UNIVERSITY OF TWENTE.

Comfort and control

The relation between comfort and the kind of control in energy saving Smart Homes.

Bachelor thesis Psychology

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Samenvatting

Om de klimatologische veranderingen te voorkomen is het noodzakelijk om de energieverbruik in de huishoudelijke sector te reduceren. Smart Home technologie kan helpen om de energieverbruik te reduceren maar heeft ook andere positief of negatief invloeden op de comfort van de gebruiker. Het doel van dit onderzoek is informatie te verkrijgen over wat soort en level van comfort potentieel Smart Home gebruikers zullen accepteren onder inachtneming met hun optimaal level van automatiseerde controle om energie te besparen. Voor dit doel werd een kwalitatief onderzoek in maart/april 2015 met een steekproef van 16 studenten of mensen die recentelijk zijn afgestudeerd uit Enschede en de buurt gedaan. Gebaseerd op de antwoorden die in de interviews werden gegeven zijn twee personas van potentieel Smart Home gebruikers gemaakt die informatie over hun wensen van comfort en automatie in een energie besparend Smart Home kunnen geven. In dit onderzoek werd verschil gevonden over welk level en soort automatiseerde controle gebruikers comfortabel en acceptabel zouden vinden. De acceptatie van een level of soort van automatiseerde controle met betrekking op comfort werd door verschillende motivaties zo als geld kunnen besparen en de eigen houding tot energie besparen beïnvloed. In het algemeen wensen gebruikers een zo hoog mogelijk level van comfort.

Abstract

To prevent the climatic change it is necessary to reduce energy consumption in the domestic sector. Smart Home technology can help to reduce energy consumption, but it might have further positive and negative influences on the comfort of the user. The aim of this research is to determine the level of comfort potential Smart Home users accept while taking their optimal level of automated control in order to save energy into account. Therefore a qualitative research was done in March/April 2015 including a sample of 16 students and persons who recently finished their studies in Enschede or the surrounding area. Based on the answers given in the interviews two personas of potential Smart Home users could be created. These personas provide information on desires for comfort and automation in an energy saving Smart Home. In this research differences of level and kind of automated control users would think about as comfortable and acceptable were found. The acceptance of a level or kind of automated control regarding comfort is influenced by motivations like the possibility to save money and the personal attitude towards saving energy. In general users desire a level of comfort as high as possible.

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1. Introduction

In this chapter the importance of saving energy and the potential influence of Smart Homes on this is explained. Furthermore the way Smart Homes technology influences the users feeling of comfort is illustrated as well as the aim of this research.

1.1 Saving energy

One of the recently most important topics is to prevent global warming and to keep the effect of climate changes within acceptable limits (Xavals, 2005). Therefore it is necessary to reduce energy consumption, because one of the most important reasons for global warming is CO2 emitted from facilities producing energy from fossil resources (Brandoni & Polonara, 2012). Another reason for reducing the energy consumption is that while there are great differences between energy consumption in different countries within the European Union, the general request for energy is expanding and exceeds the energy production of some countries (Alcántara & Duarte, 2002; Gaspar, & Antunes, 2011). One of the major energy consumers are buildings and devices in the domestic sector (Anvari-Moghaddam, Monsef, & Rahimi-Kian, 2014). Based on this it is concluded there is a great demand to reduce energy consumption, especially in buildings of the residential and tertiary sector. By this a rise in energy demands is prevented.

For saving energy there are different strategies to pursue this goal. Poortinga, Steg, Velk & Wiersma (2003) describe three different strategies to save energy in a household. The first strategy is to reduce energy consumption of the product by technical improvements. The second way is to change the usage of a product. The third is to shift the consumption. The reduction of energy consumption and the change of usage are direct interventions to save energy. These two strategies focus on the product. Shifting the consumption is an indirect strategy focusing on the reduction of the energy consumption of manufacturing, logistics and disposal. By this it is concluded that there are different strategies to reduce the energy consumption.

Based on the given literature it is concluded that saving energy is an important topic. It is necessary to be aware of the fact that one of the most important sectors for saving energy is the domestic sector. In this sector different strategies can be used to save energy. One way to support the reduction of energy consumption in this specific sector is using Smart Home technology (Paetz, Dütschke, & Fichtner, 2011). Smart Home technology uses two strategies explained by Poortinga et al. in 2003 to save energy: Saving energy by technical improvements and change of usage of the devices by automating them.

1.2 Smart Home

While this topic is strongly discussed, there is still no clear definition of a Smart Home because there are different names and definitions in use (Jeong, Salvendy & Proctor, 2010). The term 'Smart Home' is sometimes used for the whole of future homes. In this paper the term 'Smart Home' will be used for the whole of future homes including all features, as explained in the following section. According Jeong et al. (2010) different names with different meanings are gathered under the name 'future home': ‘Connected home', 'digital home', 'adaptive house', 'aware home' and 'Smart Home'. These terms are commonly used for the term 'future homes' while each of them has its own definition. 'Connected home' is defined as an environment where different digital devices are connected to each other, while 'digital home' focuses on sharing digital media and providing digital content services via internet as stated by Jeong et al (2010). Adaptive houses provide the capability to learn patterns of use, which supports the owner in running the house in an economical manner (Jiang, Liu, & Yang, 2004). Aware homes are described by Jang, Lee and Woo (2001) as homes with residential environment that can recognize information about the home, the users and the usage. Smart Homes are described by him as services focused on automation that can administer and control different devices by local or remote control. Another definition by Briere and Hurley (2003) describes a Smart Home as a harmonious conglomerate of devices and capabilities that communicate via network. Jeong et al. (2010) state that these different names are commonly used interchangeable in practice and that nearly always intelligence is involved in every kind of definition. In this case **i**ntelligence describes a software system that can react and adapt to different cases in a flexible way. This is to react to the situation in the best way possible and desired and to deal with different situations occurring by using more or less specific predefined rules. In this paper the term Smart Home will refer to a future home including all features as stated above. Based on this different definitions of a Smart Home it is clear that Smart Homes contain different technical possibilities with different purposes. While every definition is different to the others Smart Homes have some common attributes: they contain different technical devices.

According to Dewsbury Bruce, Taylor, & Edge (2001) Smart Home devices can be categorized in passive and active devices. According to them active devices are switches or control panels that enable the user to interact directly with the system taking their own decisions into account. Active devices have a low level of automated control. Passive devices on the other hand include sensors and receivers and the user has no direct contact with the functions of passive devices. Passive devices can empower and enable the living experience of the user without having direct contact to the user while active devices need to have direct contact. Passive devices have a

higher level of automated control. By this differentiation it is concluded there are different levels of user control and by this different fields of application. First there is a level of user control that requires the choice and interaction by the user, which is defined as active devices with a low level of automated control. While there is a great level of control the user is required to make decisions himself. A study by Paetz et al. (2011) shows that users might experience difficulties if they have to make a choice but do not know how to react to the situation. This leads to a greater level of discomfort. Another study of Poortinga et al. (2003) shows that measures in that users have to take action lead to discomfort what supports the conclusion by Paetz et al. (2011). The second level is a great level of automated control with passive devices that provide a low level user control. In exchange to this the system works automatically without the need of interaction or choices made by the user. Wilson, Hargreaves and Hauxwell-Baldwin (2013) found similar results and stated that there is a range from fully manual controlled systems (active devices) to fully automatically controlled (passive devices) systems. User experience different levels of comfort with a given level of automated control. According to this study this feeling depends on the situation as well as the type of task. In some cases people need to have a low level of automated control and more manual control to feel comfortable. This is mostly true if flexibility to act in a not standardized way is needed and automated control would disturb this flexibility. Flexibility is the opportunity to act in a not standardized way (Wilson et al., 2013). A higher level of flexibility means there are less or no restrictions in the freedom to act while a low level of flexibility means there are more restrictions limiting the user in his desired actions. In other cases manual input is felt uncomfortable because the user does not want to spent time and energy on this task. This is mostly true for minor tasks with a low level of arousal like turning on the light.

When Smart Homes were introduced in the early 1980s the main focus was to enhance the level of comfort (Stefanov, Bien, Bang, 2004). Xin, Wenxue, Jialin and Jiannan (2005) state that while the possibilities of Smart Homes have exceeded the early ideas one of the aims of Smart Home technology is still to improve comfort. Improving comfort is a broad field because everybody has his own idea about what comfort is. Xin et all. (2005) assert that there is no general idea of what comfort is, but that there are small parts of comfort in different parts of a persons life, like the comfort in someones home. Further they state these parts of comfort sum up to a total or general feeling of comfort. Friedwald, Da Costa, Punie, Alahuhta and Heinonen (2004) found that Smart Home technology can offer great opportunities to make life of the user easier. One of the most important things they found was that while having a great opportunity to enhance the users comfort there are also risks that the technology can lower the level of comfort by restricting the users freedom. One way of restricting this freedom was found in automated control of devices or

processes. This is because the user has a low level of control over passive devices and hereby is unable to change the working process if it does not apply to the current situation. Anvari-Moghaddam et al. (2014) conclude that one of the most important things for a user is that his own need for comfort is ensured. A Smart Home might play an important role to ensure this need and to find the optimal balance between comfort and other demands like saving energy. This leads to the conclusion that while having the aim and opportunities to enhance users comfort there are also risks bound to Smart Home technology, depending on the provided level of user control. This depends on the current situation and the fact, that there is no objective definition on how strong the need of comfort in different situations is and what the users preferences for comfort are.

One of the other features a Smart Home might have beside enhancing comfort is to provide technical support for saving energy (Paetz et al., 2011; Wood & Newborough, 2006). This technology can enhance comfort by supporting the user or can reduce comfort by restricting the user (Anvari-Moghaddam et al., 2014). Paetz et al. (2011) found there are different ways a Smart Home might help saving energy. One is to monitor energy consumption. A display or similar output device displays information about energy consumption of different devices, sections of the home or the whole unit. Providing suggestions on saving energy is possible as well. Another method stated by Paetz et al. (2011) to save energy is automated control of electrical devices. An example therefor is the automated washing machine only turning on in evening hours to shift the energy consuming work to times of the day when energy is less expensive and less needed. This helps avoiding high peaks of energy consumption on daytime and to balance the needed average of energy production to a minimum throughout the day. Another example would be to turn off the air conditioning if the window is open. These methods are strongly connected to the strategies for reducing energy consumption earlier explained by the results of Poortinga et al. (2003). The usage of automated control to save energy is a technical improvement while giving feedback on the energy consumption is a way to change the user's energy consuming behavior. This is an example for systems that enhance comfort having possibilities to save energy as well. For example one might use automated control for lifting the jalousies for comfort reasons, but also to reduce power consumption of the climatic devices or the lights. But as everyone features his personal definition on what is comfortable situational differences are in all likelihood, because the feeling of comfort by using different types of devices depends on the situation.

The study of Paetz et al. (2011) shows that users are interested in saving energy as long as they do not feel restrictions in their behavior. The users had problems to react in a reasonable manner to given feedback, for example provided by displays demanding a decision, leading to discomfort. This is connected to a study by Anvari-Moghaddam et al. (2014) who identified one of

the greatest challenges for saving energy in a smart home as the users wish for a certain level of comfort. One of the motivations that were most identified to save energy and accept a lower level of comfort was the possibility to save money (Wood & Newborough, 2006). Ueno, Sano, Saeki and Tsuji (2005) state there have to be more motivations to save energy than only saving money. This is supported by the results of Banfi, Farsi, Filippini and Jakob (2006) who found out people are willing to spend money for saving energy. Wood and Newborough (2006) found other motivators like self-competition and the pursue for goals. Further a study by Gifford (2007) found out behavior and motivations differ by context. That means in this context the reasons for saving energy are mostly motivated by the wish to save money, but there are other motivators as well. While wishing for saving energy, users have a wish to balance a certain level of comfort they want and the loss of comfort they have to accept for saving energy. Based on this it can be concluded there are different kind of motivation to save energy and everyone has his own wishes for comfort he wants to ensure. The balance between these two points one person wishes differs by person and context. A Smart Home wanting to meet this balance has to be designed in a way it can achieve this aim. One way to design a Smart Home meeting the user's wishes is User Centered Design.

1.3 User Centered Design

User Centered Design (UCD) is a process of design to ensure that the design of a product fulfills the needs and wants of the user (Abras, Maloney-Krichmar, & Preece, 2004) The UCD focuses on the needs and limitations of the user through all phases of the design process (Vieritz, Yazdi, Schilberg, Göhner, & Jeschke, 2011). Abras (2004) states that UCD aims for the product to meet the requirements of the user instead of changing the behavior of the user to meet the requirements of the system. It is proven that UCD helps to become a success for the product and to meet the requirements of the customer (Vredenburg, Mao, Smith, & Carey, 2002). Furthermore UCD can help to avoid design errors and by this saving money through involvement of the user in the design process (Gould, Boies & Lewis, 1991). Because of this UCD is recommended to improve the usability of a product (Vieritz et al., 2010; Bevan, 2000). The term usability describes whether a user can use the product in practice or not to fulfill the purpose of the product. It is important to guarantee the usability for a product, because if it is not ensured it is one of the most occurring reasons for having problems with a product (Harty, 2011). One method that is used in the User Centered Design-process to ensure the usability of a product is the persona-method.

A persona is a fictional person with typical characteristics of a person of a target group (Castro, Acuña, & Juristo, 2008). The persona-method was originally introduced by Cooper (1995) to identify users more clearly. Before that they were only abstract persons for developers they could

not approach in a reasonable way. Personas can help to design a product in a way that ensures the usability of the product is as high as possible for the expected user. Snyder, Sampanes, White & Rampoldi-Hnilo (2011) describe personas as an important tool for developers because they can help in the developing process to keep focus on the users essential needs. They help the development team to understand the expected user and keep them in mind when development decisions have to be made. The usage of personas has many advantages (Pruit and Adlin, 2006). One of these advantages is that personas are role focused and that they put a human face on the data of the users, making it easy for design- or development teams to identify with the prototypical user. One further advantage is that the data a persona contains can help to validate or invalidate preconceived assumptions that the design- or development team has about the expected users. By this personas help the team to stay focused on the development of a design that will satisfy the key user. In addition to these advantages Snyder et al. (2011) add that personas present functional requirements in the context of the users life by giving a showcase of the features a user wants or is currently using. By giving a detailed day-in-life-use-case a persona makes it easier for the design- or development team to understand how the real user would use the product.

While a persona can resemble a typical person of the target group, there is also an anti-persona (Castro et al., 2008). An anti-persona resembles a fictive person who is clearly not part of the target group. An anti-persona can be useful to show the restrictions of systems and which group of users the system will not match. A persona is developed from empirical data of the expected user, representing a typical set of characteristics that the users will have. It contains a one or two page long description of a person that include a name, picture, demographics, job title, major responsibilities, goals and tasks that are related to the product and information about the environment (Snyder et al., 2011). Based on this it can be concluded that personas are a valuable tool to develop a product with a high usability.

Castro et al. (2008) developed a system for creating personas in an effective and reliable way that is named Persona*. The goal of this was to make the persona-method usable for a broad range of developers. This was done by standardizing the steps to create a persona. In this standardized method the analyzed data collected from the expected users is summarized in user profiles.

1.4 Aim of this study

Saving energy is an important goal for our society and Smart Home-technology can help to achieve this goal. Literature showed that users have different ideas about what comfort is for them personally, and which kind of control (automated or manual) they want. Furthermore they have

different reasons why they would get motivated to save energy. Out of this literature two different scales with two opposite dimensions can be extracted. The scales are a high level of automated control (passive devices) versus a low level of automated control and manual control (active devices) on the one hand and comfort versus discomfort on the other hand. Friedwald et al. (2004) found a connection between comfort and the kind of control in a Smart Home. He states a high level of automated control can restrict the users freedom and can result in a lower level of comfort. One method to save energy named by Paetz et al. (2011) is using automated control of technical devices what can lead to a lower level of comfort like stated by Friedwald et al. in 2004.

From the literature as written above different hypotheses can be extracted. The first hypotheses is people differ in the desired kind and level of control for feeling comfortable. Furthermore these different levels of automated control and manual control lead to comfort for different people and the accepted levels of discomfort are different between persons. The last hypotheses is there are different motivations to accept or decline discomfort for saving energy.

While there is much literature on using automated control of devices in Smart Homes, there is little information about what kind or level of comfort Smart Home users would wish for and which kind of control they would desire for feeling comfortable. Further there is no information about what level and kind of automated or manual control Smart Home users would accept to save energy. To find information on this the aim of this study is to find an answer to the question: Which kind of level of comfort do potential Smart Home users accept while taking into account their optimal level of automated control in order to save energy?

Answering this question is important, because with this information developers in a User Centered Design team can develop Smart Home technology in a way that fits the needs of the users for comfort and the common need for saving energy to an optimum.

2. Method

In this chapter the sample, material and methods used for data collection and analysis are described.

2.1 Participants

In order to inquire the research question, a qualitative study was conducted in March/April 2015. The used sample contained 16 participants, eight man and eight women, in the age between 20 and 52 years (M = 26,875, SD = 9,992) who are living in Enschede or the surrounding area. It was important that all participants live more than a year in the Netherlands and are able to speak Dutch to ensure respondents can understand the questions of the interview and are familiar with the

Netherlands way of thinking over saving energy. The respondents were Netherlands or German. The selection of participants was based on an availability sample of students of the University of Twente and Saxion Hogeschool Enschede and persons who had recently finished their studies at one of these institutions. They were recruited via face to face recruitment and asked if they are willing to voluntarily participate in this research. The choice of this sample was motivated by different studies with the results that students, independent of their gender, age and discipline of study, are interested in new technology because they get in touch with it in educational settings every day (Padilla-Meléndez, del Aguila-Obra & Garrido-Moreno, 2012; Edmunds, Thorpe & Conole, 2012; Paetz et al., 2011). This interest lasts a while after graduating, making students and graduates a group of potential Smart Home users (Nkosi, Asah, & Pillay, 2011; Paetz et al., 2011). These results show there is no reason to exclude older students, graduates or specific disciplines of study from the sample.

2.2 Materials

In this research a semi-structured interview was used. In the interviews a graphical explanation of a Energy-Smart-Home-Concept was applied to illustrate the concept. Furthermore a questionnaire about demographic facts was used. The interviews were recorded on a smartphone or laptop for further analysis. The text was written in OpenOffice Writer and the transcription was done by using the tool Listen-n-write. Analyzing and coding of the interviews were done by using the program Atlas.ti. For statistical analysis the program SPSS was used.

2.3 Design

In this research a semi-structured interview (Appendix A) was used for gathering data. Each interview was between 25 minutes and 65 minutes (M = 41,925 min; SD = 10,182). Semi-structured interviews are recommended for researching facts in early states of research (Kromrey, 2000; Baarda, De Goede en Teunissen, 2005). Early stages of research are stages there is not enough knowledge available to make the situation at hand clear. In this stage a semi-structured interview can help to collect data about not entirely known or unknown topics in a structured way. During the interview the interviewer possesses the possibility to interact in a structured way with the participant and if needed change or expand questions for further information.

Baarda, De Goede and Teunissen (2005) advise to ask easier questions at the beginning of the interview before moving to more complex ones. Because of this the participant is asked to fill in a questionnaire that asks demographic facts (Appendix E) in a first step. This provides data on the social, private and living situation of the participant.

In the next step the interview starts. The interview is structured in five topics. Topics one to four are part of a research on roles in households connected to Smart Home technology not analyzed in this research. This research still profits from these four topics, because the participant is able to think about the topic of Smart Homes in advance and form his own thoughts on it. This is needed to answer questions in topic five in a good way.

The first topic 'Handling of technology' (*Omgang met technologie*) is used to have the respondent think about his behavior and thoughts that are connected to the usage of technology. The second topic 'Handling of energy' (*Omgang met energie*) is used to have the respondent think about his usage of energy and what his own feelings, beliefs and thoughts are on this topic. In the third topic 'Roles in the household' (*Rol in het huishouden*) the interaction of the participant with other persons living in the household is asked with the aim to list different roles in the household linked to the usage of technology and energy. The fourth topic 'The energy-smart home' (*Het energie-smart home*) contains an explanation of the concept of an Energy Smart Home. In this explanation pictures (Appendix D) are used to illustrate the concept. The leading points for this explanation are listed in the interview (Appendix A). The explanation and pictures were extracted from a video developed by Rodden, Fischer, Pantidi, Bachour and Moran in 2013 for the purpose of explaining the concept of an energy saving Smart Home. This topic was used to ask for the respondent thoughts on the concept of the Energy Smart Home and whether he would like to use this concept.

Topic five deals with comfort and control in a Smart Home and is used for analysis in this research. First a short introduction to the participant about comfort and what kind of control (levels of automated control and manual control) are possible in a Smart Home, based on the literature, is given. For the definition of comfort it is important to explain that everyone has his own definition of what comfort is for him personally and what he senses as comfortable. To minimize the influence of the explanation on the answers of the participant no examples are given. This is necessary because it cannot be expected that every respondent knows the definition of comfort and which kinds of control are possible in a Smart Home. These explanations are written in the interview and are read aloud for the participant. After this introduction the interview continues about the topic. The respondent is asked what kind of control he prefers and for which reasons. Further questions were asked about which influence the respondent would expect on his comfort by using Smart Home technology and for which reasons he would accept discomfort. For each of this questions different points are listed which can be used to get further information for this topic.

2.4 Procedure

The research was done by two researchers who interviewed eight respondents each, four

women and four men. Each researcher got through one test interview before gathering the final data to ensure the functionality of the interview and to make last changes in order to receive the best results possible. Furthermore this was practical training to take the interview.

The potential participants were asked directly if they want to participate in a research about Smart Homes voluntarily. This was done via telephone or face to face. After accepting to participate in this research the participants received an email (Appendix C) with a suggestion for an appointment. Furthermore it was suggested in this mail that the location for the interview would be at the respondents place. This was to give the respondent the opportunity to see his home while thinking about the answers and to improve imagination on the thoughts and wishes he has about his own place. An information letter (Appendix B) was attached to the mail for giving some information about the research.

After an appointment was made, the researcher visited the respondent at home to take the interview. The interviewer welcomed the participant at the research and gave further explanations about the research aims, length and structure. The research procedure was explained and the participant was informed about his rights to ask questions and to stop participation at any time. In addition to that the participant was informed the interview would be recorded for further analysis and everything he says in the interview is handled confidential. The researcher asked the participant if he had any questions up to that point and whether he accepted these terms. If the participant accepted this terms he had to sign a paper for informed consent (Appendix F). After this the participant was asked to fill in a questionnaire about demographic facts (Appendix E) used to collect data about the social, private and living situation of the participant. Afterwards the recording was started.

The next step was to take the semi-structured interview. The interviewer went through the five topics presented in section 2.3 and the questions listed in these topics. For further information the researcher had the option to use sub-questions that are listed in subitems under the questions to ask for further information. These optional questions were the only ones used to ask for more information. At different points of the interview the time was registered to ensure the interview would not last more than one hour in total if possible. After completing the third topic the researcher put the graphic of the house (Appendix D) on the table, the basement aligned with the participants point of view. The interviewer explained the concept based on the items listed in the interview (Appendix A). While going through the elements he puts the picture of the components belonging to the element onto the graphic to illustrate the concept. Afterwards the interview resumed. At the beginning of the fifth topic the explanations of comfort and control listed in the interview were read aloud to the respondent before the interview resumed.

At the end of the interview a short conclusion was given and the respondent was asked if he had any questions or wants to add something to the interview. If the respondent did not have anything further to add, the recording was stopped. A short debriefing was given to the respondent that contained the research aims of the two researches. The respondent was thanked. After this the interviewer saw the respondent off and left the house.

2.5 Data-analyses

The persona technique by Castro et al. (2008) was used to develop personas for potential users of Smart Home technology with focus on comfort. In this research the steps one to five and seven of this technique were used. The first step of the persona technique is 'State Hypotheses'. In this step different hypotheses about possible personas are formulated based on the literature described in chapter 1. The hypotheses for the personas are extracted out of the two dimensions discovered in the literature as written above and are described in Table 2.1. Furthermore in this first step the recorded audio files were transcribed with Listen-n-write.

Table 2.1

Hypotheses for personas

1. There is more than one persona.
2. Personas differ in the desired kind of control to feel comfortable.
3. Personas differ in the desired level of automated control.
4. Personas have different motivations to accept discomfort or not.

The second step of the persona technique is to 'identify behavioral variables'. In this step relevant variables are identified and organized. This was done using Atlas.ti. For the analysis of the data gathered in the semi-structured interview the approach for qualitative data analysis described by Baarda, De Goede and Teunissen (2005) was used. Essential themes were identified in the results of the interview. This was done by identifying important text passages and organizing them in themes relevant for this research. The coding was done by using a template analysis (Appendix G) as described by Cassel and Simon (2004). In this template analysis a schema for coding is constructed based on the themes found in the interviews.

In the third step 'Map interview subjects to behavioral variables' a score is created for each variable to organize the statements of the respondents. Each statement is assigned to a score (Appendix H). Quotes of interviews that resemble this statements are used to illustrate these result.

The fourth step is 'Identify significant behavioral patterns'. In this step significant behavioral

patterns are identified. Respondents who share many variables can be grouped. If more respondents are gathered with common behavioral patterns they are used to create a persona (Appendix H).

To create a complete impression of a persona, in step five (Synthesize characteristics and relevant goals) motivational data is used to complete the characteristics of the persona. Different variables determining different goals and values are synthesized to a full set of a persona's characteristics. This is relevant to illustrate all relevant variables determining what the persona would be and how such a person would behave and which motivation and values are important to this person.

The seventh step (Expand the description of attributes and behaviors) is to create the persona. In this step the collected results are used to describe the persona in detail and giving her a concrete and personal profile with picture and narrative.

The method by Castro et al. (2008) has more steps that are not performed in the current research. This was done because these steps are used to make the persona usable for designers in practical work. In the current research the personas are used to identify and illustrate behavioral patterns for the purpose of gaining information. They are not determined for designing purposes, so the further steps of Castro et al. (2008) are not necessary for the aim of this research.

3. Results

This section contains two parts. The first part describes the variables identified in the data from the interview and illustrates them by giving representative quotes. In the second part, the personas Lotte and Tim which could be identified based on this results are described. In this sections the results are depicted as male (he) or female (she), but they also apply to the opposite sex.

3.1 Identified variables

The step 'Identify behavioral variables' by Castro et al. (2008) resulted in total in six variables connected to a variable degree. All variables identified have direct or indirect influence on the feeling of comfort in a Smart Home. In the second step by Castro et al. (2008) the variables are organized and different scales are given to each variable. The assigned ranges of the scores are illustrated in table 2.1.

Table 3.1

Variables and ranges

Variable	Range
1. Probability to use Smart Home technology	Would use it if it is possible to improve comfort - Would use it if the gain of comfort is greater than the sacrifices in comfort - Would not be likely to use Smart Home technology because no gain is expected
2. Desired level of autonomy to feel comfortable	High – Somewhat high – Balanced – Somewhat low - Low
3. Desired kind of control to feel comfortable	High level of automated control – Moderate level of automated control – Balanced – Low level of automated control – Manual control
4. Accepted influence of the system on the user's life while still feeling comfortable	Restricting influence - More restriction than support - More support than restriction - Supporting influence
5. The accepted level of discomfort in a Smart Home	Much discomfort – Some discomfort – Not much discomfort – Nearly no discomfort – No discomfort
6. Motivations for accepting discomfort to save energy	Primarily money – Primarily personal attitude

3.1.1 Description of the variables

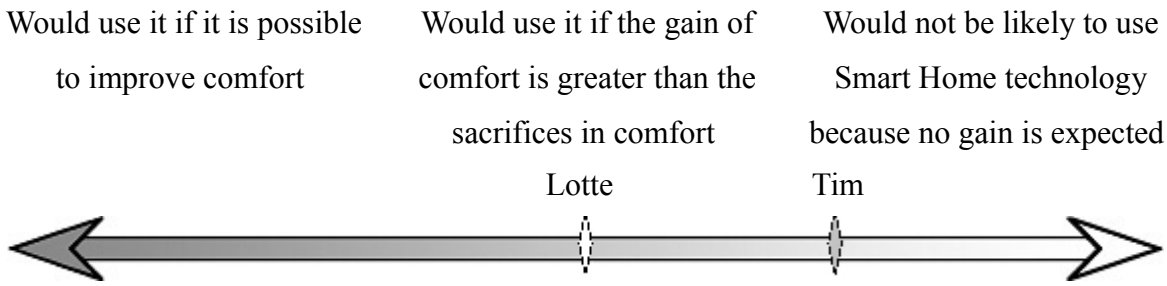
In this section the variables identified and connected to comfort are described and illustrated by a representative quote. The results could identify two important behavioral patterns used to create two personas of a potential Smart Home user. Respondents who are not scaleable on a variable are not scaled. This was done because information not given cannot be interpreted, otherwise it would corrupt the results. The full percentages and distribution data are listed in Appendix H. A full graphical illustration of the distribution is given in Appendix I. The quotes are translated from Dutch to English. The original quotes are given in Appendix J.

Variable 1: Probability to use Smart Home technology

The respondents differ in the probability under which circumstances they might use Smart Home technology. In the interviews respondents reported they would use Smart Home technology if it improves their personal comfort. The higher the gain of personal comfort as a whole and the lower the sacrifice of some other part of the personal comfort is, the more likely the respondent would use it. The persona Lotte would be likely to use Smart Home technology if the gain is somewhat greater than the sacrifices of her comfort, while Tim is less likely to use Smart Home technology because he expects the gain would be less than the sacrifices he had to make concerning his comfort.

"And for me the comfort of what I gain has to be ten times as big as that what is asked from me. I would say it has to be really a bit more. Compared to what I can achieve by other ways it must be really better than what I can do by myself." (Persona Lotte, Respondent 9)

"I can't imagine that everything is automated because it is to difficult if I do not want something, it is discomfort because I am not flexible anymore." (Persona Tim, Respondent 11)



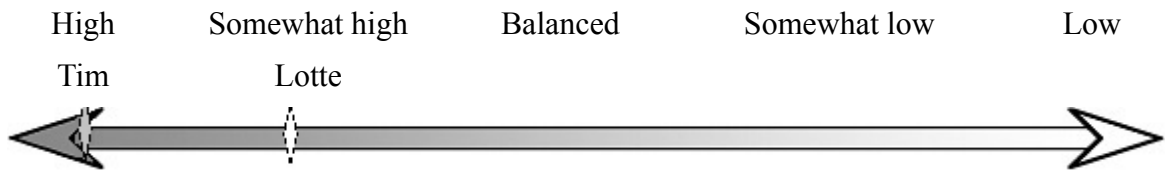
Graphic 3.1. Grouping of probability to use Smart Home technology

Variable 2: Desired level of autonomy to feel comfortable

In general respondents reported the desire for a high level of autonomy in their Smart Home. They want the possibility to act flexible in their life. For this reason the respondents wished for an option to retrieve manual control over devices using automated control if necessary and full manual control over devices they need to use flexible or which possess potential danger. The persona Tim desires a higher level of autonomy than Lotte. He wants to make his own decisions every time anew, while Lotte would accept to make a choice once and allow the Smart Home to execute her choice. If they can choose for it by themselves, Lotte and Tim are also more likely to accept restrictions in their comfort.

"It has to be extremely easy. It may only need two seconds in total if I'm going on vacation that my lights don't turn on anymore. Easy exceptions have to be possible. It has to turn off with one button. So the two seconds maximum." (Persona Lotte, Respondent 15)

"I want it available if I want it. I depend on being able to use the computer." (Persona Tim, Respondent 4)



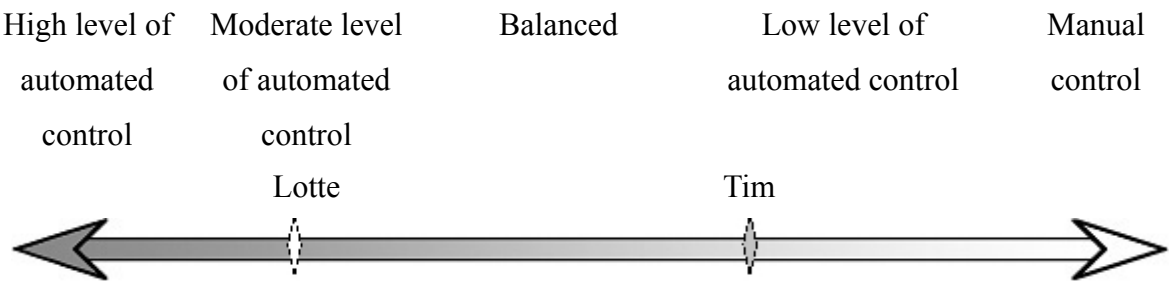
Graphic 3.2. Grouping of the desired level of autonomy to feel comfortable

Variable 3: Desired kind of control to feel comfortable

Respondents differ in the kind of control they think is comfortable. Some respondents wish for a moderate level of automated control while others want a low level of automated control. Lotte would prefer a moderate level of automated control as long as she has the option to retrieve manual control over the system to maintain her autonomy. Tim would merely use a low level of automated control like timer clocks, because he wants to ensure his full autonomy without intervention of an intelligent system. Both Lotte and Tim would use automated control of devices for minor technologies like music or television, lights in the house, heating and for systems providing information like the weather report.

"If you are at home and don't have to do the laundry anymore and have much time and peace to rest or to cook." (Persona Lotte, Respondent 14)

"I do not think it is bad if I have to switch the one or other on manually." (Persona Tim, Respondent 12)



Graphic 3.3. Grouping of the desired kind of control to feel comfortable

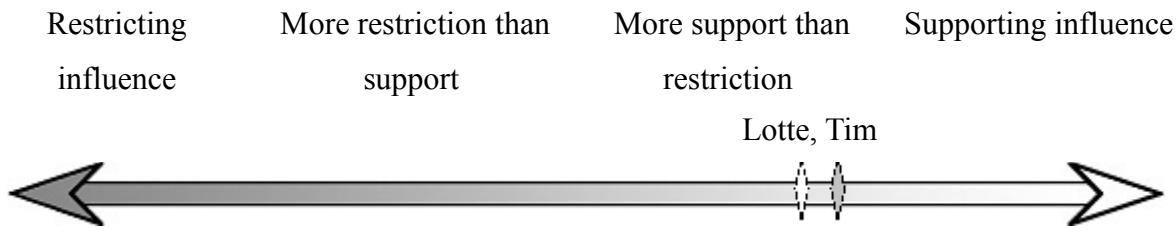
Variable 4: Accepted influence of the system on the user's life while still feeling comfortable

In this variable influence means something causes a change in the life of the user. Respondents reported a system providing support for tasks in their everyday life would have positive influence on their life because it causes their life to change in a desired way. On the other hand, technology that would restrict the user in his life by forcing him to act in a specific way would have negative influence on the life of the user as it causes the life to change in a not desired way. Many respondents reported they would only accept positive influences on their life by Smart Home technology like providing support, but they would not accept restrictions in their life. Restrictions resulting out of technology in general would lead to an lower, unaccepted level of comfort while support by technology leads to a higher level of comfort, which is accepted by the user. Restrictions can occur if the autonomy of the user is restricted, for example by malfunctions of the system or a too complicated way to control the system. Furthermore it was stated restrictions emerging from a system influencing and controlling the life of the user would lead to discomfort. The most mentioned reason to wish for an option to retrieve manual control over systems with automated control was the respondents expected malfunctions or other restrictions by using intelligent technology they were unable to accept. Supporting influences like providing information to the respondent, for example the weather report or automated control for simple tasks, lead to a higher level of comfort as desired. There is just a minor difference between Lotte and Tim for this variable. Lotte would only accept slightly more restrictions than Tim, but both need more support than restrictions to feel comfortable. If one of them would have to sacrifice a part of their comfort, they would be most likely to sacrifice a little part of flexibility in their life. For example, they would consider performing activities at a different time than usual, like doing the laundry in the night.

"If you wake up that you can touch the wall and you see the weather of today. Or that you can see that in your refrigerator there is this and that. And you can still make this and that recipe out of

this. Than you have more support." (Persona Lotte, Respondent 16)

"I think that therefor it would be great if it would not have such an influence on your life that you have to make choices based on: do I have to save energy or not?" (Persona Tim, Respondent 4)



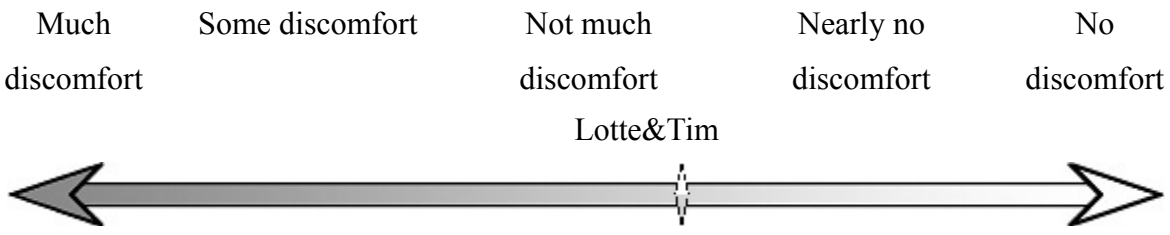
Graphic 3.4. Grouping of the accepted influence of the system on the user's life while still feeling comfortable

Variable 5: The accepted level of discomfort in a Smart Home

Respondents reported that they would mostly accept just a low level of discomfort or nearly no discomfort from Smart Home technology. If the discomfort would be higher the participants are less likely to use Smart Home technology. The personas Lotte and Tim have no difference in this variable.

"I think I would have very little patience for it because I am so headstrong I would very fast think: I simply do it myself." (Persona Lotte, Respondent 9)

"On my work I would sacrifice comfort. At home I would even pay a little bit more if I can get more comfort by it. There I would not sacrifice much comfort." (Persona Tim, Respondent 11)



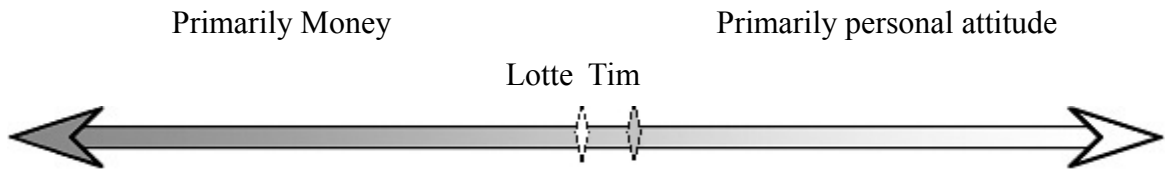
Graphic 3.5. Grouping of the accepted level of discomfort in a Smart Home

Variable 6: Motivations for accepting discomfort to save energy

There are two motivations reported to accept discomfort for saving energy: The possibility to save money one can spent on other things and the own attitude resulting in a good personal feeling. Both the additional money that can be spent and the good feeling were reported as part of the personal comfort. Lotte would accept a low level of discomfort to save energy if she is able to save money and has an attitude supporting this. For Tim money is likewise a motivation to accept discomfort in order to save energy, but not as much as for Lotte. This is because a respondent integrated in Tim reported that money would be no motivation for him to save energy. Tim gets motivated to accept discomfort in order to save energy if he had an attitude to save energy like Lotte.

"We use much energy and such things bring damage, too. I feel responsible for this. And that I would like to do something for, so therefore." (Persona Lotte, Respondent 15)

"Sometimes I want to enjoy the moment and I don't want a device reporting how much it costs what I'm doing." (Persona Tim, Respondent 3)



Graphic 3.6. Grouping of the motivations for accepting discomfort to save energy

3.2 Persona

Two important behavioral patterns could be identified in this data. Out of this data two personas could be created. Persona Lotte is based on eleven respondents and persona Tim is based on five respondents. The full scores are represented in Appendix K.

Persona Lotte

"It is nice as long as it works, but it is good to know where the emergency-button is."
Lotte is a 26 years old student at a Dutch University. She lives in a flat near her university she arranged for her personal needs and has installed Smart Home technology in it. She loves the support this technology gives her in her life, but she has some concerns the technology might turn out to restrict her in her life, for example by malfunctions or if exceptions to an automated rule have to be made. Lotte installed many switches providing the feature to switch the system from an automated mode of control to a manual mode. But up to this day she has not used these switches, as there were no situation requiring it. Even if she has some concerns about malfunctions she loves to live in her flat as she feels comfortable and save inside. Comfort is a really important thing for her, because only in a comfortable home she is able to rest at ease after a hard day.

On a regular day the lights in Lotte's room slowly enlighten at 6:30 am. The roller shutter automatically goes up and the window opens up a bit. The simulation of the rising sun Lotte loves so much wakes her up nicely several minutes before the alarm clock rings. Lotte starts the new day energized. A small screen on the wall displays information on the weather she has to expect today. Lotte gets up and leaves for the bathroom. The light in the bathroom, an energy saving light-bulb, turns on slowly while the light in her bedroom dims steadily. The Smart Home helps Lotte to save energy because she thinks it is important for today's world and it provides a good feeling. She learned this from her parents. But not only because of her attitude she wants to save energy, but she can also save money for nice things. To Lotte both her attitude and the possibility to save money are equally important.

Today the shower turns on as she enters the bathroom. After the shower she makes

breakfast while the music in the kitchen automatically starts to play. She loves to make food by herself. She would never accept an automation of cooking. Not only because she loves to cook but also because she is unable to trust technical devices executing potentially dangerous tasks like using the furnace. After having her breakfast, she leaves the house to go to university. When Lotte closes the door, the Smart Home automatically turns off all technical devices and as well as light and the temperature of the heating is lowered to save energy. Technical devices in the whole house are generally only turned on when they are needed.

After a day of work at university Lotte comes home. The moment she turns the key in the door, the lights go on and the music starts to play again. The heating has already turned on some time ago, based on a program remembering the time Lotte will be back today. This data is only used inside the home and is not given to third parties. Lotte had the fitter to install the technology in a way to prevent uploading of data to third parties from the beginning because privacy is important to Lotte. Lotte enters the warm house and starts to make diner. After finished diner Lotte has to do some work for her studies. She turns on her laptop and starts working. Devices she needs to use flexibly are not automated in Lottes Smart Home. Flexibility is a matter of comfort to her she does not want to miss. To save energy she would accept if she has to be a little less flexible, but not much. For some things like devices she wants or has to use at any moment she would not accept any restrictions in her flexibility.

After finishing her work it is already late. Lotte goes to her room while the Smart Home turns off the lights slowly and shuts down all technical devices. She lies down in her bed and gives the Smart Home a sign by clapping her hands two times that she wants to sleep now. A sensor in her bedroom registers this sign and the Smart Home dims out the light.

Graphic 3.2.1. Reprinted of [Smiling Lady With Arms Crossed] (n.d.). Copyright freedigitalphotos.net. Retrieved at http://0adb8101b7ae4114a392-dfaacb9b5d3eae26a1de1132d02b2b65.r33cf3.rackcdn.com/smiling-lady-with-arms-crossed-100108475.jpg

Persona Tim

"Comfort is the feeling to be free."

Tim is 30 year old and has recently finished his study at a Dutch University of Applied Sciences and started working last week. He lives in a rented house in the surroundings of the city together with his girlfriend. He feels comfortable in his house because he can do whatever he likes to without feeling restrictions in his way of life. For him this comfort is one of the most important things in his life.

On a regular morning Tims alarm clock rings at 6:30 am. He loves to stay in bed for some time to become awake before getting up. After some minutes he turns on the light with a remote control and stands up to go to the bathroom. After taking a shower he gets some breakfast. He loves to eat his toast in the morning so he put his toaster on a time clock that makes his toast every day at half past seven. All he has to do is to set up the time clock the evening before and put some bread inside the toaster. This is an idea he had to be able to smell the toast in the morning by the time he comes down the stairs. He is interested in most modern technologies but thinks of it as too complex and unreliable for really important tasks. On the other hand for tasks like making a toast he can trust this simple technology. After breakfast he leaves the house. At eight o'clock the heating turns down automatically as it is not needed with nobody being home. This is important for Tim because he thinks saving energy is an important thing in today's modern world. For him it is more a question of his own attitude and a good feeling and not to save money. For this reason he connected a movement sensor at the lights outside the house as well. If nobody is there, they do not have to be turned on. In the rare case Tim or his girlfriend are back earlier than usual he accepts the house not being warm for a short time. Throughout the day the technical devices in Tim's

house do not need any energy.

After a day of work Tim gets home. The light outside turns on by the movement sensor and makes it easy to find the keyhole. When Tim enters his house the heating is already turned on by a timer clock half an hour before Tim comes back and he enters a warm house. This is important for Tim as he wants to feel warm and comfortable in his home. To feel comfortable it is important for him to have everything under his own control. He wants to know what technical device is used when and for what purpose. Things he has automated are automated in a way he has still the full control over them and no kind of artificial intelligence or program can intervene. This is because he is really skeptical about whether too much modern technology would restrict him or not. Or maybe it could gather data about him, something he would not want because for him privacy is a matter of comfort.

After entering his home, he makes diner for him and his girlfriend. They eat together in the evening. After this he wants to watch a movie with his girlfriend. Yesterday they were in the theater so he does not know what program runs on television. He takes his tablet and looks up the programs. They choose to watch a video in the end. After watching it Tim turns off the technical devices and the lights before going to bed.

Graphic 3.2.2. Reprinted of [Pensive-Man] (n.d.). Copyright freedigitalphotos.net. Retrieved at http://0adb8101b7ae4114a392-dfaacb9b5d3eae26a1de1132d02b2b65.r33.cf3.rackcdn.com/pensive-man-100149500.jpg

4. Discussion

The aim of this research was to answer the question which kind or level of comfort potential Smart Home users would accept while taking into account their optimal level of automated control in order to save energy. For this aim data from interviews was analyzed and two personas of potential Smart Home users were created based on the persona technique by Castro et al. (2008). Six variables were identified influencing the feeling of comfort in an energy saving Smart Home related to the level of automated control. There is an important difference between the two personas. The first persona, Lotte, on the one hand appreciates a higher level of automated control as long as she has the possibility to retrieve manual control if needed to feel comfortable. On the other hand, the second persona Tim would need a lower level of automated control and more autonomy in his choices to do something or not to feel comfortable.

Lotte and Tim would like to have the comfort maximumly possible, just as both of them would only accept trading a little of their personal feeling of comfort for another part of comfort to save energy in a Smart Home. While both of them have different definitions of their personal

comfort, both think their flexibility of doing as they wish and the feeling of possessing control over their life are part of their comfort. For reasons like saving money and their own attitude they would trade in a little of their flexibility to save energy in a Smart Home. This is a trade of flexibility (a part of comfort) for another kind of comfort and not a sacrifice. It can therefore be concluded that users would accept only to trade a small part of their comfort for another part of their comfort in order to saveo energy and desire the highest level of comfort possible. The definition of comfort differs from one person to another, but the flexibility of doing something as intended and the control over their life are always part of it. By this users differ in the level of automated control they desire, because they think of different levels of automated control as supporting or restricting their life and providing them comfort.

4.1 Comfort

In the present research differences of the definition of what people define comfortable were found, like the personas Lotte and Tim illustrate. Xin et al. (2005) came to similar results and stated everybody has his own personal definition of what comfort is to him. Furthermore Xin et al. (2005) stated there are small parts of comfort like the feeling of comfort in someones home. These small parts add up to a general feeling of comfort. In the present research evidence for this statement was found, because the flexibility to act as desired and the feeling of having control over his own life were found to be small parts of comfort in homes and were in every definition of comfort in homes present. Furthermore comfort in homes was a part of a more general level of feeling comfortable. Another part of this general level of comfort was people having money to spent for things they want as well as a good feeling. In contrast to the research of Xin et al. (2005) this research found that while having differences in the definition of what comfort is for someone, there are few things that every definition of comfort has in common. Every definition includes both flexibility to act as desired and the necessary feeling of having control over his own life. An explanation for this could be that while Xin et al. (2005) gave a statement about the definition of the general feeling of comfort, the present research found common parts of comfort for a more specific kind of comfort like comfort in a home. Based on this it can be concluded there is a general feeling of comfort built up from different smaller parts of comfort like comfort in someones home, the comfort to have money to spent and the comfort of sensing a good feeling. Further it can be concluded that even if there are differences in the definition of what someone defines as comfort the definitions share some things regarding the comfort at home. This means that if someone designs technology to enhance comfort for homes, he has to give account to the flexibility and the feeling of the user's control to ensure the feeling of comfort can be enhanced for as many user as possible.

The present research showed users are not likely to accept much discomfort emerging from usage of Smart Home technology in order to save energy. This supports the results of Paetz et al. (2011) who stated users are interested in saving energy as long as they feel no restrictions by this. Most respondents declared they would expect restrictions by using this technologies, but they would not accept much restrictions. Because of this people desire to have an option to retrieve manual control on automated systems. This is related to results of a research by Friedwald et al. (2004) who stated that while having the opportunity to enhance the comfort of the user on the one hand, Smart Home technology has a great potential to lower the feeling of comfort by restricting the users freedom on the other hand. Using automated control of devices or processes the user cannot change if it does not fit the current situation are one example for reasons leading to discomfort provided by those devices. These concerns were reported by the respondents of the present research as well. This supports the results by Anvari-Moghaddam et al. (2014) who concluded one of the most important things for a user is the assurance of his own need for comfort as well as having a balance between the optimal level of comfort and other demands to be found, like saving energy. It can be concluded that the restrictions on the user's life should be as small as possible to enable the user to accept Smart Home technology more likely.

The motivations found in the present research having an influence on the acceptance of a lower level of comfort or even discomfort to save energy are saving money and the personal attitude of someone towards saving energy. Users potentially getting motivated to accept a lower level of comfort in order to save energy supports the results of Paetz et al (2011) who found people can get motivated to save energy if they can save money as a result. Wood and Newborough (2006) found motivations like self-competition and the aim for goals can be motivations to save energy. This is connected to the result users can be motivated to save energy if their own attitude supports this. Part of the own attitude can be someone having the goal to save energy for example to prevent the climatic change. In the present research respondents reported saving money leads them to the possibility to spent money for nice things, also being a part of their comfort. For the respondents, saving energy because of the own attitude led to a good feeling, being a part of their comfort as well. In general it can be concluded the possibility to save money and the personal attitude towards saving energy are the most important motivations for most users for trading a part of their personal comfort (like flexibility) for another part of their personal comfort (like saving money to spend on other things). This supports the results by Gifford (2007) who found there are different motivations to save energy, but users try to hold a certain balance in the level of their general feeling of comfort. For this reason Smart Home technology having the purpose to save energy may restrict the user's life just a little if he wishes to save energy and if he can save money. Furthermore this point is

related to the finding of the present research users being more likely to accept a lower level of a single part of comfort (like flexibility) if the benefit for the total level of comfort is assured. The reason for this is if they are able to exchange a small part of their flexibility for a bigger part of money or a good feeling users are more likely to accept the restrictions they experience regarding their flexibility, because only one part of their comfort decreases while the total level of comfort increases. The conclusion from this is users do not sacrifice a part of their comfort but trade it for another part of their comfort to gain an enhancement in the general level of comfort.

4.2 The desired level of automated and manual control to feel comfortable

The persona Lotte is an example of a user who would use a high level of automated control to support her feeling of comfort. She would mostly use high automated devices like sensors and receivers which are, following Dewsbury Bruce et al. (2001), categorized as passive devices. She would use them to empower her life quality like Dewsbury Bruce et al. (2001) suggested as the main purpose of usage. To retrieve manual control for options in case of malfunction she would like to have active devices like switches. Tim in contrast would mostly use active devices and only a low level of automated control like time clocks and sensors for few objects, but he would not want them to be intelligent. Based on this it can be concluded that passive devices can enhance the life quality and hence comfort, but user have concerns towards passive devices because of expected malfunctions and desire active devices to have more control over their life. Users have less concerns towards active devices than towards passive devices. Furthermore this suggests a certain level of manual control by active devices is required to feel comfortable. This is partly a contrast to findings by Paetz et al. (2011) and Poortinga et al. (2003) who found active devices can lead to discomfort if users do not know how to react to a required input. Following Wilson et al. (2013) users have different ideas of the degree they feel comfortable with, considering a certain level of manual or automatic control in different situations and different kinds of tasks. Users not knowing how to react to a required input is a situation in which a high level of manual control leads to more discomfort. The results by Wilson et al. (2013) can give an explanation for the differences between the results of the present research and the results of Paetz et al. (2011) and Poortinga et al. (2003). While they found users feel discomfort if they do not know how to react to a required input of an active device, this is a specific sort of situation as there is no regular pattern the user could use to solve the problem. This case just illustrates manual control leads to discomfort for this sort of situation. On the other hand, the case of retrieving manual control over an automated system in case of malfunction is another specific case of situation in which level of automated control being too high leads to discomfort while a higher level of manual control leads to a higher level of comfort.

By this the findings by Wilson et al. (2013) explain that there are differences between the desired levels of automated and manual control in different cases to feel comfortable. This explains the differences between the results of the current research and the results by Paetz et al. (2011) and Poortinga et al. (2003). For the persona Tim who desires a lower level of automated control, every time he chooses to automate or not automate a device is a special case on its own that requires him to decide whether a more automated or a manual control would lead to a higher level of comfort for him. Based on this it can be stated that this research supports the results of Wilson et al. (2013), concluding there are differences for the desired level of automated control in different cases to feel comfortable.

Another finding by Wilson et al (2013) was people preferring manual control by active devices for tasks requiring a high level of flexibility. These results are supported by the present research as the persona Lotte wishes to have manual control over devices she needs to use at any moment. She has to have an option to retrieve manual control over automated devices to ensure her flexibility. The persona Tim needs an even higher level of manual control and desires the flexibility to change the choice to automate something at any given moment. By this results it can be stated active devices are desired for making exceptions in automated devices and for tasks requiring a high level of flexibility. Because flexibility is a basic part of comfort, like stated above, the usage of active devices can help to ensure a certain level of flexibility and hereby enhance or ensure the feeling of comfort of an user. This is supported by the results of Wilson et al. (2013) who stated active devices are needed to ensure the flexibility to act in an not standardized way and by this to ensure the feeling of comfort of a user.

On a more technical level this research showed that users have some concerns towards intelligent technology and expect the possibility to make errors, to be hard to control and to have the potential to control the user's life. This is based on the respondents' personal experiences with malfunctioning technology and various movies, leading to the desire of a certain level of manual control of the respondents. This provides support to the statement by Harty (2011) stating technical devices having to meet the requirements of usability and accessibility to prevent problems with the product. The experiences leading to the mistrust of users towards modern and intelligent technology are based on technology that did not match these requirements. For this reason Smart Home technology has to match these requirements if it should to be accepted by users as a valuable addition to their comfort. This could be done like Abras et al. described in 2004 by using UCD.

4.3 Strong and weak points of this research

A strong point of the present research is the usage of a standardized way to analyze the

collected data like Castro et al. (2008) suggested. This standardized way of analyzing the data makes the data analysis repeatable and more reliable. This is because the standardized method by Castro et al. (2008) provides a guideline on how the data can be analyzed reliably. This prevents the analysis from errors occurring from the usage of not validated methods for analysis.

The interview was done by two interviewers. This reduces the probability of influence by the manner of how one of the interviewers behaved on the results. If an interview is done by only one interviewer, he has the potential to cause the respondent to answer in a certain way by his personal behavior and the fashion he asks questions. If there are more interviewers like in this research, the potential of one interviewer to cause all answers to be in a certain way is reduced as he does not perform all the interviews. This makes it less likely that the interviewers attitude and behavior have caused the results to be in a by the interviewer desired way and makes the results more reliable as they are more likely to reflect the user's true thoughts.

In the current research a semi-structured interview was used. This kind of interview provides the possibility to react to the answers of the respondent in a flexible way. This ensures the respondent conveys all information he rates as important without being restricted by the interview items. This is positive for the results as the results provide information on the thoughts important to the respondents. Therefore it is more likely the results give a proper idea about what respondents think instead of what the interview might have made them to answer. This supplies more reliable results, because they are less likely to be caused by the method and more by the actual thoughts of the respondents.

The first limitation of the present research is that some respondents were not totally sure of their attitude towards Smart Home technology and changed or developed their attitude during the interviews. Some respondents used information about Smart Home technology they got while doing the first part of the interview, which was not analyzed in this research, to adjust their own attitude towards their wishes for control and comfort. This might have influenced the results of this research. For example respondents of a possible research in the future similar to this one, who would not have the information from the first part of the research available, could give other responses to the questions as they are not influenced by the additional information. On the other hand, respondents who had more time to think about the topic of this research and had time to gather information could have developed another attitude towards the topic and thus have also given different answers. This would mean the answers the respondents gave in the interviews were correct at the time of the interview but are now not absolutely reliable anymore.

The second limitation is the used sample contained 16 respondents living in Enschede and the surrounding area. The respondents were all students or had recently finished their studies. By

this all statements given based on the results of this research are only valid for this group of potential users, because other groups could have given other responses. Other groups are for example older persons who need support in their daily life like Fellbaum and Hampicke (2001) suggest. Furthermore the variables age and nationality are not homogeneous in this sample. Two respondents were older than the rest of the sample and two respondents were German while the other respondents were Dutch. This might have some influence on the results because German respondents could have potential differences regarding their education that could have an influence on their attitude towards saving energy and Smart Home technology making the attitude different from the attitude of the Dutch respondents. Furthermore it is conspicuous that both of the older respondents are part of the persona Tim, representing 40% of this persona. It is possible that a bigger group of older respondents would have changed the results, for example to a more critical attitude towards Smart Home technology. This would mean that a sample of older students would have given different results than a sample of only younger students. The current sample is neither only young nor old and by this cannot fully represent one of this groups but only the current mixed sample. Therefore this research can be seen as a guideline for further researches containing bigger samples and other groups like older persons needing support in their daily life.

The third limitation is the results not being checked for errors and redundancy like recommended by Castro et al. (2008). Therefor it is not ensured the personas represent the respondents in a completely correct way. For example the personas could be checked by asking the respondents if they are able to identify themselves with one of the personas. If respondents can identify with a persona, it is likely that the personas resemble the respondents correctly and, consequently, are reliable.

The fourth limitation is that the inter-rater reliability of this research is problematic. The reason is that while the interviews have been taken by two interviewers, only one researcher has analyzed the data for this research. This could have influenced the way the data were analyzed, because the own attitude and view of the interviewer could have had influence, like analyzing the data in a for the researcher desired way with desired results. This could have changed the results to a certain degree in a way the researcher expected.

4.4 Recommendations

It can be recommended to check the results of this research as Castro et al. (2008) suggested in the sixth step of his persona technique that was not performed in the present research. This could be done by using qualitative methods like member checking to make sure the personas resemble the user entirely. This would be useful in order to ensure the personas to be useful to design Smart

Home technology for potential groups of users. If a persona is not based on reliable data this might lead to mistakes in the design process as the product is designed for a wrong user (Castro et al., 2008).

An arising recommendation for further research is researches should be done on the reasons why people have critical attitudes towards modern technology. This is important because if this attitude continues, potential Smart Home users are less likely to use Smart Home technology because of their negative attitude towards modern technology.

Another recommendation for further research is that this research should be done on different groups of potential Smart Home users, like older people needing support in their daily life, in order to check if other groups have similar or different desires regarding comfort and the kind of control over devices. This could help to create a more accurate representation of a potential Smart Home user and would provide a better understanding of their target group to designers.

The last recommendation is designers of Smart Home technology should pay attention to the wishes of comfort, control and flexibility and additionally the concerns towards modern technology potential users might have. These wishes and concerns could have an important influence on whether or not the users are willing to accept Smart Home technology in their home, because respondents showed that if these wishes are not fulfilled and the concerns persist they are less likely to use Smart Home technology. By this designers should ensure that Smart Home technology is only automated up to a level users still feel comfortable with and do not sense restrictions in their daily life.

4.5 Conclusion

The aim of this research was to answer the question which kind or level of comfort potential Smart Home users would accept while taking their optimal level of automated control in order to save energy into account. From the results it can be concluded that Smart Home users desire a level of comfort as high as possible. Every potential user had a different definition on what comfort is for him. The definitions of their comfort consisted of small parts of comfort like comfort in homes, the comfort of having money to spend for desired things and the comfort of having a good feeling. These small parts add up to a greater level of general comfort. For comfort in homes two smaller parts of comfort were an element of every definition and desired by potential Smart Home users - the flexibility to act in a not standardized way and the feeling of having control over the personal life. Potential users would accept a lower level of their comfort of acting flexible, for example for the purpose of saving energy, if they gain comfort to save money for things they desire or gain comfort of feeling good in exchange to this. They would not sacrifice a part of their comfort but

trade it for another part of their personal comfort. The higher the gain of the other part of comfort, the more likely users will trade.

This research shows that the kind and level of control have an influence on the feeling of comfort. Potential users desire different levels of automated control to feel comfortable. Their wish for manual control and acceptance of automated control are influenced by the negative expectations of modern technology people have. A certain level of manual control is necessary for all users to feel comfortable while there are differences of how much automated control users desire in their home while still feeling comfortable. If Smart Home technology having the purpose to save energy restricts the user's life, most users would be uneager to accept much discomfort caused by this, even if they have the motivation to accept it.

If Smart Home technology wants to be successful in the domestic sector it has to be personalized to the user's needs with regard to the wished level of automated control and the desired level and kind of comfort of the person. Furthermore the restrictions arising out of using Smart Home technology for the purpose of saving energy have to be as small as possible to suit the user's wishes.

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Appendix:

Appendix A

Interview

Begin
bedankt voor je deelname
dit interview is voor mijn bacheloronderzoek binnen Psychologiestudie op UT
doel: achterhalen wat potentiele gebruikers van smart homes vinden en waarom
interview bestaat uit aantal onderwerpen over die ik je vragen ga stellen
wat je zegt en je persoonlijke gegevens worden vertrouwelijk behandeld
alle antwoorden zijn goed. je kunt gewoon vertellen wat je denkt
tussendoor vragen
audio-opname, om informatie later te kunnen analyseren. geef je toestemming?
heb je nu nog vragen?
(opname-apparatuur aanzetten)

tijd:
Omgang met technologie

1. We beginnen met je thuis. Stel je even voor welke ruimtes je in je hele huis hebt. Wat voor technische apparatuur heb je hier? *'technische apparatuur' = heeft stroom nodig*
2. Hoe gebruik je je persoonlijke apparatuur?
   - waarvoor
   - wat gebruike je het vaakst
   - wat gebruik je minder vaak
3. Wat voor moderne apparatuur heb je thuis? Met modern bedoel ik recentelijk ontwikkeld, maximaal een paar oud.
   - Wat is het modernste wat je hebt?
4. Wat vind je van nieuwe technologieën in het algemeen?
   - wat vind je belangrijk voor gebruik
   - Hoe komt dat?

tijd:
Omgang met energie

5. Kun je wat vertellen over je energieverbruik thuis? kernwoorden:
   - activiteiten die energy verbruiken
   - apparatuur die energy verbruikt
   - hoeveel *bijv. veel/weinig, meer/minder dan*
   - kosten *bijv. hoog/laag, meer/minder dan*
   - besparen – doe je dat, weet je hoe (kennis), hoe doe je dat (acties)
   - Wat vind je belangrijk bij het gebruik van energie?
   - Waarom? Hoe komt dat?

tijd:
Rol in het huishouden

6. Je hebt het net al ingevuld, maar kun je voor mij kort samenvatten hoe je woonsituatie is?
   - soort woning? *bijvoorbeeld huis of flat*
   - met hoe veel mensen?

- wat voor relatie? *bijvoorbeeld familie, vrienden, of woongroep*

7. Stel je nu alsjeblieft voor, wat je "thuisgevoel" is. *(wat betekent thuis zijn).*Wat is daar belangrijk voor je? Kernwoorden:

– Kun je dat uitleggen? Hoe komt dat?

8. Hoe delen jullie thuis technische taken en klussen op? *Je zei net... Kun je dat nog verder uitleggen? Wil je nog iets toevoegen?*
- wie installeert apparatuur
- wie onderhoudt/repareert apparatuur
- Hoe komt dat?

9. Wie let thuis op het energieverbruik? *Je zei net... Kun je dat nog verder uitleggen? Wil je nog iets toevoegen?*
- Hoe komt dat?

10. Denk even terug aan wat we net hebben besproken over hoe jullie thuis samen leven. Wat is jouw rol daarin? *'rol' = bijdrage aan gezamenlijk wonen, takenpakket*
- mbt. technologieën
- mbt. energiegebruik
- Hoe ben je in die 'positie' gekomen?
- Is die verdeling prettig voor jou?
- Wat vind je belangrijk bij je 'rol'?
- voorbeeld (feiten/acties + beleving)
- Hoe komt dat?

tijd:

Het energie-smart home

- onderzoek gaat over smart homes
- Ik ga nu uitleggen wat dat is en wat het te maken heeft met energie.
- vragen mag tussendoor
- Ik ga nu plaatjes neerleggen. Als we hier straks over praten, kun je ze graag ook aanwijzen en verschuiven.
- huis-plaatje neerleggen, gedraaid naar de respondent: Stel je voor dat dit je woning of huisje is. jij, activiteiten
- energieleveranciers: Dit verbruikt energy. energieleverancier, kosten
- smart meter: Hoe kun je nagaan hoeveel je verbruikt? smart m., display, gebruik aanpassen
- variabele energietarieven: twee weg communicatie door smart meter, prijzen aanpassen
- smart apparaat: Moet je dat nou alles zelf bijhouden? apparaten kunnen zelfstandig werken op basis van informatie over energievoorraad en -prijzen
- (het) communicatieplatform: Hoe "weet" de apparatuur dat? wireless datatransfer tussen...
- remote toezicht en controle: Prijzen zijn hoog als veel mensen tegelijkertijd energie gebruiken, en dus laag als verder niemand dat doet. Moet je dan steeds 4:00 's nachts je was doen omdat dan de energieprijzen laag zijn? je apparaten besturen en verbruik bijhouden, via cloud en display
- automatisch energierooster: geoptimaliseerd energieverbruik volgens automatisch vastgelegde planning; Het systeem integreert daarbij de informatie van je smart meter (verbruik en prijzen) en jouw voorkeuren.
- autonome software agent: een stap verder. Een software agent houdt informatie bij over energie, kosten, apparaturen en je voorkeuren. Het systeem kan gewoontes leren en voorspellingen doen. De agent neemt beslissingen voor jou en/of voor de energieleverancier en beheert zelfstandig je apparatuur. Jij kunt voorkeuren aangeven via een display en eventueel toestemming geven of wijgeren voor wat de agent doet. De agent kan meer passief zijn individueel advies geven. Of hij kan je apparaten volledig automatisch controleren.

11. Heb je hier nog vragen over?
12. Wat vind je van deze technologieën? Wijs ajb. de kaartjes aan.
13. Wat bevalt je aan deze smart home technologieën? *Je zei net... Wil je daar nog iets aan toevoegen of zijn er nog andere dingen die je niet bevallen?*
    - Hoe komt dat?
14. Wat bevalt je niet aan een smart home? *Je zei net... Wil je daar nog iets aan toevoegen of zijn er nog andere dingen die je niet bevallen?*
    - Hoe komt dat?
15. Wat zouden smart home technologieën kunnen toevoegen aan jullie gehele huishouden?
    - voorbeeld (feiten/acties + beleving)
    - Waarom denk je dat dat zo is?
16. We hebben net je omgang met energie thuis besproken. Je zei dat je ... (5. parafraseren). Denk je dat dit zou veranderen door smart home technologie?
    - Zo ja, hoe? Zo niet, waarom niet?
17. Denk even terug aan wat we over je "thuisgevoel" hebben besproken. Je zei dat je ... (7. parafraseren). Wat voor effect zou een smart home hierop hebben?
    - Zou je je meer thuis voelen?
    - Zo ja, hoe komt dat? Zo niet, waarom niet?
    - Wat voor invloed zou dat hebben op je gebruik van smart home technologieën?
    - voorbeeld (feiten/acties + beleving)
18. Stel je voor je zou de mogelijkheid hebben om smart home technologieën aan te kunnen schaffen. Zou je ze thuis willen hebben?
    - Welke wel of niet? Wijs ajb. de kaartjes aan.
    - Waarom wel of niet?
    - Zo ja, waarvoor zou je ze gebruiken?
    - Wat vind je aantrekkelijk aan die technologieën? *voordelen*
    - Wat zou je tegenhouden om die technologieën te gebruiken? *nadelen*
    - voorbeeld (feiten/acties + beleving)

tijd:

Comfort (kort voorlezen)

Iedereen heeft een eigen idee van wat hij comfortabel acht en welk level van comfort hij wenselijk vindt. Smart Home technologie kan een grote invloed hebben op het gevoel van comfort in een huis. Als je niet zeker weet wat jij als comfortabel acht in je huis, denk dan even na over wat je wensen voor een comfortabel huis zijn. Denk eraan welke rol Smart Home technologie in je huis voor je comfort zou kunnen spelen.

Controle

Er zijn twee verschillende manieren hoe Smart Home techniek kan worden gecontroleerd: Het intelligente computer systeem in het huis kan geprogrammeerd worden om op een bepaalde manier de techniek automatisch aan en uit te zetten en te besturen. Of de gebruiker kan de techniek in het huis handmatig controleren via een schakel, App op het Smart Phone of op andere manieren.

19. In hoeverre denk je dat een Smart Home invloed heeft op het comfort in je huishouden? *(Mogelijk verband met thuisgevoel)*
20. Als alles mogelijk zou zijn, wat wil je dat een Smart Home kan, zodat het bijdraagt aan jouw comfort?

- Wil je bepaalde dingen graag geautomatiseerd hebben?
- Wil je bepaalde dingen niet geautomatiseerd hebben?
- In welke mate wil je dit (niet) geautomatiseerd hebben?
- Zo ja, waarom?
- Wat draagt dit volgens jou bij aan je comfort?

21. Een Smart Home zou comfort kunnen bieden, maar het kan echter ook dat een Smart Home discomfort kan bieden. Wanneer denk jij dat een Smart Home geen comfort kan bieden?
    - Waarom?
    - In hoeverre / In welke mate zou je dit accepteren?
    - Wat zijn je redenen om dit te accepteren?
22. Denk terug aan het Energy-Smart-Home.
    In hoe verre ben je bereid comfort in te leveren om energie te besparen? (Als dit al bij vraag 21 werd beantwoord, dan alleen doorvragen op de punten beneden.)
    - Welk soort comfort zou je opgeven?
    - Waarom?
    - Zou je een voorbeeld kunnen geven?

tijd:

Afsluiting

(opname-apparatuur uitzetten)
we zijn nu klaar met het onderzoek
bedankt voor je tijd
heb je nog vragen of opmerkingen?

Appendix B

Informatiebrochure

In deze brief wil ik je informeren over het onderzoek waarvoor je je hebt aangemeld.

Het doel van dit onderzoek is te weten te komen wat mensen van een *Smart Home* verwachten, hoe ze over *Smart Home* technologieën denken en waarop ze deze beoordelingen baseren zijn. Het onderzoek bestaat uit een persoonlijk interview dat ongeveer 60 minuten zal duren. Je zal door een onderzoeker geïnterviewd worden die je verschillende vragen zal stellen. In dit interview gaat het alleen om je eigen mening. Je hoeft dus geen bepaalde voorkennis te hebben en er zijn geen goede of foute antwoorden.
Het interview wordt opgenomen met audio-opname apparatuur. De verzamelde data wordt vertrouwelijk behandeld, volledig geanonimiseerd verwerkt en niet door derden worden ingezien. Het interview is geheel vrijwillig en je mag op elk moment van het interview stoppen zonder dat dit verdere consequenties voor jou heeft. Na het interview heb je het recht je medewerking bij het onderzoek op elk moment in te trekken. Je data zullen in dit geval worden vernietigd en zullen niet in het onderzoek worden verwerkt.
Na afloop van het volledige onderzoek kun je, indien je dat wenst, middels een debriefing over de verkregen resultaten op de hoogte worden gesteld.

Met vriendelijke groet,

Lisa Scheifler (l.scheifler@student.utwente.nl),
Johannes Terwort (j.terwort@student.utwente.nl)

Appendix C

First e-mail
Beste NAAM,

Leuk dat je mee wilt doen aan ons onderzoek! Zoals besproken zullen we binnenkort samen een interview houden over Smart Home technologieën en hun gebruik. Dit interview maakt deel uit van Lisa's en mijn Bachelorondersoek aan de Universiteit Twente. Het zal ongeveer 60 minuten duren. Nu wil ik graag een afspraak met je maken om het interview af te nemen. Ik stel voor om op DATUM tussen TIJD en TIJD bij jou thuis af te spreken. Welk tijdstip komt je goed uit? Mocht je dan niet kunnen, op welk moment zou je liever willen afspreken?

Voor het interview hebben we een plekje nodig waar we ongestoord kunnen praten en waar we aan een tafel kunnen zitten. Verder hoef je niets voor te bereiden. Je gegevens zullen vertrouwlijk worden behandeld en later anoniem in het onderzoeksverslag worden weergegeven.

Mocht je vóór je eigen interview iemand spreken die al aan dit interview heeft deelgenomen, bespreek dan alsjeblieft geen details van het onderzoek met diegene. We willen namelijk graag dat je onbeïnvloed naar je eigen interview komt. Voor en na het interview zul je genoeg gelegenheid hebben om vragen te stellen aan de interviewer.

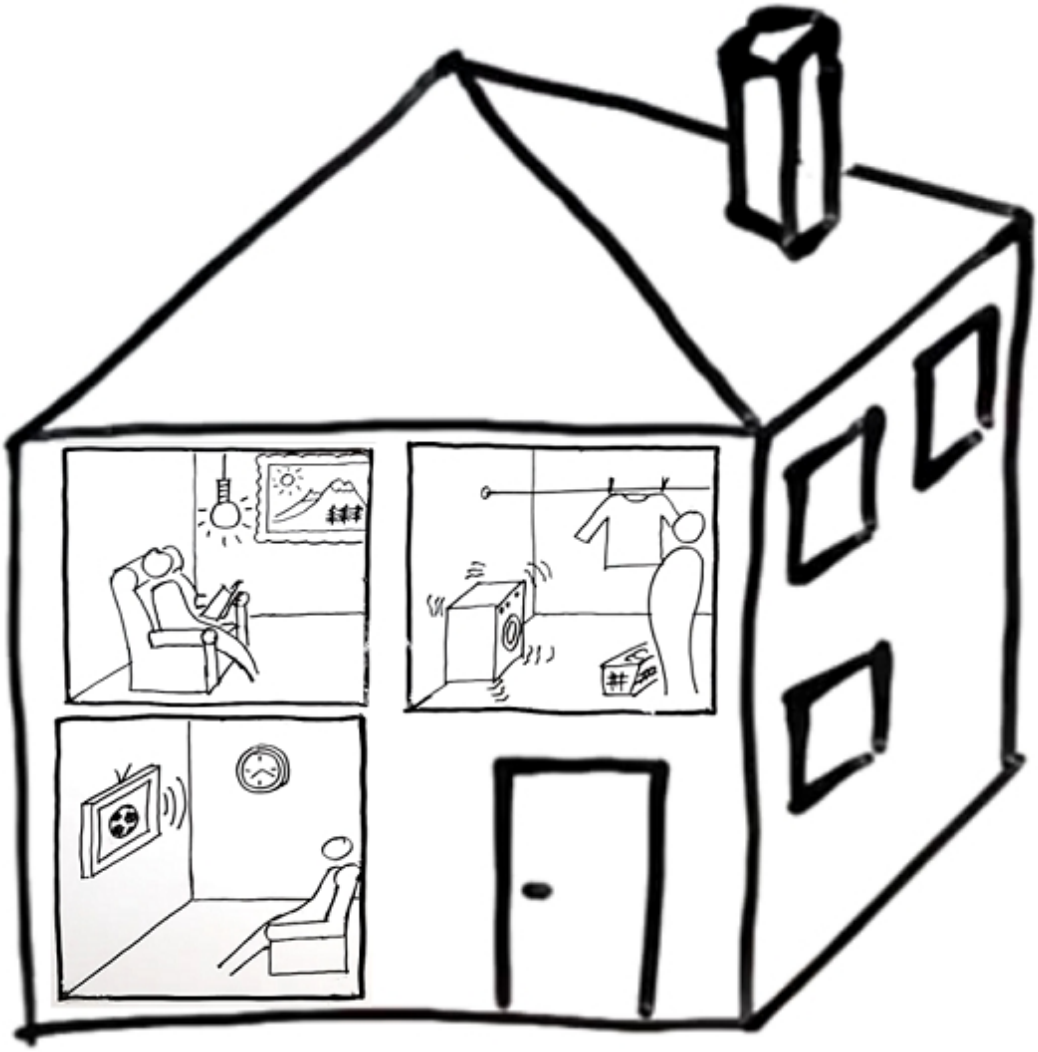
Mocht je nu alvast vragen hebben hoor ik het graag.

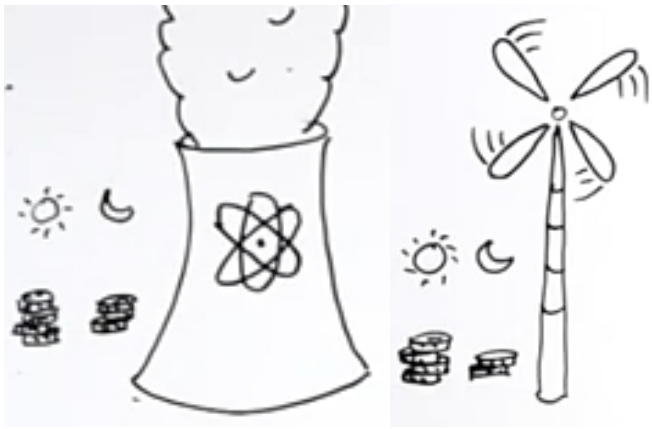
Het zou fijn zijn als je met de reactie ook je adres en de naam aan de deur kunt meedelen om te weten waar het interview precies zal plaatsvinden.

Groetjes,
Johannes

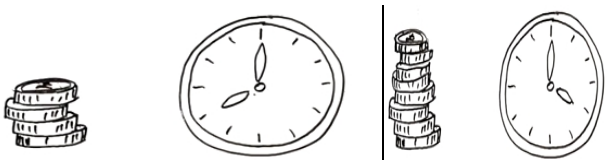
Appendix D

Graphics of an Energy Smart Home for explaining the concept

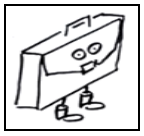




1. energieleveranciers



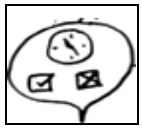
3. variabele energietarieven



8. autonome software agent

9. individueel/automatisch

2. smart meter



4. smart apparaat

7. automatisch energierooster

6. remote toezicht en controle

5. (het) communicatieplatform

Graphic Smart Home
Extracted from a video by Rodden, Fischer, Pantidi, Bachour & Moran (2013).

Appendix E

Demographics

Datum: _____

Onderzoeker: _____ Respondentnummer:____

Demografische gegevens

- Nationaliteit:
- Woonplaats:
- Leeftijd:
- Geslacht: man / vrouw
- Opleiding/professie en specialisatie:

Thuis-informatie

- Aantal mensen in je huishouden:
- Status: bij familie / met vrienden / op me zelf / studentenhuis / anders, namelijk…
- Type: eigen huis / gehuurd huis / flat / anders, namelijk…
- Aantal jaren van verblijf:

Appendix F

Informed consent

Ik verklaar hierbij dat ik duidelijk ben geinformeerd over de aard en methode van het onderzoek. Mijn vragen zijn naar tevredenheid beantwoord. Ik stem geheel vrijwillig in met de deelname aan dit onderzoek over de meningen van potentiele *Smart Home* gebruikers over *Smart Home* technologieën. Ik behoud daarbij het recht deze instemming weer in te trekken zonder dat ik daarvoor een reden hoef op te geven en ik besef dat ik op elk moment mag stoppen met het onderzoek. Indien mijn onderzoeksresultaten gebruikt zullen worden in wetenschappelijke publicaties, dan wel op een andere manier openbaar zullen worden gemaakt, zal dit volledig geanonimiseerd gebeuren. Mijn persoonlijke gegevens zullen niet door derden worden ingezien zonder mijn uitdrukkelijke toestemming.

....

Naam proefpersoon Handtekening

Voor verdere informatie over het onderzoek kun je contact opnemen met Lisa Scheifler (telefoon: 06-26241294; e-mail: l.scheifler@student.utwente.nl) of Johannes Terwort (telefoon: +49176-75051793; e-mail: j.terwort@student.utwente.nl). Voor eventuele klachten over dit onderzoek kun je contact opnemen met de secretaris van de Commissie Ethiek van de faculteit Gedragswetenschappen van Universiteit Twente, mevr. J. Rademaker (telefoon: 053-4894591; e-mail:j.rademaker@utwente.nl, Postbus 217, 7500 AE Enschede).

Ik heb toelichting gegeven over het onderzoek en ben bereid nog opkomende vragen over het onderzoek naar vermogen te beantwoorden.

....

Naam onderzoeker Handtekening

Appendix G

Schema for coding

19. Invloed op comfort:

20. Level van control:

    20.1: automation

    20.2: manual control

    20.3: reason/motivation

    20.4: impact on comfort

21. Discomfort:

    21.1: Situation

    21.2: acceptance of the situation

    21.3: reason/motivation

22. Discomfort for saving energy

    21.1: Kind of comfort (If there is any)

    21.2: reason/motivation

Appendix H

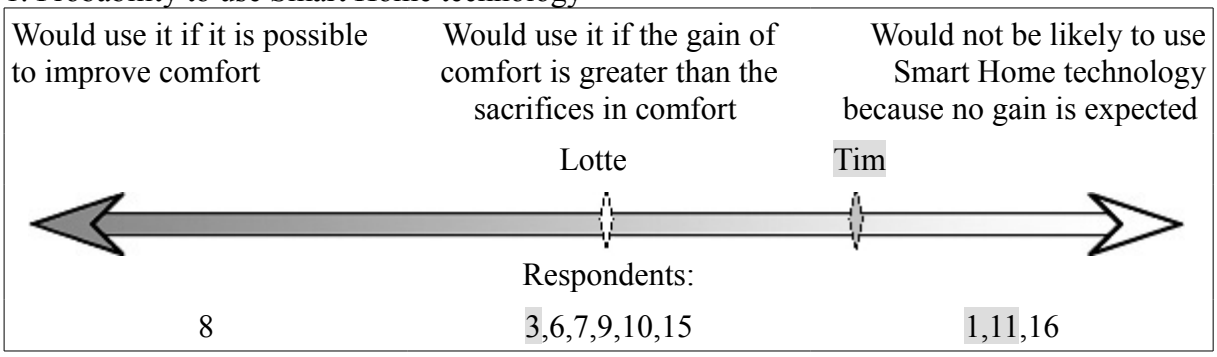
Percentages and distribution of respondents

No	Variable	Range	Percentage global (Out of 16)	Percentage variable intern	Respondents
a	Age	20-35	87,5	87,5	1,2,3,4,5,6,7,8,9,10,13,14,15,16
		35-60	12,5	12,5	11,12
b	Gender	Male	50	50	4,6,7,8,12,13,14,15
		Female	50	50	1,2,3,5,9,10,11,16
c	Level of Education	University	81,25	81,25	1,2,3,4,5,6,7,8,9,10,13,15,16
		Applied University	18,75	18,75	11,12,14
d	Nationality	Netherlands	87,5	87,5	1,2,3,4,5,6,7,8,9,10,11,14,15,16
		German	12,5	12,5	12,13
1	Probability to use Smart Home technology	Would use it if it is possible to improve comfort	6,25	10	8
		Would use it if the gain of comfort is greater than the sacrifices in comfort	37,5	60	3,6,7,9,10,15
		Would not be likely to use Smart Home technology because no gain is expected	18,75	30	1,11,16
2	Desired level of autonomy to feel comfortable	High	31,25	31,25	1,3,4,11,12
		Somewhat high	68,75	68,75	2,5,6,7,8,9,10,13,14,15,16
		Balanced			
		Somewhat low			
		Low			
3	Desired kind of control to feel comfortable	High level of automated control			
		Moderate level of automated control	68,75	68,75	2,5,6,7,8,9,10,13,14,15,16
		Balanced	6,25	6,25	4
		Low level of automated	25	25	1,3,11,12

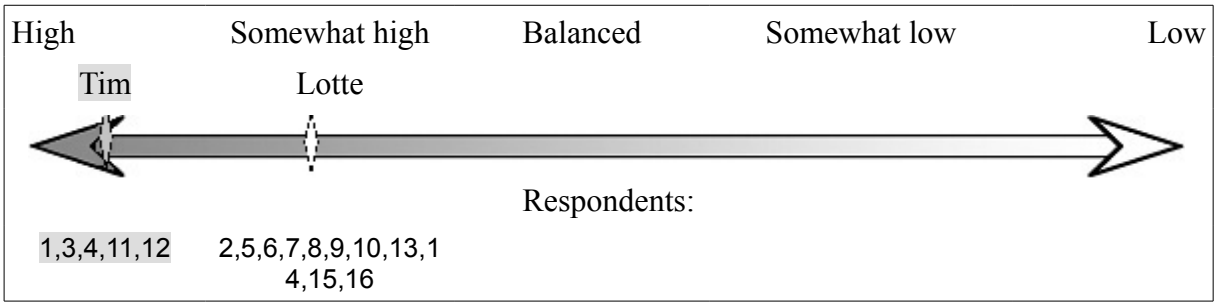
		control			
		Manual control			
4	Accepted influence of the system on the user's life while still feeling comfortable	Restricting influence			
		More restriction than support			
		More support than restriction	62,5	62,5	1,2,5,7,8,10,11,12,13, 15
		Supporting influence	37,5	37,5	3,4,6,9,14,16
5	The accepted level of discomfort in a Smart Home	Much discomfort			
		Some discomfort			
		Not much discomfort	56,25	60	2,3,4,6,7,10,12,13,14
		Nearly no discomfort	37,5	40	1,8,9,11,15,16
		No discomfort			
6	Motivations for accepting discomfort to save energy	Primarily money	62,5	55,55	4,5,6,7,8,9,10,13,15,16
		Primarily personal attitude	50	44,44	5,6,8,9,11,13,15,16

Appendix I
Graphical illustration of the distribution of respondents and personas for each variable

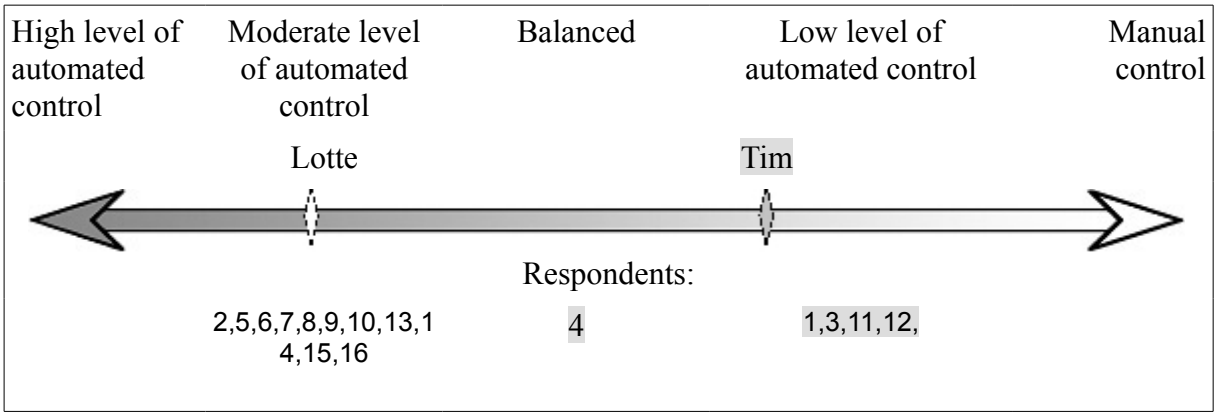
1. Probability to use Smart Home technology



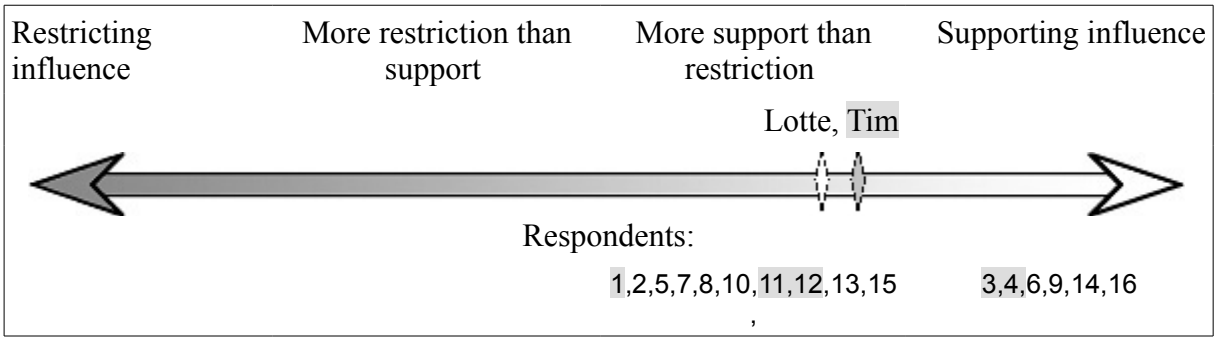
2. Desired level of autonomy to feel comfortable



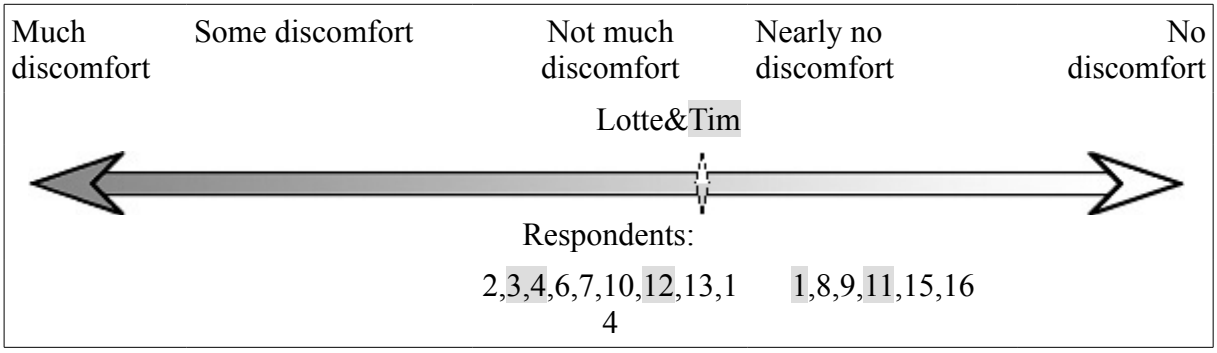
3. Desired kind of control to feel comfortable



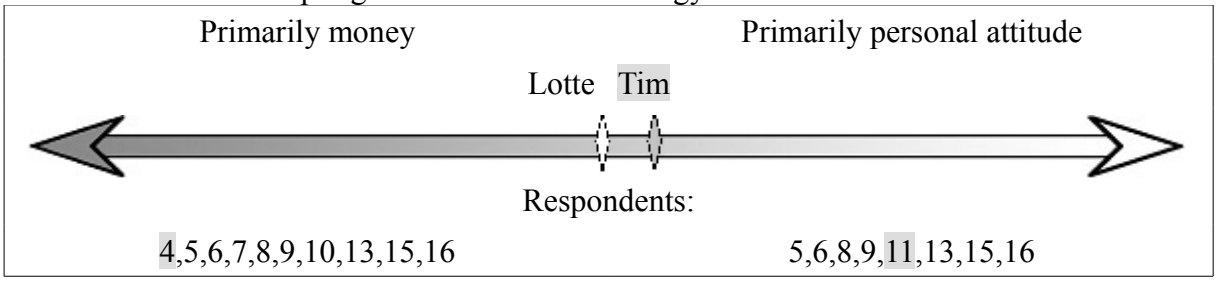
4. Accepted influence of the system on the user's life while still feeling comfortable



5. The accepted level of discomfort in a Smart Home



6. Motivations for accepting discomfort to save energy



Appendix J

Original quotes and translations

Variable	Quote Dutch and number respondent	Translation English
1. Probability to use Smart Home technology	*En voor mij zou de comfort wat je krijgt zeg maar een tienvoudig moeten zijn van wat gevraagd is. Zeg maar dat zou echt een stuk moeten meer zijn zeg maar. Vergeleken met wat ik anders zou kan behalen moet het dan echt beter zijn dan wat ik zelf kan doen. (Respondent 9)*	*And for me the comfort of what I gain has to be ten times as big as that what is asked from me. I would say it has to be really a bit more. Compared to what I can achieve by other ways it must be really better than what I can do by myself.*
	Ik kan me niet voorstellen dat het allemaal geautomatiseerd is omdat het te moeilijk is als ik iets niet wil, het is discomfort omdat ik niet meer flexibel ben. (Respondent 11)	*I can't imagine that everything is automated because it is to difficult if I do not want something, it is discomfort because I am not flexible anymore.*
2. Desired level of autonomy to feel comfortable	*Het moet extreem makkelijk zijn. Het mag alleen 2 seconden duren in totaal dat als ik op vakantie ga dat mijn licht er niet meer aan gaan. Makkelijke uitzonderingen moeten mogelijk zijn. Het moet uit gaan op een knop. Dus die twee seconden maximaal. (Respondent 15)*	*It has to be extremely easy. It may only need two seconds in total if I'm going on vacation that my lights don't turn on anymore. Easy exceptions have to be possible. It has to turn off with one button. So the two seconds maximum.*
	Ik wil het beschikbaar hebben als ik het wil. Ik ben er afhankelijk van de computer te kunnen gebruiken. (Respondent 4)	*I want it available if I want it. I depend on being able to use the computer.*
3. Desired kind of control to feel comfortable	*Als je thuis bent moet je niet nog de was moeten doen en heb je veel tijd en rust daardoor om lekker te rusten*	*If you are at home and don't have to do the laundry anymore and have much time*

	of te koken. (Respondent 14)	*and peace to rest or to cook.*
	Ik vindt het niet erg het een of andere handmatig in te schakelen. (Respondent 12)	*I do not think it is bad if I have to switch the one or other on manually.*
4. Accepted influence of the system on the user's life while still feeling comfortable	*Als je wakker wordt dat je op de muur kunt raken en je ziet het weer van vandaag. Of dat je ziet in de koelkast zit nog dit dit en dit binnen. En deze recepten kan je daar nog van maken. Dat je nog meer ondersteuning heeft. (Respondent 16)*	*If you wake up that you can touch the wall and you see the weather of today. Or that you can see that in your refrigerator there is this and that. And you can still make this and that recipe out of this. Than you have more support.*
	Ik denk dat het dus goed zou zijn als het niet een dusdanig invloed op je leven zou hebben van dat je moet beslissingen maken aan de hand van: moet ik nu wel of niet energie gebruiken? (Respondent 4)	*I think therefor it would be great if it would not have such an influence on your life that you have to make choices based on: do I have to save energy or not?*
5. The accepted level of discomfort in a Smart Home	*Ik denk dat ik heel weinig geduld voor zou hebben omdat ik zo eigenwijs ben zou ik heel snel denken: ik doe het gewoon zelf. (Respondent 5)*	*I think I would have very little patience for it because I am so headstrong I would very fast think: I simply do it myself.*
	Op werk zou ik comfort inleveren. Thuis betaal ik ook een beetje meer als ik er meer comfort van heb. Daar zou ik niet veel comfort inleveren. (Respondent 11)	*On my work I would sacrifice comfort. At home I would even pay a little bit more if I can get more comfort by it. There I would not sacrifice much comfort.*
6. Motivations for accepting discomfort	*Wij gebruiken heel veel energie en zo dingen geven ook schade. Ik voel me*	*We use much energy and such things bring damage, too. I*

to save energy	*er verantwoordelijk voor. En daar wil ik graag iets aan doen dus daarom. (Respondent 15)*	*feel responsible for this. And that I would like to do something for, so therefore.*
	Soms wil ik de moment genieten en niet dat een apparatuur me vertelt hoe duur het is wat ik doe. (Respondent 3)	*Sometimes I want to enjoy the moment and I don't want that a device reports how much it costs what I'm doing.*

Appendix K

Percentages between personas and intern

No	Variable	Range	Lotte % (of 11)	Tim % (of 5)	Lotte out of perceptions	Tim out of perceptions
a	Age	20-35	100	60	100	60
		35-60		40		40
b	Gender	Male	54,54	40	54,54	40
		Female	45,45	60	45,45	60
c	Level of Education	University	90,90	60	90,90	60
		Applied University	9,09	40	9,09	40
d	Nationality	Netherlands	90,90	80	90,90	80
		German	9,09	20	9,09	20
1	Probability to use Smart Home technology	Would use it if it is possible to improve comfort	9,09		14,28	
		Would use it if the gain of comfort is greater than the sacrifices in comfort	45,45	20	71,42	33,33
		Would not be likely to use Smart Home technology because no gain is expected	9,09	40	14,42	66,66
2	Desired level of autonomy to feel comfortable	High		100		100
		Somewhat high	100		100	
		Balanced				
		Somewhat low				

		Low				
3	Desired kind of control to feel comfortable	High level of automated control				
		Moderate level of automated control	100		100	
		Balanced		20		20
		Low level of automated control		80		80
		Manual control				
4	Accepted influence of the system on the user's life while still feeling comfortable	Restricting influence				
		More restriction than support				
		More support than restriction	63,63	60	63,63	60
		Supporting influence	36,36	40	36,36	40
5	The accepted level of discomfort in a Smart Home	Much discomfort				
		Some discomfort				
		Not much discomfort	54,54	60	60	60
		Nearly no discomfort	36,36	40	40	40
		No discomfort				
6	Motivations for accepting discomfort to save energy	Primarily money	81,81	20	56,25	50
		Primarily personal attitude	63,63	20	43,75	50