in general. As can be seen in the Trust Relationship Model (see chapter 4) many different things affect trust. It is our understanding that trust in RVC's can be built as a joint effort by many different aspects, but it takes only one of these to catastrophically fail in order for the trust built to be torn down again. For example bad and error prone usability may destroy trust, even when other things that supposedly should have a positive effect on trust are designed in a perfect way to foster trust. This is why it is important to be wary of test results, and to at least try to identify which design aspect is affecting the result.

## 7.4 Issues with Finding Testers

A goal we had set for ourselves that we failed to achieve during the thesis was to get testers without any direct relation with ourselves. We first attempted to reach out through public noticeboards in university campuses and public libraries around town. We also attempted to reach people indirectly by having people we knew set up notices in company spaces were they worked. Both of these failed however, and in the end we were forced to use friend and family members to test our prototype.

To speculate as to why our notices did not get any responses we believe that a traditional paper notice is not a good approach to reach the kind of people that owns RVCs. To begin with when we have been talking to people about RVCs they seem to view it as an upcoming futuristic technology and most people who we have been in contact with who are owners of RVCs are either tech-savvy early adopters or in a close relationship with such a person. We suspect that it would have been easier to reach such people through the Internet instead. Also the locations of the notices themselves might have been part of the problem, at least when it comes to the public ones. Perhaps putting up the notices in a place which in closer proximity to where people buy RVCs would have been more effective.

As for the impacts of having trouble with finding testers, the largest one was that finding testers took too much time. This lead to us only doing the minimum amount of tests required to test every version of our prototype, whereas we would have wanted to do two or three times the amounts of tests. Another risk was homogenisation of our group of testers. This was not really a problem as we was able to find people with significantly different backgrounds, but if we would have continued doing more tests we would have started to see a narrowing of the types of people in our circle of acquaintances that owns RVCs.

The takeaway for us was that finding the right test participants is harder and more time consuming than expected, but unfortunately it is a necessary part of designing and testing. While asking people we already knew did give us the test participants we needed to proceed with the project, it will not be a suitable method for similar scenarios in the future, especially in a professional environment.

## 7.5 Ethics

This section will list a few ethical concerns that came up during the thesis that were on the boarder of what could be considered the scope of the thesis. Therefore, they will be grouped together in this section, but we encourage the reader to dig deeper into these subjects if they find them interesting.

While making the literature study we encountered an article which stated that humans acceptance of a robot is influenced by how well the perceived gender of the robot corresponds to the stereotype of the task it is carrying out (Tay et al., 2014). The example they gave was a security robot receiving better responses in their study when assigned male traits rather than female, whereas a female healthcare robot was viewed more positively than a male one. This begs the question of whether when robots beings a more common aspect of people everyday lives will reinforce gendered stereotypes or if the stereotyping that robots receive is a reflection of the stereotyping humans are facings. We would urge caution when applying gendered traits to an RVC and avoid it unless there is a good reason to do so.

Something we talked about, but did not act on, was using deceit in order to affect trust positively. A big part of this thesis has been focused on transparency and its affect on trust. But what if the user thought their device was giving them transparent information, while in fact some crucial information were being kept secret? Or what if the RVC pretended to be smarter than it actually was? We believe using deceit in these, and similar ways, in order to trick users into trusting an RVC, or any robot, may be tempting for designers if data indicated it to be successful. We do however also have concern about the negative effects of users finding out that they have been deceived and lied to. This is something we hope designers stay clear of in the future, since we suspect this practice might have a greater negative effect on trust in RVCs and robots in general, rather than in just the own product.

Another ethical concern to consider is the privacy concerns that comes from having a robot in your home that collects data and uploads it to the Internet. In 2017 New York Times wrote an article about RVCs collecting data from people's home and potentially selling it to third parties, though they later went back on the claim (Astor, 2017). This however, sparked concerns for a future in which data collecting robots become more common and what issues that could bring (Bharadwaj, 2019).

We consider this to be a major privacy concern as more and more robots and AI enter into a domestic setting. Whether it's your vacuum cleaner, intelligent personal assistants, or previously dumb devices turning smart, we think users should have some kind of control of what data is collected in their homes and who that data is shared with. And as designers we should keep this in mind when we develop products in these areas.

# 8

# Conclusion

Automated robots that ordinary people need to interact with are becoming more common inside our homes. RVCs and robotic lawnmowers are a few examples of these. As robotics is taking the step from the laboratory and factory based environments into the domestic setting the aspect of trust is starting to become a more important subject to study.

This thesis was conducted based on a desire to learn about existing research and theory regarding trust in domestic robots. It was also of interest to investigate differences and similarities between different fields of automation, and how that can be applied to design. In order to achieve this we raised two research questions:

**RESEARCH QUESTION**

- What affects users' trust in domestic robots, specifically robotic vacuum cleaners?
- How can design facilitate an appropriate level of trust?

To answer the first research question the Trust Relationship Model (see **??**) was developed based upon the literature study and the subject expert inquiry. This model was then amended and reinforced by research done through prototyping and user studies. A new text was written about transparency and its effect on trust was written as a result.

The second question turned out to be harder to answer. The literature study showed that there was a significant lack of research done on overtrust. As such we can answer what to do to create more or less trust between a user and an RVC, but to answer what an appropriate level of trust is would require more research that we considered to be outside the scope of this thesis.

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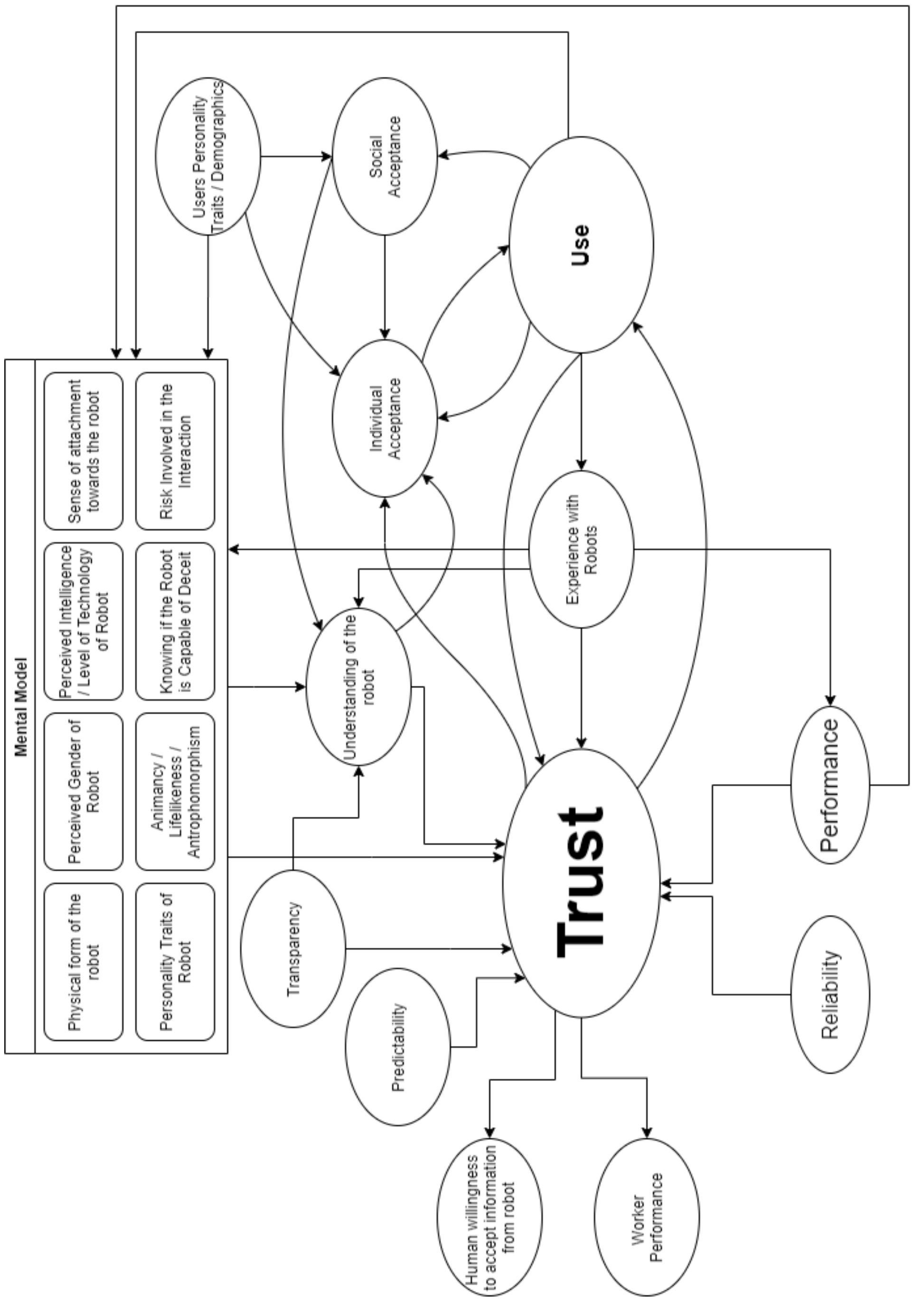
# A
# Appendix 1: Literature Study



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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A Cognitive Model of Trust for Biological and Artificial Humanoid Robots | Sorbello, Rosa<br>Cali, Carmelo<br>Tramonte, Sal<br>Nishio, Shuich<br>Ishiguro, Hiros<br>Chella, Antoni | Supplementa l Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-21 | In note | Björn |
| A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Pan, Ye<br>Steed, Anthon | Academic OneFile through Chalmers Lib | | | | x | | | x | | | | | 2019-03-22 | In note | Björn |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Daniela Conti | IEEE through Google scholar | | (x) | | | | | | x | | | Not "trust" but good words like "perception" | 2019-03-21 | In note | Björn |
| A Long-Term Human-Robot Proxemic Study | Michael L. Wa | IEEE through Google scholar | | x | | | | | | x | | | "Domestic robots" early in introduction | 2019-03-21 | In note | Björn |
| A Meta-Analysis of Factors Affecting Trust in Human-Robot Interaction. | Hancock, Pete<br>Billings, Debor<br>Schaefer, Kris<br>Chen, Jessie Y<br>de Visser, Ewa<br>Parasuraman, | Complement ary Index through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Hampus |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Liang YJ<br>Lee SA | MEDLINE through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn & Hampus |
| An Uncanny Game of Trust: Social Trustworthiness of Robots Inferred from Subtle Anthropomorphic Facial Cues. | Mathur, Maya<br>Reichling, Dav | Complement ary Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-22 | In note | Björn |
| Artimetrics: Biometrics for Artificial Entities | Roman V. Yar | IEEE through Chalmers Lib | | x | | | | | | x | | | | 2019-03-20 | In note | Björn |
| Avatars in Pain: Visible Harm Enhances Mind Perception in Humans and Robots | Swiderska, Ale<br>Kuester, Denn | Science Citation Index through Chalmers Lib | | | | x | | | (x) | | | | Doesn't not contain "trustworthiness" at all, but seemed interesting | 2019-03-21 | In note | Björn |
| Can you hold my hand? Physical warmth in human-robot interaction. | Nie, Jiaqi<br>Park, Michelle<br>Marin, Angie L<br>Sundar, S. Shy | Complement ary Index through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| Can You Trust Your Robot? | HANCOCK, P.<br>BILLINGS, D.<br>SCHAEFER, K | Supplementa l Index through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Hampus |

| Name of Article | Author(s) | Database | Search Terms: | Trust | HRI | Robot(s) | Automation | Automative | Trustworthi | Domestic R | Robotic vac | Cited by oth | Comment | Date of access | Biblographic Inf | Read by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Kim, Ki Joon<br>Park, Eunil<br>Shyam Sunda | ScienceDirect through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| Classification of Robot Form: Factors Predicting Perceived Trustworthiness | Schaefer, Kris<br>Sanders, Trac<br>Yordon, Ryan<br>Billings, Debor<br>Hancock, P.A. | Supplemental Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-22 | In note | Björn |
| Detecting Engagement in HRI: An Exploration of Social and Task-based Context | Castellano, G.<br>Leite, I.<br>Pereira, A.<br>Martinho, C.<br>Paiva, A.<br>McOwan, P.W | Scopus through Chalmers Lib | | (x) | x | | | | | | | | A little bit outside search criteras, but was manually deemed to be value to the study. | 2019-03-21 | In note | Björn |
| Dispositional trust – Do we trust autonomous cars? | Lazanyi, K.<br>Maraczi, G. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | Jaichandar Ku | IEEE through chalmers Lib | | (x) | | | | | | | x | | | 2019-03-22 | In note | Björn |
| Effects of Changing Reliability on Trust of Robot Systems | Desai, M.<br>Medvedev, M.<br>McSheehy, S.<br>Yanco, H.<br>Vázquez, M.<br>Bruggeman, C<br>Steinfeld, A.<br>Gadea-Omelc | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Sarkar, Satrag<br>Araiza-Illan, D<br>Eder, Kerstin | arXiv through Chalmers Lib | | | | x | | | x | | | | | 2019-03-21 | In note | Björn |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | Castro-Gonzál<br>Scassellati, B.<br>Admoni, H. | Scopus through Chalmers Lib | | | | x | | | x | | | | | 2019-03-21 | In note | Björn |
| Employing user-generated content to enhance human-robot interaction in a human-robot trust game | Liang, Y.<br>Lee, S.A. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Human-robot interaction: Developing trust in robots | Billings, D.R.<br>Schaefer, K.E.<br>Chen, J.Y.C.<br>Hancock, P.A. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Human-Robot Interaction: How People View Domestic Robots | Maria Vittoria (<br>Anna Saggese | Google scholar | | x | | | | | | x | | | Part of "Proceedings of the First RoboCare Workshop" | 2019-03-21 | In note | Hampus |

| Name of Article | Author(s) | Database | Search Terms: | Trust | HRI | Robot(s) | Automation | Automative | Trustworthi | Domestic Ro | Robotic vac | Cited by oth | Comment | Date of access | Bibliographic Inf | Read by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Improved human-robot team performance using Chaski, a human-inspired plan execution system | Shah, J. Wiken, J. Williams, B. Breazeal, C. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Increasing trust in human–robot medical interactions: effects of transparency and adaptability | Kerstin Fische | Chalmers Lib | | x | | | | | | x | | | From Paladyn, Journal of Behavioral Robotics vol. 9 | 2019-03-20 | In Note | Hampus |
| Interactive Robotic Vacuum Cleaner | Juzovitski, Dm | Google scholar | | x | | | | | | | x | | Lol, den här hittade jag med search term "robotic vacuum cleaner", maybe we should at that one? Master's thesis Lund University | 2019-03-20 | In note | Hampus |
| Lessons learned from robotic vacuum cleaners entering the home ecosystem | F.Vaussarda, . | ScienceDirect through Google Scholar | | (x) | | | | | | x | | | "Trust" isn't used in absctract or title, but text still seems relevant | 2019-03-21 | In note | Hampus |
| Living with a Vacuum Cleaning Robot | Julia FinkEma | Springer through Google scholar | | (x) | | | | | | x | | | Contains good words like "adopting" and "perception". In abstract, mentions a framework for developing domestic robots that we probably should look up. | 2019-03-21 | In note | Björn |
| Maintaining Trust While Fixated to a Rehabilitative Robot | Jensen, L.U. Winther, T.S. Jørgensen, R. Hellestrup, D.N Jensen, L.C. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | Schaefer, K.E. | Scopus through Chalmers Lib | | x | x | | | | | | | | Chapter of book Robust Intelligence and Trust in Autonomous Systems | 2019-03-20 | In note | Hampus |
| Multi-modal Feedback for Affordance-driven Interactive Reinforcement Learning | Cruz, Francisc Parisi, Germar Wermter, Stefa | arXiv through Chalmers Lib | | | | x | | | x | | | | | 2019-03-22 | In note | Björn |
| Perception of own and robot engagement in human–robot interactions and their dependence on robotics knowledge | Hall, Joanna Tritton, Terry Rowe, Angela Pipe, Anthony Melhuish, Chri Leonards, Ute | ScienceDirect through Chalmers Lib | | | x | | | | x | | | | | 2019-03-21 | In note | Björn |

| Name of Article | Author(s) | Database | Search Terms: | Trust | HRI | Robot(s) | Automation | Automative | Trustworthi | Domestic Ro | Robotic vac | Cited by oth | Comment | Date of access | Bibliographic Inf | Read by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Robot Vacuum Cleaner Personality and Behavior | Bram Hendriks | Springer through Google scholar | | | | | | | | x | | | Not within criteria, but seems very relevant. | 2019-03-21 | In note | Hampus |
| Robotic Motion Learning Framework to Promote Social Engagement | Burns, Rachae Jeon, Myoung Park, Chung H | Complementary Index through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Balazs Daniel Trygve Thome Peter Korondi | Directory of Open Access Journals through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | Shiomi, Masah Hagita, Norihir | Complementary Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-21 | In note | Björn |
| Social interaction moderates human-robot trust-reliance relationship and improves stress coping | Lohani, M. Stokes, C. Mccoy, M. Bailey, C.A. Rivers, S.E. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| The future African workplace : the use of collaborative robots in manufacturing | Poisat Paul Calitz Andre P Cullen Margar | African Journals through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | Alessandra Ro | Chalmers Lib | | x | | | | | | x | | | From Paladyn, Journal of Behavioral Robotics vol. 9 | 2019-03-20 | In note | Hampus |
| The Role of Reciprocity in Verbally Persuasive Robots | Seungcheol A Yuhua (Jake) I | Complementary Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-21 | In note | Björn |
| Trust calibration within a human-robot team: Comparing automatically generated explanations | Wang, N. Pynadath, D.V Hill, S.G. | Scopus through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Chen, M Nikolaidis, S Soh, H Hsu, D Srinivasa, S | arXiv through Chalmers Lib | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |

| Name of Article | Author(s) | Database | Search Terms: | Trust | HRI | Robot(s) | Automation | Automative | Trustworthi | Domestic Ro | Robotic vac | Cited by oth | Comment | Date of access | Biblographic Inf | Read by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Using explanations to provide transparency during trust-guided behavior adaptation. | Floyd, Michael Aha, David W. | Complementary Index through Chalmers Lib | | | | x | | | x | | | | | 2019-03-22 | In note | Björn |
| When stereotypes meet robots The double-edge sword of robot gender and personality in human–robot interaction | BenedictTayaY | ScieneDirect through Google scholar | | x | | x | | | | | | | Searched for "trust" and "domestic robots". Had no relevant mentions of domestic robots, but many mentions of trust. | 2019-03-21 | In note | Björn |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Salem, M. Lakatos, G. Amirabdollahia Dautenhahn, K | IEEE through Google scholar | | x | x | | | | | | | | | 2019-03-20 | In note | Björn |
| You Want Me to Trust a ROBOT? The Development of a Human-Robot Interaction Trust Scale. | Yagoda, Rose Gillan, Dougla | Complementary Index through Chalmers Lib | | x | x | | | | | | | | | 2019-03-21 | In note | Björn |

| Article | Observations | Type |
|---|---|---|
| The future African workplace : the use of collaborative robots in manufacturing | Article brings up the fourth industrial revolution and the usage of smaller industrial robots. | Meta |
| The future African workplace : the use of collaborative robots in manufacturing | Trust determines acceptance - *"Human–robot trust determines a worker's acceptance of a Cobot in a collaborative work environment."* | Human |
| The future African workplace : the use of collaborative robots in manufacturing | *"Billings et al. (2012) indicates that human characteristics, environmental characteristics and robot characteristics influence human–robot trust. Additional factors include usability, social acceptance, user experience and societal impact (Weiss, Bernhaupt, Lankes & Tscheligi, 2009)."* | Meta |
| The future African workplace : the use of collaborative robots in manufacturing | *"The major challenges for South African and African businesses that introduce Cobots at the employee level are fear of redundancy, retrenchment and increased unemployment"* | Human |
| The future African workplace : the use of collaborative robots in manufacturing | *"The major training needs for the introduction of Cobots at employee level are greater technical training, trust and safety, understanding robotic functionality and employee loneliness"* | Human |
| The future African workplace : the use of collaborative robots in manufacturing | *"'In the long term there might be some emotional support needed as the job might become lonely without other humans in the proximity'"* | Human |
| The future African workplace : the use of collaborative robots in manufacturing | Feeling that the robot depend on the human leads to trust | Robot |
| The future African workplace : the use of collaborative robots in manufacturing | feeling that the human is in control leads to trust. | Human |
| The future African workplace : the use of collaborative robots in manufacturing | *"Interestingly, the automotive manufacturer respondents, some of whom have introduced Cobots, did not think 'culture' had a major impact on HRI"* | Environment |
| A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Robots are prefered to avatars when seeking advice. | Human |
| A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Physical presence leads to trust | Robot |
| A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Gender can influence trust in computer recommendation systems. | Robot |
| A Comparison of Avatar-, Video-, and Robot-Mediated Interaction on Users' Trust in Expertise | Respondent throught "Robots must be intelligent" (humanoid robot in this case) so they trusted them more. | Human |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Robot does low-risk objective first in order to build trust. | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Robot intentionally fails at non-critical task inorder to build more accurate trust. | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | *"Over-trusting robot autonomy may lead to misuse of such systems, where people rely excessively on automation, failing to intervene in the case of critical failures"* | Meta |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | *"On the other hand, lack of trust leads to disuse of autonomous systems: users ignore the systems' capabilities, with negative effects on overall performance."* | Not-included |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | "the robot should monitor human trust and influence it so that it matches the system's capabilities." | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Robot used partially observable Markov decision process to allow it to respond differently to how it percieves human trust in it. | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Humans do not expect robots to deceive them. As such trust is based on how humans precieve the ability of the robot. | Human |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Failure has a negative impact on trust. | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | *"robot performance in the earlier part of the task has a more pronounced impact on trust"* | Robot |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | "primacy effect" a congitive bias affects trust. | Not-included |
| Trust-Aware Decision Making for Human-Robot Collaboration: Model Learning and Planning | Trust matters less if the risk is low, and vice versa. | Environment |
| Employing user-generated content to enhance human-robot interaction in a human-robot trust game | (Positive) user-Generated Content (UGC) did not **directly** affect trust. | Environment |
| Employing user-generated content to enhance human-robot interaction in a human-robot trust game | Positive UGC affected users see robots as a technology as more useful and easier to use, as well as improved users mood while interacting with the robot. | Environment |
| Employing user-generated content to enhance human-robot interaction in a human-robot trust game | Postive UGC made users care more about the robot. | Environment |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | *"It is essential for robots to be highly usable to achieve increased acceptance among target population"* | Robot |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | Social acceptance is increased with use. | Human |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | *"For elderly to trust and establish a mutual understanding with robot it should be easily acceptable, that is robotic role should be easily identifiable with its functions and capabilities. Robotic role can be identified by the user by looking at its form along with its capabilities that it in line with its form."* Basically robot form should indicate function | Robot |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | *"Affective interaction plays a key role in level of acceptance among elderly"* | Human |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | *"It has been shown that the elderly are attracted to robots, raising the promise that appropriately designed robots could play an important role in their treatment"* | Human |
| Easiness of acceptance metric for effective human robot interactions in therapeutic pet robots | The study measures easiness of acceptanced using metrics such a "*length of time to initiate interaction, total interaction time, time needed to identify perception-reaction phenomenon, its occurence, number of violations and affective interaction factor."* | Meta |
| Dispositional trust – Do we trust autonomous cars? | Article addresses lack of trust. | Not-included |
| Dispositional trust – Do we trust autonomous cars? | *"For them present-day robots are regarded as tools that can extend human capabilities and compensate for human limitations, hence they are trusted to help and not harm."* They refer to most people | Human |
| Dispositional trust – Do we trust autonomous cars? | Article divides trust into dispositional and historical trust, and state that only the latter can be influenced by HCI. | Meta |
| Dispositional trust – Do we trust autonomous cars? | "*Numerous empirical studies have pointed out correlation between the preformance of the system and the trustor's level of trust"* | Robot |
| Dispositional trust – Do we trust autonomous cars? | An important factor of robot trust is predictability | Robot |
| Dispositional trust – Do we trust autonomous cars? | *" - Make the trustor understand the fuction of the robotic system"* | Human |
| Dispositional trust – Do we trust autonomous cars? | *" - Raise awareness of the fact that robots are not alike humans! Robots might achieve specific goals in their own ways"* | Environment |
| Dispositional trust – Do we trust autonomous cars? | *" - Provide the trustor information on WHY the robot acts in a certain way!"* | Robot |
| Dispositional trust – Do we trust autonomous cars? | *" - Provide information about past performance of the system to raise rational expectations on."* | Robot |
| Dispositional trust – Do we trust autonomous cars? | *" - Robots are not flawless. Humans should be aware of the robots' limitations"* | Human |
| Dispositional trust – Do we trust autonomous cars? | The study (of Hungarian young adults) show no siginificat difference in initial trust between male and female respondents. | Human |
| Dispositional trust – Do we trust autonomous cars? | Respondents were more willing to give up control in situations that were considered boring. | Human |
| Living with a Vacuum Cleaning Robot | *"They found that within their concept of robots, people distinguished between 'Roomba' and the great mass of 'other robots'"* | Environment |

| Article | Observations | Type |
|---|---|---|
| Living with a Vacuum Cleaning Robot | People think robots are smarter than they are: *"Nevertheless, participants expected a domestic robot to be intelligent and able to learn."* | Human |
| Living with a Vacuum Cleaning Robot | Typical users: *"Data revealed that Roomba users were equally likely men or women, and tended to be younger with higher levels of education or technical backgrounds"* | Human |
| Living with a Vacuum Cleaning Robot | *"In terms of the impact on housekeeping, it has been shown that in comparison to a traditional vacuum cleaner (VC), the Roomba changed people's cleaning activities and how they used other tools. The robot affected cleaning routines, by increasing cleaning activities, encouraging multi-tasking, collaboration, and making cleaning a concern for everyone in the home"* | Human |
| Living with a Vacuum Cleaning Robot | *"Sung et al. further observed that people customized their Roomba (e.g. with drawing or putting stickers on it) to express its 'identity' (or gender) and show its value to the household. Intimacy and positive emotional attachment, such as assigning an identity to the robot, led to greater acceptance of the product in general and the perceived usability"* | Human |
| Living with a Vacuum Cleaning Robot | *"However, also with domestic robots, long-term studies found that people's interest, engagement and fascination with the robot decreased over time"* | Human |
| Living with a Vacuum Cleaning Robot | *"These and other observations highlight that the robot was used as an independent tool and differently from a classic VC."* and *"However, the experience broadened most people's mind and more importantly, how the robot appeared changed qualitatively over time from 'fancy new robot' to 'just another cleaning tool'."* | Not-included |
| Living with a Vacuum Cleaning Robot | Robots destroying expensive carpets was a concern brought up the study: *"These and other observations highlight that the robot was used as an independent tool and differently from a classic VC."* | Human |
| Living with a Vacuum Cleaning Robot | People want to hide their roomba when not used: *"'Still, this is a vacuum cleaner and you don't want to have your vacuum cleaner next to your dining table when you are having dinner or friends are coming over. It looks too much like work!'"* | Human |
| Living with a Vacuum Cleaning Robot | Difference precieved usefulness between genders: "*This again was due to the fact that women (as the main users) evaluated the robot's vacuuming power whereas men regarded more generally that the robot could help cleaning and would thus be a useful device.*" | Human |
| Living with a Vacuum Cleaning Robot | "*...the robot encouraged people to make a variety of adjustments to their home (mostly in the first two weeks of the study)*" | Environment |
| Living with a Vacuum Cleaning Robot | *"The majority of households (6 out of 9) did not perceive the robot as useful, as they didn't feel their home became cleaner or they could save some time "* | Human |
| Living with a Vacuum Cleaning Robot | Household composition matters: "*Tiny rooms with a lot of corners and homes with door sills are not suitable for Roomba, as it decreases its efficiency or can make it impossible for it to move around autonomously. Besides this, households generally didn't like to make adjustments to their home to enable the robot to work. For people living alone it seemed easier to adjust the space but as soon as several people share one place changes are not made easily and it would cause some effort to get everybody's agreement (e.g. to put the problematic carpet away).*" | Environment |
| Living with a Vacuum Cleaning Robot | Roombas are easy to use, but hard to master: "*it required to learn how to optimally use it*" and *"The robot needs to be used in a different way than a usual vacuum cleaner but not everybody was willing to learn how to use it."* | Human |
| Living with a Vacuum Cleaning Robot | Habits and beliefs affects the interaction: "One participant believed no one could do the cleaning as efficient and properly as herself and thus she did not accept any help with it, neither from her husband, nor from a cleaning service, nor from a robot. The robot was simply not compatible with her personal beliefs." | Human |
| Living with a Vacuum Cleaning Robot | *"Some devices in a home might not be very practical or even hard to use, however, they find their place as they hold a great personal value (e.g. evoke attachment)."* | Environment |
| Living with a Vacuum Cleaning Robot | Lower trust leads to less use: *"When people did not trust/rely on the robot, they didn't want to leave the room/home when the robot was switched on. However, this does not meet the robot's intended way of use."* | Human |
| Living with a Vacuum Cleaning Robot | Social factors affects use: *"This encouraged H1 to keep on using the robotic VC, as he experienced a positive social impact.*" | Human |
| Living with a Vacuum Cleaning Robot | There are often "hidden" expenses that users are not aware of. E.g. brushes need changing and increased electricity costs. | Robot |
| Living with a Vacuum Cleaning Robot | "*People are curious to try out a new robot in their home."* | Human |
| Living with a Vacuum Cleaning Robot | "Cleaning strategies are deeply rooted habits" | Human |
| Living with a Vacuum Cleaning Robot | "*A robot does not profoundly change cleaning roles."* e.g. gender roles | Human |
| Living with a Vacuum Cleaning Robot | *"Roomba is not a replacement of the vacuum cleaner"* and "*However, it can reduce the amount of vacuumcleaning session and helps people keep their homes clean."* | Robot |
| Living with a Vacuum Cleaning Robot | *"Beliefs are more important than the environment."* | Environment |
| Living with a Vacuum Cleaning Robot | *"The social impact of functional robots is overestimated."* and "*People tend to basically anthropomorphize even a simple functional robot, by talking to it directly or by using communication traits that are comparable when relating to a pet or other human. However, the phenomenon wears off when people become familiar with the robot.*" | Human |
| An Uncanny Game of Trust: Social Trustworthiness of Robots Inferred from Subtle Anthropomorphic Facial Cues. | If designing anthropomorphic robots be mindful of the uncanny valley. | Robot |
| Social interaction moderates human-robot trust-reliance relationship and improves stress coping | *"trust affects the willingness of people to accept information provided bt a robot"* | Human |
| Social interaction moderates human-robot trust-reliance relationship and improves stress coping | *"...previous work with non-social interactions has found no links between trust and reliance"* This meant that social interactions needed to be researched. | Meta |
| Social interaction moderates human-robot trust-reliance relationship and improves stress coping | Socioemotional interactions had a positive impact on the human-robot interaction. Among which was reduced stress. | Human |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | Social acceptance leads to better integration in the real world. | Environment |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | New childrens technologies usually has low social acceptance. | Not-included |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | Experiments showed that children were more interested in robots due to the way they moved, rather than how anthropomorphic their apprances were. | Human |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | There was lower social acceptance towards childcare support robotics than an other currecnt child care technologies that was tested before having interacted with such technology. | Human |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | There was no big difference in how people viewed childcare support robot systems in USA and Japan. | Environment |
| Social acceptance toward a childcare support robot system: web-based cultural differences investigation and a field study in Japan. | After having interacted with a childcare support robot system users had positive impressions of the technology. | Human |
| Avatars in Pain: Visible Harm Enhances Mind Perception in Humans and Robots | A female humanoid robotic avatar with visible wounds scored higher on person agency, consciousness, empathy, attractiveness and experience. | Robot |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | Naturalistic movement (human / animal like movement) leads to higher likability. | Robot |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | Social interactions with robots are important. | Human |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | Animancy (perceiving a robot to as being alive) is one of the most important features in a social robot | Robot |

| Article | Observations | Type |
|---|---|---|
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | Naturalistic movement leads to higher animancy. | Robot |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | If a robot looks naturalistic, people expect it to move naturalistic too. *"Although observers typically judge rovots with naturalistic bodies to be more animate, these judgements are radically altered if the robot moves mechanistically."* | Human |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | This study did not find that cheating lead to greater animancy, but cited other studies that did. | Meta |
| Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness | There is a risk of running into the uncanny valley if the robot becomes too humanlike. | Robot |
| When stereotypes meet robots The double-edge sword of robot gender and personality in human–robot interaction | The uncanny valley. | Robot |
| Sarkar2017 | When humanoid robot behaviour matches gendered sterotypes (e.g. a female voice to a nursing robot) people usually responds more positive to it. | Robot |
| When stereotypes meet robots The double-edge sword of robot gender and personality in human–robot interaction | When humanoid robot behaviour matches introverted/extroverted sterotypes (e.g. a nursing robot acting extroverted) people usually responds more positive to it. | Robot |
| When stereotypes meet robots The double-edge sword of robot gender and personality in human–robot interaction | Article state that similar studies needs to be made on non-humanoid robots, e.g. pet robots to see how they are affected by social stereotypes. | Meta |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | Better understanding the decision-making process of a robot leads to higher trust. | Human |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | Article mentions distrust. | Meta |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | More trust leads to more use. | Human |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | Understanding the robot requires transparency. | Robot |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | Study uses a military scenario. | Meta |
| Trust Calibration within a Human-Robot Team: Comparing Automatically Generated Explanations | Experiment showed that transparency matters most when there is a risk of failure. | Human |
| Detecting Engagement in HRI: An Exploration of Social and Task-based Context | *"Game and social context-based features can be successfully used to predict engagement with the robot."* | Human |
| Detecting Engagement in HRI: An Exploration of Social and Task-based Context | *"Overall features proved more successful than turn-based features; the fusion of game and social context-based features with features encoding their interdependencies leads to higher recognition performances."* | Not-included |
| Detecting Engagement in HRI: An Exploration of Social and Task-based Context | Article used the context of a game of chess to test HRI. | Meta |
| Improved human-robot team performance using Chaski, a human-inspired plan execution system | HRI is benefited from adapting strategies for teamwork involving only humans. | Meta |
| Improved human-robot team performance using Chaski, a human-inspired plan execution system | During the experiment testers reported an increase of performance with higher scores of trustworthiness, and not a higher score of robot performance: *""Participants in the Implicit Teaming group agreed with the statement "the robot is trustworthy"more strongly than people in the Explicit Teaming group, a statistically significant difference (p<0.05). However, Implicit group participants did not agree more strongly than Explicit group participants that the team worked fluently together, the robot performed well, or that the team members shared common goals.* | Human |
| The Role of Reciprocity in Verbally Persuasive Robots | When users have been helped by the robot they are more likely to agree to do tasks that they are perceiving as helpful towards to the robot. | Human |
| The Role of Reciprocity in Verbally Persuasive Robots | There is a difference in behaviour when comparing physical robots and avatars. (This should be taken under consideration when reading articles that have computer simulated robot. ) | Meta |
| The Role of Reciprocity in Verbally Persuasive Robots | Physical robots are seen as more likeable, sociable and friendly compared to computer agents. | Robot |
| Classification of Robot Form: Factors Predicting Perceived Trustworthiness | Appearance of the robot matters when it comes to trust. | Robot |
| Classification of Robot Form: Factors Predicting Perceived Trustworthiness | Trust leads to use. | Human |
| Classification of Robot Form: Factors Predicting Perceived Trustworthiness | When the robots appearance match its intended use people are more likely to accept the robot. | Robot |
| Classification of Robot Form: Factors Predicting Perceived Trustworthiness | Article uses Sander's 3-factor model of trust. | Meta |
| Perception of own and robot engagement in human–robot interactions and their dependence on robotics knowledge | Greater familiarity with robotics leads to a more positive interaction with the robot. | Human |
| Perception of own and robot engagement in human–robot interactions and their dependence on robotics knowledge | Humans react to non-verbal gestures that the robot makes and it makes them more likeable (as long as the robot makes likable gestures like nodding) | Human |
| Can You Trust Your Robot? | "Deception plays an important, but often overlooked, role in the development and maintenance of trust." | Robot |
| Can You Trust Your Robot? | "... (HRI) is only one subset of the larger issue of human-automation interaction" | Meta |
| Can You Trust Your Robot? | A "human fear of robots' becoming self-aware, rebelling and destroying humans" exist in movies osv | Human |
| Can You Trust Your Robot? | Law of Robotics is mentioned | Meta |
| Can You Trust Your Robot? | Science fiction is mentioned | Meta |
| Can You Trust Your Robot? | DEFINITION OF ROBOT "Robots (aside from those found in science fiction stories) have been defined in a variety of ways, but a standard definition of a robot was created by the Robot Industries Association (RIA): a robot is 'a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks'" | Robot |
| Can You Trust Your Robot? | If we adhere strictly to this definition, we currently use robots all the time | Robot |
| Can You Trust Your Robot? | Robots are more powerful than humans, but should follow the humans command | Robot |
| Can You Trust Your Robot? | "... we assume that robots should have a physical form akin to the human body and artificial intelligence that operates similar to a human brain.Danger arises because we see robots as constrained human beings and assume they possess other human characteristics as well. This is an unfortunate case of attribution error." | Robot |
| Can You Trust Your Robot? | "Humans generally view present-day robots as tools that can extend their capabilities and, to some degree, compensate for human limitations (Chen, Barnes, & Harper-Sciarini, 2010). For a robot to be effective in this sense, the human must trust it to do its job consistently and effectively." | Human |

| Article | Observations | Type |
|---|---|---|
| Can You Trust Your Robot? | "robots as active, interdependent teammates" are becoming more common => more problems and challenges in "human-robot collaborative environments" | Robot |
| Can You Trust Your Robot? | Humans must trust a robot to do their job, but also act as expected and in the best interest of the team. (Regarding collaboration) | Robot |
| Can You Trust Your Robot? | Appropriate trust while enhance the advantages of the robot | Robot |
| Can You Trust Your Robot? | DEFINITION OF TRUST: "Trust is a relational concept that requires a minimum of three elements. Two agents are needed: one an actor or transmitter of information and the other being acted on, or the receiver of that information. A viable communicationchannel between these two agents is also a necessary require-ment." | Meta |
| Can You Trust Your Robot? | "the outcomes of trust provide feedback to the human teammate, leading to adjustments or changes in the degree of trust in the robotic system" | Human |
| Can You Trust Your Robot? | "... this calibration of trust may affect reliance on the system, the effectiveness of the human-robot collaboration, and thus the overall interaction." | Human |
| Can You Trust Your Robot? | technology allows us to create robotic systems that can employ deception to their advantage. | Robot |
| Can You Trust Your Robot? | Deception may affect HRI, create a miss-match, possibly resulting in altered trust level | Robot |
| Human-robot interaction: Developing trust in robots | Article is based on military research | Meta |
| Human-robot interaction: Developing trust in robots | Article brings up the importance of appropriate levels of trust | Meta |
| Human-robot interaction: Developing trust in robots | Article divides trust into robot-related, human-related, and enivroment characteristics. | Meta |
| Human-robot interaction: Developing trust in robots | Articles brings up dispositional and history based trust. | Meta |
| Human-robot interaction: Developing trust in robots | Article is a meta analysis of current development of human-robot trust. | Meta |
| Maintaining Trust While Fixated to a Rehabilitative Robot | Most users did not feel insecure by being fixated to a robotic arm. | Human |
| Maintaining Trust While Fixated to a Rehabilitative Robot | Most users felt insecure when the robotic arm that they were fixated to moved into their personal space | Human |
| Maintaining Trust While Fixated to a Rehabilitative Robot | Getting familiarised with the robot made people feel safe. E.g. let them try out the emergency stop in a safe environment. | Human |
| Robotic Motion Learning Framework to Promote Social Engagement | The Chameleon Effect - humans unintentionally copy other people during interaction | Human |
| Robotic Motion Learning Framework to Promote Social Engagement | Imitation passively leads to empathy and rapport for the recipient. | Human |
| Robotic Motion Learning Framework to Promote Social Engagement | Robots can use imitation to make humans more comfortable around them. | Robot |
| Robotic Motion Learning Framework to Promote Social Engagement | Experiment with algorithm to mimic human gesture. | Meta |
| Robotic Motion Learning Framework to Promote Social Engagement | Study used a humanoid robot. | Meta |
| A Cognitive Model of Trust for Biological and Artificial Humanoid Robots | Article proposes a model for simulating how a robot would trust a person, and deals with A.I. that seems out of scope of our thesis. | Not-included |
| Can You Trust Your Robot? | Sci-fi can play a roll in forming our excpectations of robots | Environment |
| Can You Trust Your Robot? | Sci-fi "provides a clear picture of the issues of trust and deception in HRI" | Environment |
| Can You Trust Your Robot? | Robots can determine the gulability of another robot, then trick it | Robot |
| Can You Trust Your Robot? | "Does the individual's understanding of the intent of the robot match the actual intent? If the answer is yes, then trust is likely to develop. If the answer is no, then deception may be present and trust may not be as likely to develop." | Human |
| Can You Trust Your Robot? | "The robot's failure rate (at least according to the human's perception) will increase, and the perceived reliability of the system will decrease. Consequently, the human may not be as quick to trust or use the robot in future operations." | Robot |
| Can You Trust Your Robot? | "An individual may also experience changes in self-confidence in his or her abilities, which may affect mutual trust levels." | Human |
| Can You Trust Your Robot? | Designing for deception "might complicate trust and 'poison the well' of robot use." | Robot |
| Can You Trust Your Robot? | Humans see it as greater risk to trust anything they know may be deceptive. | Robot |
| Can You Trust Your Robot? | Trust in a robot can also be affected by the frequency of deception (Wagner & Arkin, 2011). | Robot |
| Can You Trust Your Robot? | There are certain contexts in which deception may be warranted. | Environment |
| Can You Trust Your Robot? | "However, when deception leads to negative outcomes, trust is almost always affected." | Robot |
| Can You Trust Your Robot? | Robot performance-based factors and robot attributes are the largest contributors to trust in HRI. | Robot |
| Can You Trust Your Robot? | Knowledge of performance, functionality, and capabilities of the robot can facilitate the development of trust. | Robot |
| Can You Trust Your Robot? | Contains guidelines for designing HRI | Meta |
| Can You Trust Your Robot? | If deception is the goal, designers can attempt to create a false sense of transparency. | Robot |
| Can You Trust Your Robot? | If gaining trust is the goal, engineers should design the robot in a way that allows the user to observe the system and better understand what the system is doing. | Robot |
| Can You Trust Your Robot? | Guideline: Transparency of the robotic system affects trust. | Robot |
| Can You Trust Your Robot? | Guideline: Human teammate's knowledge of the robotic partner affects trust. | Robot |
| Can You Trust Your Robot? | Guideline: Creation of mental models affects trust. | Robot |
| Can You Trust Your Robot? | Guideline: Use of adaptive function allocation and adaptive technology affects trust. | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | There is a correlation between the magnitude of a robot error and the loss in trust | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | Conscientiousness, agreeableness, and benevolence in participants significantly increased tendensies to trust robots | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | DEFINITION OF TRUST: "Trust determines human's acceptance of a robot as a companion and in their perception of the usefulness of imparted information and capabilities of a robot [1, 2]." | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | Higher trust is associated with the perception of higher reliability | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | Appearance, type, size, proximity, and behaviour of a particular robot will affect user's perceptions of the robot. | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "... a sense of the robot's vulnerability, through facial expressions, colour and movements, increased perceived trust and companionship, and increased disclosure." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "Lohse et al. [8] demonstrated that robots with more extrovert personalities are perceived more positively by some users." | Robot |

| Article | Observations | Type |
|---|---|---|
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "our hypothesis H1 suggested that there is a correlation between the severity of the error performed by the robot and humans not trusting the robot." | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "Our study shows that the magnitude of the errors made by the robot, and humans not trusting the robot are correlated." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "participants' trust was affected more severely when the robot made errors having severe consequences." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | We also hypothesised in H2 that the timing when the error is performed affects the trust towards robots (research question R2), and there is a correlation between the timing of when the error occurred and the magnitude of the error (research question R3 and hypothesis H3). | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "We found a strong connection between the personality traits of agreeableness, conscientiousness and emotional stability, and their disposition of trust other people." | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | low experience with robots among participants | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | extroverted participants tended to consider robots generally as a machine | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | agreeable participants tended to consider robots generally as an assistant | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "extroverted perceived Jace as a friend and a warm and attentive entity" | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "agreeable participants perceived Jace as a tool" | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "extroverted participants would like to have Jace as home companion and believe it is reliable and trustworthy in uncertain and unusual situations." | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "conscientiousness and agreeableness traits correlate with participants' propensity for trusting the robot" | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "participants' belief in benevolence of people also correlate with higher trust in Jace." | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "errors made by the robot significantly affected participants' perception of the robot." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "robot characteristics, with a special focus on performance-based factors, have great influence on perceived trust in HRI." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "Muir and Moray [31] argue that human perceptions of a machine are affected in a more severe and long-term way by an accumulation of 'small' errors rather than one single 'big' error." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "The embodiment of a robot may also have a major impact on the perception of it by humans [4]." | Robot |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | "People have individual differences, including age, gender, cultural and social habits, which may impact their perceptions of what are considered big or small errors." | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | A Mann-Whitney U-tests was used to check dependency between error rating and gender | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | A Kruskal-Wallis test was used to check dependency between error rating and age | Meta |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | No dependency was found between error rating and gender | Human |
| The impact of peoples' personal dispositions and personalities on their trust of robots in an emergency scenario | No dependency was found between error rating and age | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Understanding factors of trust is important to designing robots. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | People's attitudes is a factor of trust | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Experience is a factor of trust | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Characteristics; the robot's physical design, reliability and preformance are factors of trust | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | In the case of a non-social robot whether the robot is faulty or not did not have a significant impact on human's perception of the robot (in terms of human-likeliness, likeability, trustworthiness or competence.) | Robot |

| Article | Observations | Type |
|---|---|---|
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Trust can affect the performance of a worker | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Trust leads to acceptance | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Acceptance leads to use | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Better understanding of trust and likeability leads to designed better robots. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Trust needs to be studied long-term as small errors can build up and have more impact than a single big error. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Bad initial performance have a strong impact. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Trust over time have been modelled from from combination of errors, productivity, awareness and previous trust. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | When studying trust it is important to consider the different situations and scenarios that affects the study. | Meta |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Both objective and subjective metrics of trust should be considered in the study. | Meta |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | The study divided perceived trust into competence and trustworthiness. | Meta |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | After the experiment a non-faulty robot lead to an increase of animancy score compared to before interacting with it. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | After the experiment a non-faulty robot lead to an increase of trustworthiness score compared to before interacting with it. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | After the experiment a non-faulty and faulty robot lead to a decrease of safety score compared to before interacting with it. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | After the experiment a non-faulty robot lead to a decrease of intelligence score compared to before interacting with it. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | After the experiment a faulty robot lead to a decrease of trustworthiness score compared to before interacting with it. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Most people had low exceptions of the robot, but were pleasantly surprised by it in the experiment. | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Most people wanted a better interface (e.g. voice, face body language) as an improvement to the robot's friendliness in the experiment. | Human |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | Some of the faults programmed into the robot in the experiment was speculated to be seen as intelligence, i.e. that the robot discovered its faults and asked for them to be corrected. | Robot |
| Effects of Faults, Experience, and Personality on Trust in a Robot Co-Worker | The experiment was done as a manufacturing scenario, and might not translate into home conditions as well as other studies. | Meta |
| Robot Vacuum Cleaner Personality and Behavior | "We recommend using a personality model as a tool for developing robot behavior." | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "People are no longer in full control of what the product is doing, where and when." | Environment |
| Robot Vacuum Cleaner Personality and Behavior | "Aspects of anthropomorphism are reported in studies on the experience of robot vacuum cleaners." | Robot |
| Robot Vacuum Cleaner Personality and Behavior | People name it, ascribe a gender, and personality to their Roomba | Robot |
| Robot Vacuum Cleaner Personality and Behavior | Studies have shown that people prefer more extraverted and agreeable personalities over more introverted and formal ones when interacting with a computer [15] and a robot [16]. But these studies by Reeves and Nass [15], and Meerbeek, Hoonhout, Bingley and Terken [16] focus on applications with a social function, whereas a robotic vacuum cleaner primarily serves service purposes. | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "The personality serves as a design guideline, as suggested by Meerbeek, Saerbeck and Bartneck [1]," | Meta |
| Robot Vacuum Cleaner Personality and Behavior | "In order to find out what robot vacuum cleaner personality people desire, a semi-structured interview was done with six participants, two women and four men. They were selected because they were likely to be early adopters of robot vacuum cleaners." | Meta |
| Robot Vacuum Cleaner Personality and Behavior | "The robot vacuum cleaner in the video is represented by simply a cardboard box, as in this study the focus is on behavior." | Meta |
| Robot Vacuum Cleaner Personality and Behavior | "An iRobot Roomba robot vacuum cleaner was used as a test platform for the motion aspects of the behavior to be designed. This Roomba was manually controlled by means of a joystick via a Bluetooth connection. A microcontroller was used to control the light, which consists of six separate LEDs. The vacuuming sound of the robot vacuum cleaner was recorded from a conventional vacuum cleaner, whereas additional sounds were designed by using sound development software." | Meta |
| Robot Vacuum Cleaner Personality and Behavior | " Designers can make use of this phenomenon by deliberately designing a robot vacuum cleaner personality. This, by going through a process of determining personality, developing behavior in an iterative way and evaluating the user experience of the robot vacuum cleaner. We recommend using a personality model as a tool for developing robot behavior. We found it useful as a guideline when taking design decisions and helpful in developing consistent behavior." | Meta |
| Robot Vacuum Cleaner Personality and Behavior | Lists desired personality traits fig 2 page 3 | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "Out of fifteen participants, fourteen assigned a gender to the robot vacuum cleaner." | Human |
| Robot Vacuum Cleaner Personality and Behavior | "For example, one of the actors who was asked to act like a robot vacuuming a dirty spot, started to clean that spot slowly thereby making repetitive, firm movements back and forth. These motion aspects of the behavior were then described as taking place on a small plane, slow, regular and tensed." | Meta |
| Robot Vacuum Cleaner Personality and Behavior | "people prefer a calm, polite, and cooperative robot vacuum cleaner that works efficiently, systematically and likes routines." | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "We think that the designed personality is beneficial with respect to the user experience, as it helps people to form a conceptual model of the robot vacuum cleaner" | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "people expect a robot vacuum cleaner to fulfill a user need: having a clean floor." | Robot |
| Robot Vacuum Cleaner Personality and Behavior | "In future research, we want to investigate the effect of a deliberately designed robot personality on the user experience in more detail. Do people have a good understanding of the robot? Do people have trust in the robot? " | Meta |
| Robot Vacuum Cleaner Personality and Behavior | And, as watching a video prototype of robot vacuum cleaner behavior is not the same as living with such a robot, we suggest doing a longitudinal study on the user experience with a real robot vacuum cleaner, in a real domestic setting | Meta |
| Robot Vacuum Cleaner Personality and Behavior | [MY REFLECTION] Users see personalities in RVC's and their behaviour. | Robot |
| Robot Vacuum Cleaner Personality and Behavior | [MY REFLECTION] Users have preferences of the behavior and personality of RVC's. | Robot |
| Effects of Changing Reliability on Trust of Robot Systems | Drops in reliability affects trust | Robot |
| Effects of Changing Reliability on Trust of Robot Systems | Drops in reliability affects participants' self-assessments of performance. | Robot |
| Effects of Changing Reliability on Trust of Robot Systems | Trust leads to acceptance | Human |
| Effects of Changing Reliability on Trust of Robot Systems | Article mentions appropriate levels of trust. Disuse and misuse. | Meta |
| Effects of Changing Reliability on Trust of Robot Systems | There is a difference in how trust affects social and non-social robots. | Robot |

| Article | Observations | Type |
|---|---|---|
| Effects of Changing Reliability on Trust of Robot Systems | Non-social robots tends to be more task-oriented, and are more likely to be able to injure people. | Robot |
| Effects of Changing Reliability on Trust of Robot Systems | Trust affects use. | Human |
| Effects of Changing Reliability on Trust of Robot Systems | Experiment uses a real robot, e.i. not wizard of Oz | Meta |
| Effects of Changing Reliability on Trust of Robot Systems | Errors lead to distrust, but can be mitigated by transparency. | Robot |
| Effects of Changing Reliability on Trust of Robot Systems | The lag between change is trust and changes in strategy is referred to as "inertia" | Meta |
| Effects of Changing Reliability on Trust of Robot Systems | There might be a significant delay between change of trust and when the user observes the change in performance. | Human |
| Effects of Changing Reliability on Trust of Robot Systems | Perceived trust influences behaviour | Human |
| Effects of Changing Reliability on Trust of Robot Systems | Compensation for participation in experiment was based on performance. | Meta |
| Effects of Changing Reliability on Trust of Robot Systems | When users have little experience with an automated system they error on the trusting side. | Human |
| Effects of Changing Reliability on Trust of Robot Systems | Higher trust could be predicted by semantic association to risk and personal feelings about performance, rather than robot performance. | Environment |
| Effects of Changing Reliability on Trust of Robot Systems | Users behaviour changed quicker with decreased reliability than with increased. | Human |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | [MY REFLECTION] The relationship between robots and humans are changing as humans are more becoming teammates of robots, rather than operators. Thus, trust affects the likeliness of a successful interaction. | Environment |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "...there is still much to learn about how trust develops." | Environment |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "...until trust between a human and a robot is solidly established, robotic partners will continue to be underutilized or unused, therefore providing little to no opportunity for trust to develop in the first place" | Environment |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | [MY REFLECTION] It is difficult to understand how trust is developed between humans and robot, and initial distrust may prove a big problem. Self reporting is not always a good tool for measuring trust, since trust often is subjective. This paper develops a scale for measuring trust. | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "These ratings [regarding trustworthiness based on physical form] included the degree to which the robot was perceived to be a machine, a robot, and an object, as well as its perceived intelligence (PI), level of automation (LOA), trustworthiness, and the degree to which the participant would be likely to use or interact with the robot." | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | The form of a robot affects trustworthiness. | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "physical form is important to the trust that develops prior to HRI" | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The higher the rating of a robot to actually be classified as a robot, the more likely it was to be rated as trustworthy." | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "Prior experience has been shown to be related to how an individual forms a mental model of the robot and anticipates future HRI." | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | A 7-point Likert-type scale was used initially, then changed to a percentage scale with 10 % increments. | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | Survey participants were Subject Matter Experts (SME) in the army. | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | Speed of the robot does not affect trust | Robot |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | It revealed that trust was significantly greater in Time 2 (post-interaction, 100 % reliable condition) than Time 1 (pre-interaction) and Time 3 (post-interaction, 25 % reliable condition), thus supporting the hypothesis. | Human |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | trust increase after a reliable interaction | Human |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | trust decrease after a less reliable interaction | Human |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | A 40 Item Scale was developed as a scale for measuring trust | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | The 14 Items recommended by SME's was used (a subscale of the 40 item scale) | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The well-established Checklist for Trust between People and Automation (Jian et al. 1998) was included for Same-Trait analysis." | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The Interpersonal Trust Scale (Rotter 1967)" was used | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The 7-point Mini-IPIP personality assessment (Donnellan et al. 2006) was used..." | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The Dundee Stress State Questionnaire (DSSQ; Matthews et al. 1999) was included to measure human states before and after a task." | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | "The 40 item Trust Perception Scale-HRI and the 14 item sub-scale" was developed as a pre-post interaction measure used to assess changes in trust perception specific to HRI. The scale was also designed to be used as post-interaction measure to compare changes in trust across multiple conditions. It was further designed to be applicable across all robot domains. Therefore, this scale can benefit future robotic development specific to the interaction between humans and robots. | Meta |
| Measuring trust in human robot interactions: Development of the "trust perception scale-HRI" | Instructions for use of the "trust perception scale-HRI" exist. | Meta |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Article proposed a model/framework for HRI | Meta |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Article focused on industrial applications | Meta |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Seven roles for humans in HRI; Supervisor, Operator, Mechanic, Peer, Bystander, Mentor, and Information Consumer. | Meta |
| Simplified Human-Robot Interaction: Modeling and Evaluation | How well the information given by the robot's interface and by other sources compare influences the operator's trust in the robot. | Robot |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Trust affects how much user relies on the robot's interface. | Human |
| Simplified Human-Robot Interaction: Modeling and Evaluation | User's situational awareness affects how well a user can comprehend other hidden variables not displayed on the UI. | Human |
| Simplified Human-Robot Interaction: Modeling and Evaluation | Framework is based on four factors: Trust in automation, situational awareness, existing experience, and user expectation. | Meta |
| Simplified Human-Robot Interaction: Modeling and Evaluation | The use of the framework lead to an increase trust by the users. | Meta |

| Article | Observations | Type |
|---|---|---|
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Caregiving scenario | Meta |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Being recipient of caregiving acts leads to more positive perceptions of the robot. | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Caregiving leads to attachement and a sense of scurity. (work both ways) | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Caregiving robots are considered as companions rather than slaves. | Robot |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Role in HRI affects willingness to rely on the robot. | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Robots with serious and authoritative roles are seen as more conscientious and smarter than playful robots. | Robot |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Users apply social roles unconsciously when interacting with an anthropomorphic robot. | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Social presence leads to users viewing robots as less artificial and gain a more positive perception of the robot. | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Being recipient of caregiving acts leads to feeling more trust towards the robot. | Human |
| Caregiving role in human–robot interaction: A study of the mediating effects of perceived benefit and social presence | Being recipient of caregiving acts leads to feeling more attachment towards the robot. | Human |
| Can you hold my hand? Physical warmth in human-robot interaction. | Physical warmth and handholding (literally) increases feelings of friendship towards the robot. | Robot |
| Can you hold my hand? Physical warmth in human-robot interaction. | Physical warmth and handholding (literally) increases feelings of trust towards the robot. | Robot |
| Can you hold my hand? Physical warmth in human-robot interaction. | A warm touch mixed with a robotic hand leads to the uncanny valley. | Robot |
| Can you hold my hand? Physical warmth in human-robot interaction. | Article brings up tactile human-robot interaction | Meta |
| Can you hold my hand? Physical warmth in human-robot interaction. | Article uses a social robot for experiment. | Meta |
| A Long-Term Human-Robot Proxemic Study | Approach comfort distances are about the same, regardless of if it's the robot or or human who is approaching. | Human |
| A Long-Term Human-Robot Proxemic Study | Interpersonal distance between human and robot is usually between 0.45 m and 1.2m | Human |
| A Long-Term Human-Robot Proxemic Study | Robot activity influences comfort distance to robot - physical interaction allows robot to get closer than non-physical interactions. | Robot |
| A Long-Term Human-Robot Proxemic Study | Uncanny valley means people increases comfort distance. | Robot |
| A Long-Term Human-Robot Proxemic Study | Users' preferences for/liking of robots affects comfort distance. | Human |
| A Long-Term Human-Robot Proxemic Study | Study used elderly testers as elderly are seen as more likely potential users of domestic robots, than students. | Meta |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Article is a study on how cultural background influences HRI. | Meta |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | A majority of people are still sceptical or against robots in everyday contexts. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | 60% of Europeans believe robots should be banned in contexts invloving children, elderly or disable care. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | There is a difference in acceptance of robots in different EU countries. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Gender, age and personal innovativeness, the general evaulation of a particular technology and cultural background influnced acceptance. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Nationality affects enjoyment, sociability, anthropomorphism and perceived behavioural control. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Elderly Swedish usergroup likely had higher exposure to IT and were less challenged by having to program or repair robots compared to a similar Italian group. | Environment |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | SAR (Socially Assistive Robotics) = robots that are designed to help by advanced social interaction. | Meta |
| A cross-cultural study of acceptance and use of robotics by future psychology practitioners | Article speculates that investigating cultural differences will play a key role for future designers. | Meta |
| Artimetrics: Biometrics for Artificial Entities | Robot owners likely wants to customize the appearance of their robots. | Human |
| Artimetrics: Biometrics for Artificial Entities | Robots of the future might may create a security threat. | Robot |
| Artimetrics: Biometrics for Artificial Entities | Acceleration and curvature are the most important factors on what influences human perception of robot motion. | Robot |
| Artimetrics: Biometrics for Artificial Entities | There is a correlation between the speed a human decodes robot gestures, the speed she decodes human gestures, and her attitute towards robots. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Complying with a robot's requests does not significantly affect perceptions of the robot, of its reliability and of its trustworthiness. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | The robot's performance does not seem to affect user's willingness to comply with its requests. | Robot |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Whether a task the robot requests of the user is revocable or not has a significant impact on user's willingness to comply. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Trust is linked how willing users are to accept information given by a robot and their willingness to follow instructions from robots. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Findings from trust in automation and HCI can be used as a starting point for trust in HRI | Meta |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | An accumulation of smaller errors leads to a bigger loss of trust than one severe error. | Robot |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Occasional errors of a humanoid robot can increase perceived humanlikness and likeability. | Human |

| Article | Observations | Type |
|---|---|---|
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Performing faulty conditions with a non-anthropomorphic robot lead to users perceiving the robot as less humanlike. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | A combination of measured data and self-repported data is recommended by the study. | Meta |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Extroverted and emotionally stable people anthropomorphised the robot more and felt more close to it. | Human |
| Would You Trust a (Faulty) Robot? Effects of Error, Task Type and Personality on Human-Robot Cooperation and Trust | Extroversion and emotional stability did not affect trust development. | Human |
| You Want Me to Trust a ROBOT? The Development of a Human-Robot Interaction Trust Scale. | "Trust plays a critical role when operating a robotic system in terms of both acceptance and usage." | Robot |
| You Want Me to Trust a ROBOT? The Development of a Human-Robot Interaction Trust Scale. | Redeveloping lost trust takes time. | Human |
| You Want Me to Trust a ROBOT? The Development of a Human-Robot Interaction Trust Scale. | Article groups the base of trust into three characteristics; performance, function and semantics. | Meta |
| You Want Me to Trust a ROBOT? The Development of a Human-Robot Interaction Trust Scale. | Articles delves deeply into the definitions of trust and how to define trust in HRI. | Meta |
| Using explanations to provide transparency during trust-guided behavior adaptation. | Article mentions adequate trust. | Meta |
| Using explanations to provide transparency during trust-guided behavior adaptation. | The robot's ability to integrate itself with a team depends on its humans' team members trusting it. | Robot |
| Using explanations to provide transparency during trust-guided behavior adaptation. | By providing explanations it is possible for a robot to maintain trust after having performed poorly or erroneously. | Robot |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | "Successful HRI requires people to trust robots" | Environment |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | In HRI, trust affects the interaction | Environment |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Article examins how message people recieve before interaction with robot affects HRT. | Meta |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | "Anticipating HRI, people experience heightened uncertanties and lower expectations of social attraction compared with human interaction." | Human |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | 1/4 of the US feel some fear towards robots and AI | Environment |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Fear and avoidance of robots is likely to affect HRT | Environment |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Robot task perfrormance affect HRT | Robot |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | DEFINITION OF TRUST: Mayer et al. conceptualize trust as ‘‘the willingness of a party (i.e., users) to be vulnerable to the actions of another party (i.e., robot) based on the expectation that the other will perform a particular action important to the trustor.’’12(p712) | Meta |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | DEFINITION OF TRUST: Based on Mayer et al., we conceptualize trust as risk-taking and actual user behavior. | Meta |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Collaborative robots are called Co-robots | Meta |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | "messages regarding robot partners can strategically alter pending HRI by modifying user expectations." | Robot |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Postive UGC shape people’s HRT given its persuasive effects. | Environment |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | "Robots can affect people's affective state or mood." | Robot |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | The technology acceptance model was used | Meta |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | Robot-generated content (where it was displayed as from the robots perspective) instead of UGC led to no significant moderation effects. | Robot |
| Advancing the Strategic Messages Affecting Robot Trust Effect: The Dynamic of User- and Robot-Generated Content on Human-Robot Trust and Interaction Outcomes. | "... negative reviews were not examined; only positive online reviews were tested." | Meta |

# B

# Appendix 2: Interview Templates

## B.1 Expert Inquiry - Swedish

Hälsa och vara glada Introduktion av oss
Fråga om inspelning och hantering utav personuppgifter och sånt. (Fråga huruvida det passar bäst att omnämna honom/företaget eller ifall det är bättre att det är helt anonymt och han omnämns som ”expert på dammsugartillverkare”)
Har du några frågor till oss innan vi börjar?
Introduktion av vårt exjobb

- Börja med frågor om honom och vem han är i relation till vårt exjobb
- Vad jobbar du med?
- Vad är din relation till robotdammsugare?
- Hur tänker man idag när man designar robotdammsugare?
- Hur interagerar användare idag med robotdammsugare?
- Fråga om han har några idéer på saker som vi kanske inte har tänkt på.

Definiera tillit i situationen robotdammsugare.
Tacka för att han ställde upp på intervju

## B.2 Expert Inquiry - English Translation

Greet and have high spirits Introduce us
Ask about recording and handling of private data and similar things. (Ask if he would prefer to be referred to by name/his company's name, or if it is better to keep him completely anonymous and in that case refer to him as the ”expert on the manifacturing of vacuumcleaners”)
Do you have any questions for us before we start?
Introduce our masters thesis

- Start with asking questions about him and who he is in relation to our thesis.
- What do you work with?
- What is your relationship with robotic vacuum cleaners?
- What is the current line of thought when it comes to designing robotic vacuum cleaners?
- Currently, how do users interact with robotic vacuum cleaners?
- Ask if he has any suggestions regarding things that we haven't brought up.

Define trust in the setting of robotic vacuum cleaners.
Thank him for participating in the interview

## B.3 User Interview - Swedish

- Deltar du i städningen i ditt hem?
- Vad har du för erfarenheter med robotdammsugare?
  - Har du några andra erfarenheter med andra robotar eller AI?
- Kan du kort beskriva din robotdammsugare för oss?
  - Hur presetrade den?
  - Vad hade du för typ av boende då? (Lägenhet? Storlek? Trappor?)
- Har du upplevt några problem med din robotdammsugare?
- Vad upplever du att det finns för risker med en robotdammsugare?
- DEFINIERA TILLIT:

*”Mellan människor kan tillit beskrivas som en individs benägenhet att tro att en annan individ eller grupp av individer beter sig och agerar som förväntat. I det här testet, kommer vi istället definiera tillit för att beskriva känslan man har gentemot en robot i termer utav att roboten kommer att göra sitt jobb på ett tillfredsställande och felfritt sätt.”*

- Litar du på din robotdammsugare? (Varför inte? Skulle du säga att roboten är smart?)
- Litar du på robotar i allmänhet?
- Känner du att du förstår vad som händer när din robotdammsugare kör? Vad din robotdammsugare gör?
- Känner du att du får tillräckligt med information ifrån din robotdammsugare?
- Finns det någon förutsägbarhet i vad din dammsugare gör eller är det slumpmässigt? (Hade du litat på den mer om det gick att förutse vad den kommer göra?)

## B.4 User Interview - English

- Do you take part in cleaning in your household?
- What's your experience with robotic vacuum cleaners?
  - Do you have any other experience with robots or AI?
- Could you briefly describe your RVC to us?
  - How was the performance?
  - How do/did you live?
- Have you experienced any problems with your RVC?
- What do you feel are the risks involved with having an RVC?
- DEFINE TRUST:

*"Between humans, trust can be described as one individuals inclination to believe in another individual, or group of individuals, to behave and act as expected. In this test [report] however, trust will be used to describe the feeling a human user have towards a robot in terms of the robot doing its intended job in a desired manner and without fail."*

- Do you trust your RVC? (Why not? Do you think the robot is smart?)
- Do you trust robots in general?
- Would you say that you understand — what is happening [when your RVC is running]? — what your RVC is doing?
- Do you feel the information you receive from the robot is sufficient?
- Is the RVC predictable or is it more random? (Would you trust it more if it was more predictable?
- Notification*: What do you think about these two?
- Which do you prefer? Why?