MASTER

Go ahead, boost my mood!

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Go ahead, Boost my mood!

Floor van Schayik

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Preface

This thesis is the final part of the Master Human-Technology Interaction at the University of Technology in Eindhoven. During my Bachelor study Industrial Design Engineering, my interest in making user centered products was born. During my Master study Human-Technology Interaction, I felt that qualitative research was an interesting and helpful way to find out what users want. Ingrid Heynderickx helped me to find a graduation project in which I could do qualitative research to make a product more user centered. I want to thank her for that, because I found a really interesting project on which I worked with great pleasure. Especially the interviews were great. I want to thank all participants for their time, openness, and inspiring stories and I want to thank Vitalis WoonZorg Groep for supporting this project.

Special thanks to my supervisors Alina Huldtgren, André Kuijsters, and Wijnand IJsselsteijn for their valuable insights, feedback and support. Finally, I would like to thank my family and friends.

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Abstract

The growth in elderly population challenges us to focus on technologies that help elderly to live independently as long as possible. Ambient intelligent systems can assist the elderly in living independently and have potential to improve their well-being. One of these systems is the ACE-system, which recognizes the mood of an elderly person and creates an ambience which may change his or her mood (Kuijsters, Redi, Ruyter and Heynderickx, 2012). Using cameras, the ACE-system detects whether an elderly is in a negative mood and then automatically changes the atmosphere in the room for a more positive mood. The aim of this study was to investigate in what way elderly’s perceptions of the usefulness, ease of use, trust, privacy, and controllability of the ACE-system influence their attitude towards the ACE-system, to find other factors that influence the elderly’s attitude towards the ACE-system, and to find in what way these factors influence their attitude.

Semi-structured interviews were conducted to achieve this. Six factors that influence the attitude towards the ACE-system were found. First, privacy influences the elderly’s attitude towards the ACE-system. The privacy problem of the camera can be solved when the camera can be turned off and when the elderly can control who can access the video images. However, the fact that other people can see the elderly’s mood based upon the light might be problematic. Second, trust influences attitude and this effect can be mediated by the perceived usefulness. The participants trusted the mood measurement of the camera, but several elderly mentioned that they did not trust that light can counteract a negative mood. These elderly did not perceive the system as useful and therefore have a negative attitude towards the ACE-system. Third, controllability influences attitude and this effect can be mediated by the perceived ease of use. The preferences for the control of the system were diverse with a slight preference for the semi-automatic way in which the system gives a suggestion for the ambience that is best for you, but you can choose yourself to turn this ambience on or not. This is an option in between the manual option, that allows you to have a high level of control, and the automatic option, which does not enable you to control the system, but makes the system easy to use. The interface that was used in the interviews was considered as easy to use, especially after the elderly got used to it. Fourth, the ambience change caused contrasting opinions. Some elderly liked to see the ambiance change when a negative mood was detected by the camera, because it reminded them to get a more positive attitude. However, other elderly did not want to be reminded of their negative mood, because it would make them even sadder. Fifth, one third of the elderly had a positive attitude towards the ACE-system although they did not want the system. They recommend the system to others who are lonelier, needier, or gloomier. Sixth, several elderly indicated that they were already satisfied and did not want any changes or new systems anymore.
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1. Introduction

With population ageing and increased longevity, there is considerable strain on healthcare resources. Care and personal attention become too costly for societies and there are long waiting lists for care centers. As a response, elderly people continue to live independently for longer. The government encourages this, because a lot of money can be saved as long as elderly stay out of the care centers (Toussaint and Elsinga, 2010). However, independent living brings along obstacles that affect elderly’s ability to live in their own familiar environment. Negative emotions such as sadness, anxiety, loneliness and lowered self-esteem are common examples (Silk, 2015). When people grow older, their social network usually shrinks, because elderly are less mobile and people around them pass away. Being alone can reduce the motivation to be active. Dressing up when nobody is going to see it and cooking only for yourself can be demotivating and can cause sad feelings. Another common negative feeling is anxiety. Elderly can have fears of being unable to take care for themselves or to be abandoned or separated from their loved ones (Kogan and Edelstein, 2004).

1.1. ACE-system

Ambient intelligent systems can assist the elderly in living independently and have potential to improve their well-being (Cook, Augusto, and Jakkula, 2009). One of these systems is the Adaptive Ambience Creation in Care Centres for Elderly system (ACE-system), which recognizes the mood of an elderly person and creates an ambience which may change a negative mood in a more positive mood (Kuijsters, Redi, Ruyter, and Heynderickx, 2012). The development of the ACE-system is made possible by three technological developments. First, indoor light and color are proved to have an influence on people’s mood (Küller, Ballal, Laike, Mikellides, and Tonello, 2006). Second, the technological developments have introduced new possibilities to observe people’s affective state (Picard et al., 2004). Third, developments in ambient assisted living make it possible to install lighting systems that react to people and automatically adapt to their needs (Huldtgren, Katsimerou, Kuijsters, Redi, and Heynderickx, 2015). The ACE-system will detect mood by measuring facial expressions, body posture and activity level with a camera, situated in the room of the elderly (Katsimerou, Redi, and Heynderickx, 2014). A mood sensing platform analyses this context, indicates if the ambience should be changed, and gives the desired affective direction (Kuijsters, Redi, Ruyter, and Heynderickx, 2012). The architecture of this mood sensing platform is shown in Figure 1.1.
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Figure 1.1: Basic architecture of the mood sensing platform

The mood sensing platform is connected to the ambience creation platform. The ambience creation platform can create ambiences (like an activating or a cozy ambience, see Figure 1.2) to reduce negative feelings. Which ambience will be activated, depends upon the measured mood.

Figure 1.2: An activating ambience (left) and a cozy ambience (right)

As shown in Figure 1.3, a control unit will convert the measured mood into the appropriate ambience and allows the input of personal preferences by the elderly, which makes the ACE-system a complete intelligent ambience creation system. Sadness may be counteracted by an activating ambience and anxious elderly may be calmed with a cozy ambience according to Kuijsters, Redi, Ruyter, and Heynderickx (2012). They found that the cozy ambience (consisting of general lighting with a lower illumination, lower color temperature, and orange-colored accent lighting) was significantly more effective in reducing anxious mood compared to a neutral ambience. The activating ambience (consisting of general lighting with a higher illumination, higher color temperature, and cyan-colored accent lighting) was physiologically more arousing than the neutral ambience (Kuijsters, Redi, Ruyter and Heynderickx, 2015). Other senses can be added to the ambiences, like music (Laukka, 2007) and fragrance (Herz, 2002), to enhance the effectiveness of the ambience. Both fragrance and music are used to reduce negative mood states.

Figure 1.3: Intelligent ambience creation platform
1.2. Technology acceptance

Even though technology may be used to improve the well-being of independent living elderly, the acceptability of new technology by elderly appears to be low according to Mitzner and colleagues (2010). They found that independent living elderly disliked technology for various reasons, including the reliability of technology, security issues, unhelpful features of technology, and inconvenience. This suggests that the low acceptability of technology not simply depends upon being afraid and unwilling to use technology. However, the ACE-system can assist these independent living elderly in particular, because it can help them to live independently longer. Interviews with caregivers indicated that independent living elderly could have difficulties with noticing their negative mood or with taking initiative to improve their negative mood (Hultdgren, Katsimerou, Kuijsters, Redi, and Heynderickx, 2015). This makes it even more important to study the acceptance of the ACE-system by independent living elderly. For this purpose, the obstacles of acceptance of the ACE-system will be studied and possible solutions will be explored. These solutions will be transformed in a set of requirements for the ACE-system that will increase the probability of acceptance.

Acceptance of a system will take place when the user approves, favorably receives, and uses the new introduced system continuously (Arning and Ziefle, 2007). Technology acceptance is broadly studied which resulted in eight prominent models each with different sets of acceptance determents. See Venkatesh, Morris, Davis, and Davis (2003) for a review. One of these models is the Technology Acceptance Model (TAM) of Davis, Bagozzi, and Warshaw (1989). This model gained theoretical and empirical support in particular (Venkatesh and Davis, 2000). The TAM explains consistently around 40% of the variance in intention and behavior and is consistent with other acceptance theories such as the theory of planned behavior and the theory of reasoned action (Venkatesh, 1999). According to the TAM, the perceived ease of use and perceived usefulness are hypothesized to be fundamental determinants of user acceptance (Davis, 1999). The TAM was an adaption of the Theory of Reasoned Action (TRA) by Fishbein and Ajzen (1975) which suggests that behavioral intention depends on the subjective norms and the attitude towards the behavior. If a person has the intention to perform certain behavior, it is likely that the person will engage in the behavior. The right part of Figure 1.4, which shows the TAM, is based on the TRA.

![Figure 1.4: Technology Acceptance Model (TAM)](image)

Whether someone accepts a technology cannot be asked directly and cannot be measured accurately based on usage (Renaud and van Biljon, 2008). In case of the ACE-
system, it is also not possible to measure the intention to use or the actual use, because the system is still in development. However, the attitude towards the ACE-system can still be measured, because what people say tends to be influenced by their attitude (Renaud and van Biljon, 2008). Therefore, the attitude of the elderly towards the ACE-system can be measured by gauging the extent to which the elderly embraced the ACE-system based upon their comments about it.

The perceived ease of use is the degree to which a person believes that using a technology is free of effort. The ACE-system can be used without effort when it runs automatically without control by the elderly. Then, the elderly will be in a neutral ambience when the lights are turned on. However, if a sad mood is detected, an activating ambience will be applied to reduce the sadness. If an anxious mood is detected, a cozy ambience will be applied to reduce the anxious feelings. However, system controllability is another strong predictor of acceptance behavior (Wu, 2011). Wu suggests that acceptance behavior enhances under a higher level of perceived controllability. Regarding the ACE-system, the ease of use and the level of control cannot be maximized both. Although the optimal amount of effort is ensured when the system requires no control, the optimal level of controllability is ensured when the system is highly controllable. To achieve acceptance of the ACE-system by elderly, an acceptable balance between the ease of use and controllability must be found.

The perceived usefulness relates to the perceived benefits of a technology, which is the reduction of negative moods in case of the ACE-system. To ensure that the elderly rely upon the mood improvement, trust in the system has to be considered. Two trust issues could be a problem for the elderly. First, they have to trust that the system converts their facial expressions, body posture and gestures into the corresponding mood. Second, elderly need to trust the positive impact of light on their well-being. Only when they believe that the ambiances of the ACE-system can counteract their negative mood state, they can trust upon the mood improvement of the ACE-system.

Privacy is also a factor that has to be considered for the acceptance of the ACE-system. To let the system improve the elderly’s mood automatically, their mood has to be measured constantly, e.g. with a camera (Katsimerou, Redi, and Heynderickx, 2014). The most relevant problem with a camera is the lack of privacy (Fleck and Straßer, 2008). The camera will be in the home environment which is a private area. Moreover, the facial expressions are measured which means that detailed video images are necessary. If the elderly see this as a violation of privacy, this might be a reason to reject the ACE-system.

Based on the above, the factors that are hypothesized to influence the acceptance of the ACE-system by elderly are shown in Figure.1.5. The attitude towards using the ACE-system might depend on the trust, privacy and controllability of the ACE-system. The effect of trust in the ACE-system on the attitude towards using the ACE-system can be mediated by the perceived usefulness of the ACE-system. In addition, the effect of
controllability of the ACE-system on the attitude can be mediated by the perceived ease of use of the ACE-system. The resulting research question is:

In what way do the elderly’s perceptions of the usefulness, ease of use, trust, privacy, and controllability of the ACE-system influence their attitude towards the ACE-system?

![Figure 1.5: Proposed model for the acceptance of the ACE-system](image)

However, the ACE-system is a new system which makes it possible that there are more factors that influence the acceptance of the ACE-system which I did not think of. For this reason, I also want to answer the following question:

Which other factors influence the elderly’s attitude towards the ACE-system and in what way do these factors influence their attitude?
2. Related work

To be able to find out in what way the elderly’s perceptions of the usefulness, ease of use, trust, privacy and controllability of the ACE-system influence their attitude towards the ACE-system, some factors have to be studied more deeply. Therefore, the following factors will be discussed: privacy, trust and perceived usefulness, and controllability and perceived ease of use.

2.1. Privacy

Privacy is the ability to control the dissemination of information about transactions and behaviors to people who were not present (Goodwin, 1991). When people are able to control this more, they will perceive higher privacy. The positive relation between privacy and technology acceptance is already identified for various technologies. Ohkubo, Suzuki and Kinoshita (2005) for example identified privacy issues that influence the adoption of Radio Frequency Identification (RFID) technology. They found that people with high personal tolerance for privacy issues place lower importance on personal privacy and are more willing to sacrifice privacy. Therefore, these people have a higher intention to use RFID-based systems. Lee (2009) indicated that the intention to use online banking is adversely affected mainly by the privacy risk of loss due to a hacker or fraud. Nam and Rha (2009) found a negative impact of consumers’ privacy concern on consumers’ intention to use location based services. As the examples suggests, privacy is mostly studied in context of tracking people’s location, spending patterns and sharing personal data. To my knowledge, no privacy related studies have been done on the acceptance of technologies that use video to measure people’s mood in their home environment. However, cameras are often seen as a threat to privacy as in the discussion about video surveillance cameras. In western cities, video surveillance has become increasingly popular to restrain crime and guarantee security. This raised the discussion in which some see surveillance cameras as an invasion of privacy while others think: if you have nothing to hide you have nothing to worry about (Ullmann-Margalit, 2008). These surveillance cameras are situated in places where you can be seen or heard by strangers, but your home is a private place where you expect that what you do or say will not be seen or heard by someone else. Therefore, it can be expected that cameras are less accepted in a home environment. However, Caine, Fisk and Rogers (2006) found that the level of privacy concerns for monitoring cameras in elderly’s homes decreased when the elderly were low functioning. Therefore, I predict that the potential benefits of a system must outweigh the potential privacy costs. This raises the following question for the ACE-system:

*Is the perceived benefit of the ACE-system by the elderly out-weighting the decreased level of privacy caused by the cameras?*
2.2. Trust and perceived usefulness

Trust in the competence of technology means that the users perceive the technology to have the functionality or functional capability to do the task they want to be done (McKnight, 2005). Similarly, we can trust technology if it does what it is designed to do without unexpected results, delays or crashing. The positive relation between trust and technology acceptance is already identified for various technologies. Pavlou (2003), for example, identified trust as the most influential predictor of transaction intentions with computer networks, such as the Internet. If customers believed that the other party has both goodwill and credibility, they were more likely to make a transaction with computer networks. Wu and Chen (2005) found that the effect of trust on the attitude towards online tax declarations is greater than the effect of perceived usefulness and perceived ease of use on the attitude. When citizens had more trust in online-tax declarations, they were more willing to pay their tax through a virtual channel without face-to-face contact. Trust in online shopping is also a predictor of the intention to transact with an online vendor, according to Gefen, Karahanna, and Straub (2003). If consumers believed that the vendor had nothing to gain by cheating, they trusted a website more and were more willing to transact with an online vendor. In all three examples, the perceived usefulness mediates the relation between trust and attitude. The positive relation between trust and perceived usefulness is likely to occur, because consumers are more able to sense the expected usefulness after they trusted the transaction (Goodhue and Thompson, 1995). This may be the same for the ACE-system. When the elderly initially trust that the ACE-system will improve their mood, they have the idea that adopting the ACE-system is beneficial to their mood, and thus they are more likely to believe that the ACE-system is useful. The elderly have to trust the camera to measure their mood correctly and the system to counteract their negative mood with ambiences. However, as the example studies about the influence of trust on technology acceptance suggest, most studies about trust are in the context of online transactions. To my knowledge, no studies have been done on the relation between trust and technology that counteract negative moods. Lount (2010) found that mood can influence trust development, but the ACE-system has to be trusted and bought already to be able to influence mood. I could not predict trust in the ACE-system by the elderly based upon literature, which means that the following question should be answered:

To what extend do the elderly trust the fact that their mood can be improved by the ambience change and that their mood is measured correctly by the camera of the ACE-system?

2.3. Controllability and perceived ease of use.

Control is the user’s belief about the presence or absence of knowledge, resources, and opportunities required to perform a specific behavior (Venkatesh, 2000). As can be seen in Figure 2.1, perceived behavioral control is one of the factors that influences behavioral intention and behavior in the Theory of Planned Behavior (TPB) of Ajzen (1985).
The TPB predicts, like the Technology Acceptance Model (TAM), the intention to use information technology (Mathieson, 1991). The TPB was, like the TAM, an adaption of the Theory of Reasoned Action (TRA). The perception of control was an addition to the TRA to arrive at the TPB (Ajzen, 1985), but control was not incorporated in the TAM. However, perceived ease of use is related to perceived behavior control according to Venkatesh (2000). He found that control serves as anchor used by users in forming an attitude about the perceived ease of use about a new technology.

Perceived behavioral control is a predictor of technology acceptance according to the TPB (Ajzen, 1985) and perceived ease of use is a predictor of technology acceptance according to the TAM (Davis, Bagozzi, and Warshaw, 1989). The perceived ease of use is the degree to which a person believes that using a technology is free of effort. Therefore, the ACE-system may be perceived as ease of use when it runs automatically. The perceived behavioral control is the degree to which a person believes the knowledge, resources, and opportunities to perform a specific behavior are present, so the perceived behavioral control of the ACE-system would be optimal when it can be controlled manually. Another possibility is that the users of the ACE-system prefer something between a low level of control (automatically) and a high level of control (manually). Therefore, an intermediate level of control (semi-automatic) will be conceived. In this semi-automatic option, the system automatically suggests which ambience is best for the user, but the user has to approve it before the ambience changes. Which of these three levels of controllability the elderly would prefer, will be investigated.

The question which level of control will be preferred by the elderly also applies to the ambiances of the ACE-system. The elderly could prefer to adapt the cozy and activating ambience or they could prefer to use the standard cozy and activating ambiances of the ACE-system. This raises the following question:

*Do the elderly prefer to control the ACE-system automatically, semi-automatically, manually, or a combination of these three and do the elderly prefer to have control over the hue and saturation of the ambience?*

The three sub questions help to answer the first main research question. In the next chapter will be explained which method will be used to answer the three sub questions and the two main questions.
3. Method

Semi-structured interviews were conducted to explore whether the elderly’s perceptions of the usefulness, ease of use, trust, privacy and controllability of the ACE-system are key issues that influence the attitude towards the ACE-system as suggested in the previous chapter. Interviews were selected as the most suitable research method for two reasons. First, interviews enable interviewees to come up with other factors that influence their attitude towards the ACE-system. Second, possibilities to positively change the factors that negatively affect the attitude can be explored. For example, when cameras in a house are not acceptable for a participant, the attitude towards other systems that can measure mood, like a wristband, can be discussed.

3.1. Participants

Twenty five independent living elderly (14 women, 11 men, M age = 77 years, age range: 67-96 years) participated in the interviews. Fifteen participants (nine females and six males) live in apartments of Vitalis Residential Care in Eindhoven, The Netherlands. They live independently, but home care service is available to them when needed. Ten participants (five females and five males) live independently in the area of Eindhoven. Nine participants (six females and three males) live alone. The other 16 participants (eight females and eight males) live together. All participants who do not live in apartments of Vitalis Residential Care, live together. A detailed list of the participants’ data is shown in Appendix A. They were recruited for an experiment in which they had to personalize and evaluate the ambiences of the ACE-system. They could adjust several light settings in these ambiences. Subsequently, they participated in a semi-structured interview. The interview lasted about 45 minutes and participants were compensated with a voucher of €30 for participating in the experiment and interviews. The proposal for the interviews was approved by the HTI Daily Management Board and the Ethical Review Board of the Eindhoven University of Technology following the Code of Ethics of the Dutch Institute for Psychologists. All participants signed the informed consent.

3.2. Procedure

Participants were invited to visit the Philips Lighting building at the High Tech Campus in Eindhoven. Taxis were arranged for transportation. At entrance, they were welcomed and asked to read and sign the informed consent form. In order to ensure all factors would be discussed, the interviews were semi-structured. A paper-based interview guide was used which contained open-ended questions that covered all factors intended to lead towards a discussion about the factors (see Appendix B). The duration of the interviews ranged from 18 to 56 minutes with an average duration of 34 minutes. All interviews were executed in Dutch, since all participants were Dutch. The interviews consisted of eight parts, which are shown in Table 3.1.
First, the interview was introduced as an interview about systems. I explained that I was interested in their opinion and thoughts about systems they use and a new system which I would explain later. Then, I asked permission to audio-tape the interview.

Second, I discussed controllability, trust and privacy of existing systems people use in their daily life. This allowed the participants to think about these factors before they were discussed for the ACE-system later in the interview, which could help them to give a more thoughtful answer. This was considered important, because people for example tend to buy products with additional features that we may never use (Suh, Kang, and Lee, 1998). They even do not compare the price of a feature with the value the feature has for them. They compare the price of the product with the price of the product including the new feature. If an extra feature has a small price compared to the product, people would probably add it even when the feature has little value to them. According to Suh, Kang, and Lee (1998), this is a result of the loss aversion principle. When a product is purchased, additional features will be added to avoid the negative feeling of missing a feature (Biswa and Grau, 2008). This causes that people predict their desired level of control incorrectly. When participants think about how many features they use on their systems, they might have a more realistic prediction of the preferred level of control for the ACE-system. Therefore, I showed participants the remote control which is shown in Appendix D and asked them to indicate the buttons they use and the buttons they do not use. Subsequently, I discussed how their ideal remote control would look like to investigate whether they prefer a remote control with buttons they do not use or a remote control with only the buttons they use. This method was found useful during the pilot interviews which will be described in the next subsection. Hereafter, a sheet with pictures of systems like a radio, thermostat, telephone, dishwasher, television, camera, lamp, and a vacuum cleaner was shown (see Appendix E). I asked the elderly to point out a system which they use. Then a discussion was initiated about the functions on that system and whether they prefer to keep options which they do not use. Finally, the control of the light in the house was discussed to get an impression of their light preferences in the home environment. The factors trust and privacy were also discussed in general to get more realistic predictions. The discussions about these topics were initiated by the questions in the middle column of Table 3.2.
Main questions about controllability, trust, and privacy of existing systems | Main questions about controllability, trust, and privacy of the ACE-system
---|---
**Controllability**
Do you want to have control options on your systems which are not necessary to use them? | Do you prefer to control the ACE-system automatically, semi-automatically, or manually?
How much control do you have over the lights in your house? | Do you want to have control over the light color and intensity?
**Trust**
To what extend do you trust systems to be able to take over our tasks accurately? (GPS systems and automatic vacuum cleaners) | To what extend do you trust the camera of the ACE-system to be able to measure your mood?
To what extend do you believe in the power of light? (Wake up lights and light therapy) | To what extend do you trust that the chosen ambience can improve your mood?
**Privacy**
What do you think about the cameras that record you in public places? | How do you think about the ACE-system camera that records you constantly?
Do you share your mood and health with the people around you and/or with a doctor? | How do you think about the fact that the ACE-system will indicate your mood, perhaps before you noticed your mood yourself?

*Table 3.2: Main questions about controllability, trust, and privacy discussed in the interview*

Third, the ACE-system was introduced as a system in development which is able to counteract negative feelings. I showed the participant the model living room as included in Figure 3.1 The light in this model living room is changeable to give a presentation of the different ambiences. Through using a LEGO person, it was possible to link the ambiences to emotions. For example, when the active ambience was shown, I could say that the ambience was chosen by the system because of the sad feelings of the LEGO person. This technique created the possibility to discuss the negative feelings of the elderly from a distance and safe way (Blythe and Dearden, 2009). This meant that I could, for example, talk about the sad feelings of the LEGO person instead of those of the participant. Some participants also used the LEGO person to talk about feelings. A man said for example: he might feel better and becomes more active when the light gets brighter. ‘He’ refers to the LEGO person in the model living room. The LEGO persons were introduced as Susan and John. Susan is shown on the left in Figure 3.1. To enable the participant to identify with the LEGO person, the female LEGO person Susan was selected for female participants while the male LEGO person John was selected for the male participants. The model living room was introduced as John’s or Susan’s living room in which the ACE-system was installed. A representation of the cozy, activating, and neutral ambience were presented subsequently. Finally, the use of the camera in the left corner and the working of the system were clarified. Although the mood recognition by a camera and the mood improvement by the ambiances have to be studied more to prove that the ACE-system will
improve your mood, these findings were explained to the participants as proven. In this way, more information about the future ACE-system could be gathered.

Fourth, the participants were asked: “What do you think about this system?” to find out whether their first impression was positive or negative. In both cases, a discussion was started to find out what the participant liked or disliked about the system.

Fifth, the trust and privacy of the ACE-system were discussed. The discussions about these topics were initiated by the questions in the right column of Table 3.2. When the question was answered, more questions based upon the participants answer were asked to support the discussion.

Sixth, the preferred level of control of the ACE-system was explored. In order to simplify the choice, three alternatives were designed and presented to the participants on an iPad. The alternatives were represented as tabs, which are shown in Figure 3.2 and in Appendix F. The interface with the three alternatives was tested and adjusted during the pilot interviews which will be described in the next subsection. First, the option to let the system work automatically was provided. When this tab is pressed, the system shows which emotion is measured by the camera and which counteracting ambience is turned on. Second, the semi-automatic option, in which the user has to give permission before the change of ambience occurs, was provided. When this tab is activated, the system shows the advised ambience and the user can activate this ambience by pressing the picture of the ambience. Third, the manual option enables the user to activate each ambience according to his or her preference. Finally, there is an extra option to adapt the hue and saturation of the ambiences. The participants were asked which tabs they wanted on the control panel in case they had the ACE-system at home. This could be a combination of tabs or one specific tab. Besides the tabs, the interface contains an off button and yellow faces with different facial expressions. In Figure 3.2 can be seen that the face on the left has a sad expression, the face in the middle has a neutral expression, and the face on the right has an anxious expression. The faces in between are between sad and neutral and between neutral and anxious. One of the faces has a white glow around it and a white arrow. This means that the mood which is measured by the camera of the ACE-system corresponds to that face. Therefore, this changes when the mood of the user changes. The activating, neutral and cozy ambiences are also shown in the interface. The
white glow and white arrow indicate which ambience is turned on. Microsoft PowerPoint© was used to make a working model of the interface. Each slide in Microsoft PowerPoint contained a picture of the interface. Hyperlinks that referred to other slides in the same document were placed over the buttons to enable the participant to navigate through the interface (Microsoft PowerPoint, 2013). However, when the participants changed the light in the interface, I had to change this manually in the Philips Hue App (Philips Consumer Lifestyle, 2015).

Figure 3.2: Interface which allowed participants to think about their preferred level of control

Seventh, the ease of use, usefulness, and attitude towards the ACE-system were discussed with the questions as displayed in Table 3.3. The interface that was used to explore the level of control made it also possible to show the participants the possibilities of the ACE-system and made them perhaps think about how they would use the system in their home. Therefore, the ease of use of the interface could be asked. The attitude question “Do you think other people want to have the system in their home environment?” was only asked when participants did not want the ACE-system in their own home.

<table>
<thead>
<tr>
<th>Questions about ease of use, usefulness, and attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
</tr>
<tr>
<td>Do you think the interface of the system is easy to use?</td>
</tr>
<tr>
<td>What can be done to improve the interface of the ACE-system?</td>
</tr>
<tr>
<td>Usefulness</td>
</tr>
<tr>
<td>Do you think the system in total can help you?</td>
</tr>
<tr>
<td>Attitude</td>
</tr>
<tr>
<td>Do you want to have the system in your home environment?</td>
</tr>
<tr>
<td>Would you recommend the system?</td>
</tr>
<tr>
<td>Do you think other people want to have the system in their home environment?</td>
</tr>
</tbody>
</table>

Table 3.3: Questions about ease of use, usefulness, and attitude

Eight, participants were thanked for their time and participation. They were offered the opportunity to ask any questions about the interview.

3.3. Pilot Interviews

During the preparation of the interviews, pilot interviews were conducted. Parts of the interview were tested both with independent living elderly and with other people.
Complete interviews were done with four independent living elderly. These pilot interviews were used to improve the interviews, the interfaces and my interviewing skills. The following changes were applied in the interview based on the pilot test.

First, the participants had trouble to come up with systems to discuss the controllability in general in the second part of the interview. To tackle this problem, the remote control as displayed in appendix D and a sheet with pictures of systems as displayed in appendix E were introduced. For the remote control, participants were asked which buttons they use and which not. From the picture with systems they could select a system they use in their daily live to initiate the discussion about controllability. During the pilot interviews these modification were found very useful to initiate the discussion of controllability.

Second, the explanation of the ACE-system was adapted. First, the storyboard in Figure 3.3 was chosen. In this way, the functioning of the system was visualized. However, the participants had to judge if the system was easy to use, later on in the interviews. For this reason, it was easier to make a model living room in which the light could be changed. This was realized with carton boxes, cardboard, LEGO® bricks, and two Philips Hue lamps as shown in Figure 3.1. A floor lamp was used for warm or cold white light and two wall lights, which had one Philips Hue lamp behind it, were used to change the hue of the light. In this way, an approximation of the cozy and activating ambiences could be made. For the neutral ambience, both lamps were set on the default white color of the Philips Hue lamps.

![Figure 3.3: Storyboard to explain the ACE-system](image)

With regard to the explanation of the ACE-system, a number of ways were tested. It was possible to explain a lot on beforehand, like the fact that the camera images are not saved for privacy reasons. Another possibility was to explain only the key information that is required to understand the ACE-system. The last option was chosen, since the pilot interviews showed that this gave the most valuable information. Namely, the participants could come up with the privacy issues of the camera themselves which is more valuable compared to answering my privacy question.

Third, the interface was also adapted. The first version is displayed in Figure 3.4 and the final version is displayed in Figure 3.2. The faces display the mood of the participant which is measured with the camera. The face on the left is sad, the face on the right is anxious, and the face in the middle is neutral. The faces in between are between sad and neutral and between neutral and anxious.
The ambiances were displayed with pictures. The ones in the first version were hardly recognizable, so these were replaced by pictures of the ambiances in the model living room. The two horizontal bars between the faces and the ambiances were removed from the interface. The ambiances could be activated by touching the related picture in the final interface. In the automatic tab, nothing could be touched, because the system chose the ambience based upon the mood. However, the ambiances in the automatic tab were still touched during the pilot interviews. To avoid confusion, a text was displayed when they touched the images which indicated that the ambience was automatically chosen by the system. They were referred to the manual tab to change the ambience. Finally, an extra tab was added in which the color temperature and hue of the light could be changed to explore if the participants preferred this extra control option on the ACE-system.

3.4. Data analysis

The interviews were tape-recorded and transcribed for the analysis. A qualitative content analysis was used to evaluate the responses. Qualitative content analysis is an appropriate method to systematically describe the meaning of a large amount of qualitative data (Schreier, 2012). The qualitative data analysis software Nvivo (version 10, QSR International, 2012) was used to analyze the transcripts and organize the data. A coding frame was built based upon the proposed model for the acceptance of the ACE-system and the first interviews. Based upon the proposed model, three concept-driven categories were distinguished: ‘privacy’, ‘trust and perceived usefulness’, and ‘controllability and perceived ease of use’. The other three categories were data driven, i.e., they were based upon the interview data. These categories were: ‘ambience change’, ‘worse conditions’, and ‘already satisfied’. ‘Ambience change’ refers to participants’ opinions on the fact that their attention will be focused on their mood state as soon as they notice the ambience change. ‘Worse conditions’ is about participants who recommend the ACE-system to people in worse conditions, such as lonely people or gloomy people. ‘Already satisfied’ refers to participants who do not want new systems anymore. Subcategories were added to these main categories. The subcategories captured what was said with respect to the main categories. The overview of the categories and subcategories is shown in Appendix C. Quotes from one or more participants were assigned to these subcategories. One week after the quotes of the participants were
assigned to the subcategories, this process was repeated. There were quite some changes made due to the fact that quotes could be interpreted differently and participants revised their opinions sometimes during the discussion. Therefore, a third round of linking quotes to subcategories was done in which the audio recordings of questionable quotes were listened again. This time, only two changes were made compared to the coding of the second round. Therefore, this was the final version.
4. Results

The most interesting findings from the interviews will be described below divided into the six main categories: ‘privacy’, ‘trust and perceived usefulness’, ‘controllability and perceived ease of use’, ‘ambience change’, ‘worse conditions’, and ‘already satisfied’. After this, the participants who had a positive attitude towards the ACE-system will be mentioned. Quotes of the participants will support the findings. Behind each quote, the participant’s number is shown followed by an M or F and their age. The male participants have an M behind their number and the female participants have an F behind their number. ‘01.F.86’ is an 86 years old female with participant number 01 for example. Other details per participant can be found in Appendix A.

4.1. Privacy

Two privacy questions were asked to investigate whether the cameras decrease the level of privacy; a general question and a question specific for the ACE system (see Figure 4.1). First, a question about privacy in general was asked: What do you think about the cameras that record you in public places? This question is shown in Figure 4.1. On the right of the questions, the given answers are shown. These answers have a red dot when the answer is negative and a green dot when the answer is positive. On the right of these answers, the numbers of the participants that gave that particular answer are shown. In the figure it can be observed that thirteen participants have problems with the camera of the ACE-system while only three participants have problems with the cameras in public. The boxes around the numbers of these three participants are red in Figure 4.1. One of these three participants has no problems with the camera of the ACE-system, while the participant does have problems with cameras in public places. This may lead to the conclusion that there is probably no relation between the two questions about privacy in Figure 4.1.

![Figure 4.1: Answers of individual participants on privacy related question](image-url)
The other question in Figure 4.1 was about the privacy of the ACE-system. According to the participants, the ACE-system came along with privacy violation in two ways. First, the camera in their home environment violated their privacy. Second, the visibility of their moods was a violation of their privacy. Whether the visibility of their moods was a problem was not asked during the interview, because the ACE-system will be developed for elderly who live alone. However, there were still elderly who mentioned this as a problem, because people can visit them unexpectedly for example. This may indicate that the visibility of the mood is a bigger privacy problem than the cameras in their home environment.

4.1.1 Camera. Two participants had no problems with the camera of the ACE-system in their home environment on the condition that they could control the camera themselves. The first participant mentioned that it was important for him to be able to turn the camera off. “Can I turn off the camera? I could have something that makes me think: well, no camera for this moment (P05.M.86).” Although we discussed that this is possible, his attitude towards the system was not very positive in the end, because he did not like artificial enhancement of his mood. “I do not like that my mood will be modified artificial (P05.M.86).” He questioned whether the system could help others. “That may be possible, but I do not know if this is true. I cannot judge what should be pleasant for another (P05.M.86).” The other participant had no problems with the ACE-system and the camera, because he assumed that he could turn the camera off. “It is no problem, because I can turn the camera off when it bothers me (P02.M.89).”

Four participants mentioned that their privacy had to be guaranteed. The first named internet and Facebook as a problem. “I have no problems with the camera, on the condition that it does not appear on the internet or Facebook (P11.M.82).” The second participant already assumed that nobody could access the images. “No problem, because the camera records me, but nobody can see the video images. I would not appreciate that (P15.F.67).” The third participant mentioned that privacy is the most important thing we have. “If it is only for me and nobody else, I have no problem with it. If it is centrally regulated by something you do not know, I find it a bit scary. Privacy is the most important thing we have (P22.F.67).” The fourth participant mentioned that his privacy was very important to him. “If the privacy is guaranteed, which I very often doubt with this type of systems, because they can tap it all. Privacy is not guaranteed anymore, but if it was really be assured, I would have no problem with it (P19.M.81).” When this was guaranteed, he perceived the system as useful. “I do think it can help me. When I wake up in the morning and I see that the sun is shining, this is a big difference compared to the winter. That can also happen with this system I guess. Perhaps to a lesser extent, but I think it will help (P19.M.81).”

Three participants mentioned that a camera was only acceptable for people who are in a less favorable condition. One woman had problems with a camera in her own house. “It is very unusual to have a camera that measures how I feel. I do not want that. I am not gloomy (P01.F.86).” Although, she thinks the system would help for people who are
gloomy and lonely. “I think many of my peers, who are gloomy and lonely, will be helped (P01.F.86).” She would like to recommend the system to others. “When someone would say to me: I do not see it anymore, I would say: Now, there is something new on the market. Then, I would recommend it. There are people who say: you have such a nice life, I do not have that. They are a bit grumpy and then I think: they should have such light (P01.F.86).” A man insisted that a camera in a home environment would only be accepted when it improves your mood. “A camera in your home is obviously not pleasant, but if it can change the atmosphere which makes people feel better, then I would be in favor of it. When it improves your mood, you will live with it (P07.M.70).” However, he still did not accept it in his own house yet and recommended it for people with negative feelings or dementia. “It is not yet for me. I do not have negative things. This can change within the next five years. When you are suffering from dementia for example, there are different ideas compared to when you are healthy (P07.M.70).”

Another participant was afraid of the feeling of being watched. “It gives the feeling that someone spies on you. You have to get over that (P08.F.72).” We discussed how it would be when nobody is able to access the video images. This made it different for her. “That makes some difference (P08.F.72).” It was not a reason to reject the system anymore. However, she did not want the system, because she still lives together. “I think it is a great system, especially if you live alone. If you are a couple, you can always share it. If you do not feel well, you can say that to the other. However, if you are alone, I think this system would be nice (P08.F.72).”

One participant did not want a camera in her home, but approves a bracelet that measures her mood. “I do not want that, because of my privacy. Then, maybe I want a bracelet rather than the camera. Yes, I think so. I would rather have a bracelet (P03.F.84).” After we discussed the bracelet, she accepted the system. “Well, I actually like it, because you do not do that yourself. When you feel unwell, you do not think: I think the light has to change. Yes, I like that. I will be able to have that in my house (P03.F.84).”

One participant had an opposite opinion about privacy with regard to the video images. He mentioned that it would be nice when someone can monitor you. “When you need more help, it is pleasant to be monitored. The feeling that someone is there for you. If anything happens with us, we can call our neighbors who have the key which they can use to come in. That feeling is ideal when you have almost nobody (P09.M.74).” We discussed that he preferred to give his family access to the video images and if necessary a doctor or nurse. “You can decide that on forehand. When you have family, you can share it with them, but when you have almost no family or no family at all, you can give access to someone who has expertise like a doctor or nurse (P09.M.74).” He had a positive attitude towards the system. “Light can do much anyway. When you are somewhere and the light is bright, you think: chilly, cold, formal compared to a room with a little dimmed light. I believe it can help me (P09.M.74).”
4.1.2 Mood. Three participants worried about the fact that their mood could be seen by others. The first participant mentioned that it is problematic when others can see her mood when they come in unexpectedly. “When you feel sad and the light that makes you less sad is turned on and someone comes in unexpectedly, they can say: do you feel sad? Are you not happy? They can see how you feel (P04.F.86).” I asked whether this problem was solved for her if the light neutralizes when the camera notices two people instead of one. She agreed. “Yes, because I live alone. I am a widow. So, I think about how it would be for me (P04.F.86).” In the end, she still rejected the system, because she did not want to change her habits. “I will probably not work with it, because you have to learn how it works. I have my way of doing things and you need to change that again (P04.F.86).” For the second participant, it felt like being betrayed when somebody could see his mood. “When someone comes in, he can immediately see how I feel. I am not happy about that. Your situation at that moment will be betrayed (P24.M.75).” I asked if this problem was solved for him if the light neutralizes when the camera notices two people instead of one. He agreed and also noticed that it could be positive when others know how you feel. However, this goes too far for him. “From the other side, they can also take into account how I feel. However, this goes too far for me (P24.M.75).” He also was not convinced that he can use the system now, but when somebody needs help, he wants the system. “I do not need it personally. However, when I had someone in my house, who could benefit from it, I would definitely choose the system. I think of my wife for example, when she would benefit from it, I do not have to think about it. For now, I cannot see the benefits (P24.M.75).” The third participant also did not like it when others could see her mood changes. “When I am with someone else and my light would change every time, I would not like that (P25.F.68).” This problem was solved for her when the light neutralizes if the camera notices more people, but she still had problems with the perceived usefulness of the system. She still did not want the system in her home. “I do not want it yet. I do not see yet that I will feel better. I think that light will help. I cannot say why I do not want it. I also believe that light therapy works, because when the sun is shining, you feel happier than when it is foggy, so light definitely helps, but to have it at home. I think the light will be in my mind too much (P25.F.68).”

4.2. Perceived usefulness and trust

Trust in light was examined with the questions shown in Figure 4.2. The participants were asked whether they think that light therapy works and whether they think wake up lights help to wake up better. Almost all participants believed that light therapy works and only four participants do not believe that a wake up light can help to wake up better. Moreover, four participants do not believe that the ambiences of the ACE-system can improve their mood. The boxes of these four participants are red in Figure 4.2. Only two of them do not believe in the wake up light and the light of the ACE-system, which indicates no relation between the three questions about trust in light.
Four participants did not believe that their mood could be improved by light. One of them attributed his childhood for this. If he had a bad mood back then, he had to overcome it by paying no attention to his bad mood. “Light can create an ambience, but I think about it in terms of warm and cold, not as able to change my mood. However, I am old-fashioned. When I was a kid, when we disliked something: take it easy. I resolved it by telling it, but I was not allowed to complain too much (P10.F.96).” Another participant preferred darkness over light when she is in a bad mood. “I cannot imagine that I become less sad or anxious when I change the lights. Maybe I will turn some lights off to ensure that there is less light. Darkness belongs to gloominess and sadness. I have a couch with a lamp on both sides. Maybe I will turn one on and one off. Then, I would sit there and stare in front of me. I cannot imagine that I will be happy again by adjusting the lights (P17.F.76).” The following participant surely believed that light had no relation to her mood. “I do not believe that light can change my mood. You can dim your lights for a cozy atmosphere, but when you are really sad, a lamp will not help me (P11.M.82).” However, she did believe the light could help her mother in law who was sensitive for light. “When you are sensitive for light. I had a very sweet mother in law. She always felt a little depressed when the winter approached. She knew exactly how many minutes the sun rises earlier every day and then she revived. I never had this. I think it would have worked for her. I unfortunately cannot ask her anymore. She always talked about it, but I have to say: she was an excellent gardener (P11.M.82).” Another participant did also not believe the light would improve his mood. “I would not do anything with it, because if I have a certain mood, I do not think that certain lighting influences me. I do not feel good because of light; this is not something which would work for me (P21.M.69).” This participant also gave another reason why he would not accept the system. “My wife and I reached an age at which we say: well, we think it is just fine. The last ten years we live, I am 80 then and a human life is over then, we think it is fine. How we live now, the furnishing of the house for

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<table>
<thead>
<tr>
<th>Trust (in light)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do you think light therapy can reduce a depression?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In general</strong></td>
<td><strong>ACE system</strong></td>
</tr>
<tr>
<td>Thinks it helps</td>
<td>01</td>
</tr>
<tr>
<td>Does not know whether it helps</td>
<td>20</td>
</tr>
<tr>
<td><strong>Do you think that a wake up light is able to wake you up better?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In general</strong></td>
<td><strong>ACE system</strong></td>
</tr>
<tr>
<td>Thinks it does not work</td>
<td>04</td>
</tr>
<tr>
<td>Thinks it works</td>
<td>01</td>
</tr>
<tr>
<td>Does not need a wake-up light to wake up</td>
<td>02</td>
</tr>
<tr>
<td><strong>Do you trust that the ambiences can improve your mood?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In general</strong></td>
<td><strong>ACE system</strong></td>
</tr>
<tr>
<td>Does not believe that light can improve mood</td>
<td>10</td>
</tr>
<tr>
<td>Believes that light can improve mood</td>
<td>01</td>
</tr>
<tr>
<td>Does not know what to think about it</td>
<td>12</td>
</tr>
</tbody>
</table>

*Figure 4.2: Answers of individual participants on trust in light*
example, we think it is just fine. We will still live a number of years like this. Except from some
modern things we have in our house, like a computer which we have already have more than
20 years (P21.M.69).”

Not only thrust in light was investigated, but also trust in technology was examined with the questions shown in Figure 4.3. The participants were asked to what extend they trust systems to be able to take over human tasks accurately? This was asked for GPS systems and automatic vacuum cleaners. Five participants did not always follow their GPS system and did not trust that an automatic vacuum cleaner cleans just as well as we do. However, most of them trusted that the camera of the ACE-system is able to measure their mood accurately. There seems to be no relation between these answers. The participants who did trust their GPS system and automatic vacuum cleaners also believed that the camera of the ACE-system is able to measure their mood accurately. However, this accounts for only two participants.

Two participants were not sure about the fact that a camera is able to measure mood. “When the camera sees something happening, it has to determine what is going on like: is he going to eat ham? Such a thinking process. It is an instrument, not a human. Is a camera able to perceive this? When I am crying, it is also possible that I am sweating. To what extend is this included in its program? A technician and a medical person should put all this information in the computer the right way. It would be magnificent when you can record feelings, but if it is possible is what I consider (P18.M.81).” However, he trusted measuring equipment that is attached to the body. “A camera thinks that it sees mood, but it is just a cold machine. This is not the case when people are equipped with impulses, like a watch. It can have something for sadness for example. If they can realize this, it would be magnificent. Then, you can say: he was so miserable; I will show it to you (P18.M.81).” After he agreed upon a watch as measuring device, he still did not perceive the system as useful. Only when he would become a patient, he considered it as helpful. “It could be helpful when I get older, because I do believe
it. You never know what will happen to you. In special circumstances, I can imagine that the doctor might prescribe this (P18.M.81).” There was another woman who doubted if a camera could measure emotions correctly. She also had more confidence in something that was worn on the body. “I do not know if a camera can do that. Some years ago, I talked with some students from the technical university who had a shawl. When you were mad, then it was red for example. I can imagine that, because it was carried on the body. This is done by heat, hormones or neutrons. I do not know if this is possible with a camera (P22.F.67).” Three participants did not know what to think about the camera of the ACE-system. “I do not know whether a camera registers that. I just do not know (P13.F.84).”

4.3. Perceived ease of use and controllability

Two questions were related to controllability (see Figure 4.5). The first question was about the controllability of systems that the participants already use. Thirteen participants preferred no changes in the amount of options on the systems they use while the other twelve participants preferred fewer options on the systems they use. In Figure 4.5, the boxes with the numbers of the participants who preferred fewer options are filled green. This makes it easy to see which tabs they choose. It is notable that they did not choose only one tab for the ACE-system. Half of them chose a combination of two tabs. One participant even chose all three tabs. He did not consider the three tabs as many options. “I think semi-automatic would be nice, because it guides you and you can still influence it. I like that. It is like you can consult with it, which is quite nice. But on the other hand, sometimes, you are sure of yourself, you want to choose yourself. I prefer to have not too many options, but automatic, semi-automatic, and manual, I think I would leave the tabs on the system (P15.F.67).” Moreover, all participants that preferred fewer options preferred to add the ambience tab. In conclusion, whether participants preferred fewer options on the systems they used was not an indicator for the amount of tabs they chose for the ACE-system.
In the decision between the three tabs for the ACE-system, different preferences and different combinations of tabs were given. Twelve participants preferred only one tab. Two of them preferred only the automatic tab. One participant preferred this, because she considered her feelings as unreliable and trusted the system’s judgement. “I have much to do with emotions, because I had chemotherapy. Then, I feel quite good although I notice that I went too far in criticizing on everything according to my partner. If I had to set the system manually, I would say: there is nothing wrong. So, I would choose the automatic tab, because my feelings are not that reliable. My partner can feel the changes of emotion while I think: there is nothing wrong. I am alright (P22.F.67).” The other participant mentioned that it would be relaxing if the ambience will change automatically. “I think it would be relaxing for many people when the ambience changes automatically (P07.M.70).” Nine participants preferred to have only the semi-automatic tab. “That is also an alternative. Then, you can choose. That is better, because when it goes automatically, I do not have any influence (P23.M.76).” They even did not want the automatic and manual tab anymore. “I think that is a beautiful thing. I agree with that. I would choose that. It does not need to be automatically. Manual is not necessary anymore when I can do it semi-automatically (P24.M.75).” “I would like the semi-automatic tab. Then, you do it yourself. That is better, because when it goes automatically, you cannot influence is, so I prefer semi-automatic (P23.M.76).” Only one participant wanted only the manual tab. “The manual tab seems helpful for me. Automatic and semi-automatic are also helpful, but not for me (P01.F.86).”

Eight participants wanted a combination of two tabs. Most of them wanted the combination of the semi-automatic and the manual tab. “Not automatically. Completely automatic, that is not necessary for me. I would like semi-automatic. Then, I can adjust it manually. And the manual tab, because in case of power failure, I want to be able to control it...”
“I would like it manually. I want to decide which ambience I want. Not automatically, because that will drive me crazy. When the light changes every time, I would become nervous. The semi-automatic tab, I can handle that, but not the automatic tab (P21.M.69).” Four participants preferred a combination off all three tabs. “That would depend on the moment. If you are sick, you choose automatically for example. I would like to have all three (P13.F.84).” “I choose semi-automatic, but the other tabs are free. Look, the buttons are not difficult, it is very clear, you do not have to turn something. They may all stay there in my opinion (P19.M.81).”

After the participants indicated their preferred tabs, they were asked whether they wanted an extra tab that which allows them to adapt the hue and saturation of the ambiances. Only two participants did not want this tab. The first participant preferred to leave the choice to the system. “I think this deviates from automatic. It considers what works best for me and sets this automatically. I would not like to customize it again, because this does not correspond to the goal you want to achieve. The ambiances tab seems unnecessary to me. When it determines the best ambience, you do not need the ambiances tab. The system figured it out already (P20.F.68).” The other participant thought the ambiances should remain the same. “Just let them remain blue (P17.F.76).”

Figure 4.6 shows the answers on the question whether the participants perceived the interface was easy to use. The system was easy to use according to 21 participants. “You just have to tap it right? I think that is the easiest way. I like the smileys over here (P12.F.83).” “Everything is put together easily (P14.M.68).” One participant mentioned that Dutch texts are important for him (P19.M.81). Out of the 21 participants who declared the system easy to use, there are nine participants who indicated that you have to get used to it. “You have to see it through, that is all (P01.F.86).” “When I have seen it twice, I already know it I think (P06.F.69).” “I think so when it is explained to you, it is (P13.F.84).” In the case of three participants, I forgot to ask if they perceived the system as easy to use and one participant could not answer the question, because she had problems with sliding on tablets because of arthrosis of the wrist. “I cannot answer that question. I have an aversion to the control, because I have arthrosis (P20.F.68).”

<table>
<thead>
<tr>
<th>Perceived ease of use</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the interface was easy to use?</td>
<td>07 09 10 12 16 17 18</td>
</tr>
<tr>
<td>Finds it is easy to use</td>
<td>21 23 24 25</td>
</tr>
<tr>
<td>Finds it is easy to use after he/she get used to it</td>
<td>01 02 03 04 06 08 13</td>
</tr>
<tr>
<td>Finds it is easy to use, because text is displayed in Dutch</td>
<td>14 15</td>
</tr>
<tr>
<td>Cannot use it, because of arthrosis in wrist</td>
<td>19 20</td>
</tr>
</tbody>
</table>

Figure 4.6: Answers of individual participants on perceived ease of use question
4.4. Ambience change

When the ACE-system changes the light in the elderly’s room, the elderly’s attention will be focused on their bad mood state. This was discussed during the interviews and contrary answers were given. An overview of the answers is shown in Figure 4.7.

<table>
<thead>
<tr>
<th>Ambience change</th>
<th>05</th>
<th>10</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinks that his/her mood becomes worse</td>
<td>01</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinks that he/she would feel betrayed</td>
<td>06</td>
<td>08</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Thinks it is not fine to be remembered to his/her negative mood</td>
<td>02</td>
<td>03</td>
<td>04</td>
<td>12</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Sees the ambience change as a reminder to improve his/her mood</td>
<td>07</td>
<td>09</td>
<td>11</td>
<td>13</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>

**Figure 4.7: Answers of individual participants on ambience change question**

Twelve participants claimed that it would be ok for them when the light changing remembered them about their bad mood. “It would be ok for me (P03.F.84)”. “I do not think it would bother me (P02.M.89)”. Five of them even thought that they would be stimulated by the mood changing. “If I get the message: you get into a depression, I would think: go for it (P19.M.81).” “Maybe, you are going to think: I should change my attitude (P11.M.82).” “You get the advice: remember, hurry up, go for it (P09.M.74).” Nevertheless, thirteen participants claimed that they would not be pleased when their attention was focused on their bad mood. “That would be a bit annoying (P06.F.69).” “I do not think I would feel comfortable then (P08.F.72).” Six of them even thought that they would become even sadder. “It will become worse I think (P10.F.96)” “When you are grumpy and the system says: you are gloomy. I would think: shut up (P14.M.68).” “When the system would say that I am depressed, I might get depressed (P23.M.76).” Two of the thirteen participants would feel betrayed. “Then I would say: do not interfere with me (P24.M.75).” “Now they see that I feel gloomy, you have a point there (P01.F.86).”

Two participants mentioned that the light has to change slowly to avoid the negative feeling they get when their attention will be focused on their bad mood state. “Is it not possible to change the light imperceptibly? Slowing it down to make it unremarkably. When I enter a room and the light turns to green or red, I would think: damn. You would become aggressive I think. However, when you are in the room and the ambience changes gradual, I prefer that. You cannot suddenly flick a switch; it has to change gradually. Otherwise, I start campaigning against a device. I will break it down and throw it away. If it changes slowly, it would be acceptable (P22.F.67).” “I think it should go slowly, otherwise it scares you. Then it has no result. If it goes slowly, you can take a breath like: this is delightful. This will not happen when it changes suddenly (P13.F.84).”
4.5. Worse conditions

One third of the participants had a positive attitude towards the ACE-system although they did not want the system. Their opinions are shown in Figure 4.8.

<table>
<thead>
<tr>
<th>Worse conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinks the system is for people who are gloomier</td>
</tr>
<tr>
<td>Thinks the system is for people who are lonelier</td>
</tr>
<tr>
<td>Thinks the system is for people who are needier</td>
</tr>
</tbody>
</table>

**Figure 4.8: Opinions of individual participants related to the categorie: worse conditions**

In the categories above, there are already six participants who mentioned that they did not want the system themselves, but saw opportunities for people in worse conditions. This could be gloomy people (P01.F.86 and P12.F.83), lonely people (P08.F.72), or needy people (P07.M.70, P18.M.81, and P24.M.75). There are two other participants who have this opinion. One of them said that the system was not helpful for him “I do not need the light. If I would have a breakdown, then I just would listen to music or I play the clarinet or saxophone (P23.M.76).” On the other hand, he suggested the system as useful for people in care homes and residential homes, because it gives the opportunity to monitor the residents from a distance. “It seems a good system for residential homes and care homes. The people can be monitored on a distance: the light is not good, we go there to see what is happening (P23.M.76).” He doubted whether the system was useful for private use. “I do not know if it works for individuals. You maybe get into an argument with your partner when the light is not good (P23.M.76).” The other participant recommended the system for lonely people or for people in a healthcare institution. “It would be quite useful, especially when I think about the future. Especially when you are infirm or when you feel lonely. You can change the light yourself, but you do not realize that you should do this. At the moment the camera reacts, you have the possibility to adjust it. However, the camera detects it earlier. In addition, you do not think: the light should be adjusted. Then, it would perhaps be practically. When you are alone at home and you become downhearted, the system starts to think automatically for you. However, this is only for a small group. In a healthcare institution or for people who are alone. When I feel sad, my husband says: come on! Single persons could be affected (P20.F.68).”

4.6. Already satisfied

Several participants indicated that they were already satisfied and did not want any changes or new systems anymore. Their opinions are shown in Figure 4.9.

<table>
<thead>
<tr>
<th>Already satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not want changes anymore</td>
</tr>
<tr>
<td>Does not want to learn to work with new systems</td>
</tr>
<tr>
<td>Likes new technologies, but not in his/her house</td>
</tr>
</tbody>
</table>

**Figure 4.9: Opinions of individual participants related to the categorie: already satisfied**
In the categories above, there are already three participants mentioned who did not want the system themselves, because they wanted no changes (P04.F.86, P21.M.69, and P25.F.68). One other woman mentioned that she was really interested in new technologies, but she did not want it in her house. “Actually, I am an old fashioned frump who does not want to change anymore. I think everything is very nice; I go to the Dutch Technology Week. I have a few appointments there to have a look. We also look at the Smartest Home of the Netherlands. I am interested in all those things, but as soon as I am back at home, I am old-fashioned and I am sitting on an old-fashioned couch with a crocheted doily (P22.F.67).”

4.7. Positive attitude

In the categories above, participants were discussed some of which had a positive attitude towards the system after adjustments. Two participants preferred something that was worn on the body that measures their mood over a camera (P03.F.84, P22.F.67). One participant accepted the camera on the condition that his privacy was guaranteed, which he doubted (P19.M.81). The last participant preferred to be monitored by his family as addition to the light changes (P09.M.74).

Five other participants were positive about all aspects of the system. The first participant liked the fact that he could adjust his mood with the system. “If you can affect your mood, it seems useful for me to have the opportunity to adjust it (P02.M.89).” The second participant mentioned that she liked to have something which could make her happy in unhappy situations. “It would make me happy. There is always the possibility that something happens which makes you feel unhappy (P06.F.69).” The third participant liked to experiment with the system. “I would like to play around with the system. I want to find out what changes when I have different light. You are not able to try this at home yet. You have to buy all colored LED’s and replace them each time. That would be a lot of work which you can change with the system. It seems very nice to be able to do so (P13.F.84).” The fourth participant hoped that the system could replace medicines. “I would try it at least. And when I do that, I take it seriously. Otherwise, I do not do it. The idea that you help people who feel sad or anxious is a wonderful idea of course. When the system can do that, which is wonderful. It seems better than taking medicines for sure. When it can prevent that people have to take chemicals, I prefer this (P15.F.67).” The fifth participant was positive about the system, but mentioned that the price would be an important factor. “I can imagine that I want something like this in my house. However, it depends very much on the price. If it costs 5000, I would think: I will wait a while until it gets cheaper (P14.M.68).”
The aim of this study was to find in what way elderly’s perceptions of the usefulness, ease of use, trust, privacy, and controllability of the ACE-system influence their attitude towards the ACE-system, to find other factors that influence the elderly’s attitude towards the ACE-system, and to find in what way these factors influence their attitude. Interviews were conducted to achieve this. This was proved to be a helpful method, because both anticipated and unanticipated factors that influence the elderly’s attitude towards the ACE-system were found. Moreover, the elderly came up with solutions that would improve their attitude towards the ACE-system. Figure 5.1 shows a model derived from the interviews. On the left side, the findings from the interviews are shown. These findings may positively influence the main categories: ‘worse conditions’, ‘privacy’, ‘trust’, ‘control’, ‘ambience change’, and ‘already satisfied’. These in turn can influence the attitude towards the ACE-system. The effect of trust on the attitude towards the ACE-system can be mediated by the perceived usefulness. Moreover, the effect of controllability on the attitude can be mediated by the perceived ease of use.

Figure 5.1: Model of acceptance for the ACE-system derived from the interviews
Figure 5.1 shows twelve findings on the left. Nine of them are shown in a white box and three in a purple box. The nine findings in the white boxes could be translated into design recommendations for the ACE-system. For example, the finding that users want to be able to turn off the camera could be translated into the recommendation of adding a button to the ACE-system interface that enables the users to turn the camera on and off. All nine recommendations will be discussed in the next paragraph. The three findings in purple boxes could not be translated directly into recommendations and need to be studied further. These three findings will be discussed in the subsection future work.

5.1. Design recommendations

The nine white boxes on the left in Figure 5.1 show the findings of the interview that can be translated into recommendations for the ACE-system. Except from the wristband that replaces the camera, these recommendations could be already integrated in the interface. Figure 5.2 shows the new interface.

![Figure 5.1: Interface adjusted following the recommendations for the ACE-system](image)

First, the eight recommendations that are implemented in the interface, which is shown in Figure 5.2, will be discussed. After that, the wristband that could replace the camera will be evaluated.

5.1.1. Be able to turn off the camera. The attitude towards the ACE-system could be improved when the participants are able to turn off the camera whenever it bothers them, for their privacy. Although the system can be turned off, it will be useful to have the option to turn the camera off independently from the system, because the comments were intended for the camera. The option to turn off the camera has to be visible all the time on the interface, because the moments in which the camera would rather be turned off by the user, does not depend on the mood or ambience, but on the activities of the user. Therefore, the new interface, which is shown in Figure 5.2, contains a new button in the upper right corner which contains the text ‘Turn camera off’. When this button is touched, the camera turns off and the text changes into ‘Turn camera on’.

5.1.2. Control who can access the videos. The attitude towards the ACE-system could be improved when the privacy of the users is guaranteed. The video images made to measure their mood should not be saved, because the participants were very skeptical
about who could access the images. At the same time, it turned out that the attitude towards the ACE-system would also improve when family or a doctor can access the video images. Therefore, the ACE-system should also be able to save the video images and send them to the people who are allowed to see them according to the user. In conclusion, the users of the ACE-system must have the possibility to show their video images to people who they gave access to or to directly delete the video images. This possibility is added to the options tab in the new interface in Figure 5.2.

5.1.3. No light change when you are in company. The attitude towards the ACE-system could be improved when the mood of the user is not visible for others. When the cozy or activating ambience is turned on, others can interpret how someone feels at that moment. I discussed a solution with the participants. The problem is solved if the ambience turns back to neutral as soon as the camera detects two or more people in the room. This avoids that the ambience shows the user’s mood to someone else. However, some participants did not mention this privacy problem which comes along with the light changing. Therefore, it is not known whether these participants did not think about this, agree upon this, or just prefer to show their mood to other people. Therefore, the fact that users do not want to show their mood to others cannot be excluded. This indicates that the ACE-system needs two contrasting options. One option turns on the neutral light when more people are detected by the camera and the other option does not. This is added to the options tab in the new interface in Figure 5.2.

5.1.4. Good explanation of the system. The ACE-system was perceived as easy to use by the users on the condition that they understand the system, tried it a few times, learned to work with it, and that it was explained to them first. By saying this, the participants indicate that they need time to understand a system. Therefore, the challenge is to make the ACE-system more clear for elderly and reduce the time they need to understand it. It was also mentioned that the ACE-system is easy to use because the Dutch language was used. When the remote control was discussed in the beginning of the interview, participants came up with other factors that could make the remote control easier to understand. The remote control could be clearer with an explanation of each button underneath the button. It was also mentioned that the meaning of symbols can be forgotten, especially when you grow older. This suggests that systems are easier to understand for elderly if symbols are replaced by explanations of the buttons in the language of the user. Lui and Ho (2012) also found that elderly experienced greater difficulty in understanding symbols compared to younger participants. Using explanations instead of symbols may also prevent that elderly forget how the ACE-system works. Some participants indicated problems with remembering how systems work. They wonder which button they have to use and forget how to use systems that they used for years. Hultsch and Dixon (1990) also studied that elderly are less likely to remember recently processed propositions and are, therefore, less able to remember new information. When explanations are included in the ACE-system, the elderly do not have to remember the
meaning of the buttons and options. This will probably make the ACE-system more clearly for the elderly. Another way to enlarge the understanding of the system by elderly is a clear instruction. One participant complains about the instruction manuals that come along with systems (P14). He never understands them, because they are not brief and concise. Therefore, the instruction of the ACE-system should be brief and concise.

5.1.5. Control the numbers of control tabs. The preferences for the tabs automatic, semi-automatic and manual are very diverse. Some participants only want one of these tabs on the ACE-system. Others prefer a combination of two tabs or a combination of all three tabs. This preference can change when someone feels sick for example. When someone is sick, the automatic tab can be preferred while the more control is preferred when someone is not sick anymore. The ACE-system should be adjusted accordingly. When the system will be installed, the preferred tabs must become visible, but the user should have the possibility to adjust this choice. The ability to add and remove tabs is added to the options tab in the new interface in Figure 5.2.

5.1.6. Control availability of the ambience tab. Almost all participants prefer to have the tab in which they can change the hue and saturation of the cozy and activating ambience, because the ambience is seen as a personal preference. This can be caused by the experiment in which they had to personalize the cozy and activating ambience, which took place before the interviews. However, a few participants did not want to be able to adjust the ambiances. They believe that, when the system chooses the best ambience for them, the ambience will help less when they adjust the ambience. For these participants, it is important to be able to turn off the ambience tab. Therefore, the ability to add and remove the ambience tab is added to the options tab in the new interface in Figure 5.2.

5.1.7. Small number of options. The amount of options on the ACE-system should be minimalized. Half of the participants indicated that they prefer to reduce the amount of buttons on the systems they use. For the ACE-system, it should be avoided that the users want a smaller number of options. The interfaces used in the interviews were simplified during the pilot interviews. However, in order to meet all recommendations for the ACE-system, new options should be added. The participants already gave a solution to this problem when the remote control was discussed. They prefer for example a remote control with the buttons that are often used and a simple menu which contains rarely used buttons or a remote control on which the rarely used buttons only come to the surface when they are needed. The extra options of the ACE-system can be added on a place that is not always visible for the user. For example, an extra tab can contain all extra options on the condition that this tab is simple. In this way, the user will not be distracted by the extra options. This tab is added to the new interface in Figure 5.2.

5.1.8. Control visibility of ambience change. The ACE-system will turn on the activating ambience when sadness is recognized and it will turn on the cozy ambience when anxiousness is recognized. As a result of the ambience changes, the elderly will become aware of their bad mood, because they know that the ambience changes as soon
as their mood becomes bad. Their opinions about this are very interesting, since some participants claimed to be stimulated by ambience changes while other participants claimed that the ambience changes would make their mood even worse. These contradictory claims indicate that the ACE-system needs two contrasting options. One option would be for the people who see the ambience changing as a stimulating experience. This option would be an ambience change that happens in a few seconds. This is equal to the ambience change in the small cardboard room which was used during the interviews and upon which the participants based their opinions. The option for the elderly, who did not appreciate the ambience change, has to be different. This can be a very slow, unnoticeable changing of the ambience for example. This option was mentioned by participants as a solution to avoid the negative feelings they expected after a fast ambience change that focuses their attention on their bad mood. Whether this solution will work for the ACE-system, has to be tested further.

It would be helpful to make a distinction between the elderly who prefer the noticeable or unnoticeable change based on their personality, to determine which option someone prefers. It ensures that the ACE-system can be installed correctly. One suggestion is to divide the elderly in introvert and extrovert people. Extrovert people are described as outgoing, sociable, friendly, and talkative while introvert people are quite introspective, and prefer to be in small groups (Eysenck, 1954). According to Tăpuş, Tăpuş, and Matarić (2007), these different personalities preferred a different way of being helped by a robot during a rehabilitation program. The people with an introvert personality preferred to be helped in a nurturing way. The nurturing script of the robot contained phrases like: “I know it is hard, but remember that it is for your own good.”, “Very nice, keep up the good work.”, and “You did a very nice job.”. The people with an extrovert personality preferred to be helped by a robot that uses phrases like: “You can do it!”,”You can do more than that, I know it!”,” and “Concentrate on your exercise!”. This may indicate that these different personalities also prefer a different way of being helped when they are in a bad mood. The extraverts may be helped more with a noticeable ambience change that challenges them to get a more positive mindset while this does not help the introverts. Whether the introvert and extravert personality are a reason for the division in preferences for a fast, noticeable ambience change versus a slow, unnoticeable ambience change has to be investigated further.

5.1.9. Wristband instead of camera. Measuring equipment to measure mood that is worn on the body was preferred over a camera that measures mood by three participants. The ACE-system was intended with a camera, because people convey important affective information via facial expressions and body posture and because visual sensors can be unobtrusive (Katsimerou, Redi, and Heynderickx, 2014). However, one participant does not want a camera in her home environment because of her privacy and two other participants do not trust that a camera can measure their emotions well. They suggested a wristband, so a wristband might improve the attitude towards the ACE-system. However,
other elderly may prefer sensors in their house over sensory on their body. Algase, Beattie, Leitsch, and Beel-Bates (2003) found that refusals to wear and removals of devices were the largest source of data loss in their study about activity devices that were worn on the body. Therefore, a wristband is perhaps not the best solution. This needs to be studied further.

In conclusion, when the elderly have the possibility to turn off the camera, can control who can access the videos, are able to control whether the light changes when they are in company, get a good explanation of the system, can control the number of control tabs, can control the availability of the ambience tab, can access only a small number of options, and can control the visibility of the ambience change, the attitude towards the ACE-system will be improved. However, the wristband and the option for an unnoticeable or noticeable ambience change should be studied further to determine the effect on the attitude towards the ACE-system. When these recommendations will be implemented, eight participants may have a more positive attitude towards the ACE-system (P02, P03, P06, P09, P13, P14, P15, and P19). The other participants do not have a positive attitude towards the ACE-system, because of three different reasons. These will be described in the next section together with the future work that needs to be done on these three findings.

5.2. Future work

For three findings from the interviews, no practical solutions could have been found in the discussion with the participants. Eight of these participants have a positive attitude towards the system, but only recommend it to people in worse conditions (P01, P07, P08, P12, P18, P20, P23, and P24). Three participants do not trust the fact that light can counteract their negative mood (P10, P11, and P17). Three other participants do not want new systems (P04, P22, and P25). One participant does not trust the fact that light can counteract his negative mood and he does not want new systems (P21). These findings will be discussed in detail in the following paragraphs.

5.2.1 User in worse conditions. An interesting contradiction is found in the results. Participants can be positive about the ACE-system although they do not want the system. They would suggest it for other people and are quite positive about the possibilities of the system for the target group they had in mind during the interviews. At first sight, this seems to be positive for the ACE-system. However, if a large group of the independent living elderly claims that they do not need it themselves, the target group of the ACE-system can become very small. For example, there were elderly who live alone and recommend the system for single persons or expect that they want the system when they become single. However, there were no people who wanted the system because they were single. Single people maybe also do not want the system even though the participants think they want the system. In addition, some elderly said the system is for people who are needier compared to themselves, or for themselves when they become needier. The fact that they are positive about the system, but do not want it themselves,
may indicate that the elderly do not want the ACE-system because they see it as a potential threat to their independency (Yardley, Donovan-Hall, Francis, and Todd 2006). When they want the ACE-system, they may have the feeling that they admit to not be able to counteract sad and anxious feelings by themselves. Only one participant indicated that it would be helpful to have a system that improves her mood automatically, because she was not always aware of her emotions (P22). She has had chemotherapy to treat ovarian cancer and there were moments where she felt quite good, although she went too far in criticizing on everything according to her husband. Her husband could feel her changes of emotions while nothing was wrong in her own view. Therefore, she described her feelings as untrustworthy and will accept that the decisions about her emotion will be made by the system. This indicates that she does not see it as a potential threat to her independency. This is something which was also rare in other studies. 

Braun (1998), for example, found that elderly understand the importance of fall related risk factors for the general elderly population. However, they do not consider themselves to be susceptible to falling. Yardley, Donovan-Hall, Francis, and Todd (2006) had similar thoughts in their qualitative study about elderly’s perceptions of fall prevention advice. They suggested that elderly people reject fall prevention advice because they see it as a potential threat to their autonomy and identity. This may be the same problem for the ACE-system. Elderly may advice the ACE-system for people in worse conditions to avoid admitting that they cannot counteract their negative feelings themselves. A solution for this problem suggested by Yardley, Donovan-Hall, Francis, and Todd (2006) was to focus on positive benefits of improving balance to prevent falls. They expected this as more acceptable and effective for the elderly. For the ACE-system, this would mean that it will be more effective to focus on the positive mood which will be experienced when the ACE-system is used, instead of on the negative mood which will be counteracted by the system. Whether this will be a solution to avoid elderly mentioning people in worse conditions as potential users, has to be investigated in further research.

5.2.2. Increase trust in light. To develop a positive attitude towards the ACE-system, you have to trust the fact that light can counteract your negative mood. Not all participants believe that light can do this. However, they do believe light therapy helps to feel better. According to the participants, this is due to the fact that light therapy is being used by experts for a long time. Goodwin (2011) studied that people trust experts, because they think an expert would not risk his expert reputation. The reasoning of this participant can be similar. If light therapy is used in healthcare, it should work. Otherwise, the people in healthcare risk their reputation for experts in healing, so they are confident about the advantage of light therapy. Another participant, who does believe in the effect of light on a person’s mood, may have thought the same way. He states that it works, because he has read about it (P23). He maybe assumes that it would not have been written down when it does not work, because the source would put their reputation on line. To improve the trust in the ACE-system, it might help to let doctors recommend the ACE-system. Whether this
improves the trust in the counteraction of negative moods by light has to be investigated. Besides this, when the system is actually used by the elderly, they will notice that their mood improves. For this reason, it may be helpful to allow potential users to try the system for a while, before actually purchasing it. Then they will experience that light improves their mood. The system itself can also prove that light improves the mood of the user, since the yellow faces on the interface will indicate this when the mood improves. Whether a trial period helps to improve trust in light, should be investigated.

5.2.3 User wants new systems. Although the ACE-system will be developed to improve the life of independent living elderly, not all participants want the ACE-system, because some of them do not want changes in their life anymore. They do not want something new in their life despite the fact that the ACE-system will counteract their negative moods and therefore improve their lives. This is in contrast with the study of Demiris et al. (2004), who found that elderly had an overall positive attitude towards sensors and devices in their home to enhance their lives. This supports technologies being developed to improve the daily life of elderly. However, I could not found research into elderly who do not want new systems anymore to enhance their life, like the four participants in my interviews. There is research about elderly who do not want live longer (Rurup et al., 2011 and Ayalon, 2011). However, the participants who did not want changes in their life anymore, were just happy with their life at this moment, but did not want to enhance their lives with systems. Therefore, this can be a subject for further research.

As mentioned in the design recommendations section, other subjects that have to be studied further are whether elderly prefer in house sensors or body sensors and possibilities to increase trust in the fact that light can improve mood. Besides this, the acceptance of the ACE-system should be studied further. Only the attitude towards the ACE-system is explored, because the ACE-system is still in development. However, if features change or are added during the development, the attitude towards the ACE-system may change which makes it important to keep studying the attitude of the elderly.

5.3. Limitations

The study has several limitations, which might have influenced the results. Six important limitations are discussed below.

First, elderly might have less trust in the effect of the ambiences on mood and the mood measurements of the camera than they claimed during the interview. This can be due to the fact that I told them, when explaining the ACE-system, that the light improves mood and the camera measures mood. To make my explanation of the ACE-system more clearly, I chose to explain the ACE-system as a working system. I said for example “When Susan/John feels sad, this ambience helps to make Susan/John less sad.”, instead of “When Susan/John feels sad, this ambience might help to make Susan/John less sad.”. I also said “The camera measures his/her mood.”, instead of “The camera might measure his/her mood.”. The less confident sentences are more correctly, because it is not proved that a camera can measure mood accurately from a distance (Katsimerou, Redi, and Heynderickx,
However, the pilot interviews have shown that using confident sentences highly improved the understanding of the ACE-system by the participants and enabled them to better formulate their opinion. This may have increased their trust in the effect of the ambiences on mood and the mood measurements of the camera. However, when the ACE-system is fully developed and available for sale, confident sentences will be used to make sure people buy the system. Then, the amount of trust in the effect of the ambiences on mood and the mood measurements of the camera will probably be more consistent with the amount of trust during the interviews.

Second, minimizing the number of options on the ACE-system will improve the perceived ease of use of the ACE-system, but might also decrease the probability of buying the ACE-system. People tend to buy products with additional features that they may never use (Suh, Kang, and Lee, 1998) to avoid the negative feeling of missing a feature (Biswas and Grau, 2008). To ensure the acceptance of the ACE-system, the elderly both have to buy the system and have to use it, so both the features should be highlighted and the perceived ease of use should be considered. Therefore, the additional options of the new ACE-system in Figure 5.2 have to be presented very clear to maintain the perceived ease of use and they should be highlighted when the system is sold. This will probably increase the acceptance.

Third, the attitude of the elderly towards the ACE-system can be biased because the participants experienced the cozy and activating ambiences in a living room setting just before the start of the interview. They participated in an experiment in which they could adjust several light settings to adjust the cozy and activating ambience before they came to the interviews. This made it probably easier for the participants to imagine how the system would be in their own living room and how it changes their mood. However, elderly, who did not participate in the experiment, do not have this experience when they consider buying the system. Elderly without this experience might have a more negative attitude towards the ACE-system, because when they never experienced what a light change in your room can do to your mood, they might perceive the system as less useful. This problem might be overcome by offering a trial period to potential users.

Fourth, the participants who participated in the interview may differ from the potential users. The system is for example designed for elderly who live alone, because the system can only improve the mood of one person at a time. When two people are in the same room, it is unlikely that they have the same mood all the time. Moreover, two ambiences in the same room will conflict with each other. Some participants also mentioned that you can cheer each other up when you live together. 16 out of 25 participants live together, so for these participants it could have been more difficult to imagine the system in their homes. The participants may also differ from the potential users, because people who participate in experiments are probably more outgoing. People who prefer to stay at home, rather than going out and doing new things, are more likely to be depressed compared to people who go out according to Yesavage et al. (1983).
Therefore, the system will be less helpful for the elderly who participated in the interviews, which negatively influenced their attitude towards the ACE-system.

Fifth, the acceptance towards the ACE-system can differ from the results of this study, because only the attitude of the elderly towards the system is explored and not the behavioral intention and the actual usage of the system. The ACE-system is still in development which makes it impossible to ask directly whether someone accepts the ACE-system and actual usage cannot be measured accurately. The results of this study can also differ from the actual acceptance of the ACE-system, because of the small sample size. A sample size of 25 participants is not adequate to statistically test the findings. To test the findings statistically, more participants and validated questionnaires are needed. However, interviews proved to be a helpful method, because both anticipated and unanticipated factors that influence the elderly’s attitude towards the ACE-system were found. These factors can be the starting point of a future quantitative analysis.

Sixth, the perceived ease of use of the interface of the fully developed ACE-system may differ from the perceived ease of use of the interface used in the interviews. During the interviews, participants were quite positive about the ease of use of the interface. However, this interface did not include the options tab. This options tab might change their opinion about the perceived ease of use, because more options come along with a decreased perceived ease of use. The fully developed ACE-system probably needs even more options. The skin color of the user may need to be set for example for a more accurate mood measurement (Katsimerou, Redi, and Heynderickx, 2013). This has to be taken into account to keep the perceived ease of use high.

5.4. Contribution

This study contributes to the existing academic literature because it investigated the attitude towards a system which improves mood with ambiences, while prior literature on technology acceptance and ambient assisted living has mostly examined technology that does not improve mood. Moreover, the study also has a practical contribution. It has investigated the factors that are important for the attitude towards the ACE-system. These factors can already be taken into account in the early stage in the development of the ACE-system. Some findings are already translated into design recommendations for the ACE-system. The other findings are starting points for more research that can eventually add value to the ACE-system and will also contribute to other research areas. First, the fact that some elderly liked to see their negative mood and some elderly disliked to see their negative mood is an interesting finding. This has not only to be taken into account for the ACE-system, but also for other research done on systems that measure mood. When people do not like to be reminded of their mood state or do not want that others see their mood, this will reduce the chance that systems that measure mood will be accepted. Second, whether elderly prefer sensors on their body or sensors in their house, is not only interesting for the ACE-system, but this needs also to be taken into account for other systems that use sensors, like fall detection or activity monitoring. Third, the fact that some
elderly recommend the system to others in worse conditions has to be studied further. In the case of fall detection, elderly reject fall prevention advice because they see it as a potential threat to their autonomy and identity. Elderly may perceive the ACE-system also as a potential threat to their independency, but this may also account for other systems that make elderly more independent, like an alarm button or motion sensor. Fourth, some elderly mention that they do not want new systems, because they do not like changes anymore. This topic should be studied further, because this will not only have a negative effect on the attitude towards the ACE-system, but also towards other technologies that enhance elderly’s lives, like care robots or devices to have contact with family and friends.

5.5. Conclusion

Six factors appeared to be important for the attitude of independent living elderly towards the ACE-system. First, privacy influences the attitude. The camera was hypothesized as a problem, but when the camera can be turned off and when the elderly can control who can access the video images, the camera seems to be no issue for the ACE-system anymore. However, the fact that other people can see the elderly’s mood based upon the light might be a bigger problem. This was not asked during the interview, because the ACE-system will be developed for elderly who live alone, but there were still elderly who mentioned this as a problem, because people can visit them unexpectedly for example. However, this problem can be solved when the ambience changes back to neutral as soon as someone comes in.

Second, trust influences attitude and this effect can be mediated by the perceived usefulness. The participants trusted the mood measurement of the camera, but several elderly mentioned that they did not trust that light can counteract a negative mood. These elderly did not perceive the system as useful and therefore have a negative attitude towards the ACE-system. How this problem has to be solved has to be studied further, but may already be solved when the ACE-system is recommended by an expert, like a doctor, or when the systems can prove their working themselves.

Third, controllability influences attitude and this effect can be mediated by the perceived ease of use. The preferences for the control of the system were diverse with a slight preference for the semi-automatic way to control the system. When the ACE-system is controlled semi-automatically, the system gives a suggestion for the ambience that is best for you, but you can choose yourself to turn this ambience on or not. This is an option in between the manual option, that allows you to have a high level of control, and the automatic option, which does not enable you to control the system, but makes the system easy to use. The interface that was used in the interviews was considered as easy to use, especially after the elderly got used to it.

Fourth, the ambience change caused contrasting opinions. Some elderly liked to see the ambience change when a negative mood was detected by the camera, because it reminded them to get a more positive attitude. However, other elderly did not want to be reminded of their negative mood, because it would make them even sadder. To ensure
that both groups have a positive attitude towards the ACE-system, the visibility of the ambience change might play a role. Future research should investigate this.

Fifth, one third of the elderly had a positive attitude towards the ACE-system although they did not want the system. They recommend the system to others who are lonelier, needier, or gloomier. Further research should investigate whether these elderly in worse conditions want the system or whether this is a result of the fact that elderly see the ACE-system as a potential threat to their autonomy and identity. In this case, elderly in worse conditions probably do not want the system either.

Sixth, several elderly indicated that they were already satisfied and did not want any changes or new systems anymore. This is an interesting phenomenon to study further, because it can indicate that some elderly do not want new systems in their life despite the fact that they will counteract their negative moods and therefore improve their lives.


conference of the South African Institute of Computer Scientists and Information Technologists on IT research in developing countries: riding the wave of technology, (pp. 210-219), Wilderness, South Africa.


Overview of 25 participants who participated in the interviews.

<table>
<thead>
<tr>
<th>#</th>
<th>Date interview</th>
<th>M/F</th>
<th>Age</th>
<th>Residing in:</th>
<th>Single/ Together</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>mo May 18</td>
<td>F</td>
<td>86</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>02</td>
<td>mo May 18</td>
<td>M</td>
<td>89</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>03</td>
<td>mo May 18</td>
<td>F</td>
<td>84</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>04</td>
<td>mo May 18</td>
<td>F</td>
<td>86</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>05</td>
<td>tu May 19</td>
<td>M</td>
<td>86</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>06</td>
<td>tu May 19</td>
<td>F</td>
<td>69</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>07</td>
<td>tu May 19</td>
<td>M</td>
<td>70</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>08</td>
<td>we May 20</td>
<td>F</td>
<td>72</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>09</td>
<td>we May 20</td>
<td>M</td>
<td>74</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>10</td>
<td>we May 20</td>
<td>F</td>
<td>96</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>11</td>
<td>we May 20</td>
<td>M</td>
<td>82</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>12</td>
<td>we May 20</td>
<td>F</td>
<td>83</td>
<td>Vitalis Residential Care</td>
<td>Together</td>
</tr>
<tr>
<td>13</td>
<td>th May 21</td>
<td>F</td>
<td>84</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>14</td>
<td>th May 21</td>
<td>M</td>
<td>68</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>15</td>
<td>th May 21</td>
<td>F</td>
<td>67</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>16</td>
<td>th May 27</td>
<td>F</td>
<td>83</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>17</td>
<td>th May 27</td>
<td>F</td>
<td>76</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>18</td>
<td>fr May 29</td>
<td>M</td>
<td>81</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>19</td>
<td>fr May 29</td>
<td>M</td>
<td>81</td>
<td>Vitalis Residential Care</td>
<td>Single</td>
</tr>
<tr>
<td>20</td>
<td>tu June 2</td>
<td>F</td>
<td>68</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>21</td>
<td>tu June 2</td>
<td>M</td>
<td>69</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>22</td>
<td>tu June 2</td>
<td>F</td>
<td>67</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>23</td>
<td>tu June 2</td>
<td>M</td>
<td>76</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>24</td>
<td>we June 3</td>
<td>M</td>
<td>75</td>
<td>Extern</td>
<td>Together</td>
</tr>
<tr>
<td>25</td>
<td>we June 3</td>
<td>F</td>
<td>68</td>
<td>Extern</td>
<td>Together</td>
</tr>
</tbody>
</table>
The paper-based interview guide was used which contained open-ended questions that covered all factors intended to lead towards a discussion about the factors.

<table>
<thead>
<tr>
<th>Appendix B</th>
</tr>
</thead>
</table>

**Intro**
- Welcome
- Explain purpose of the interview
- Ask permission audio recording

**Control**
- Remote control
- Systems sheet
- Light in their house

**Trust**
- GSP system
- Automatic vacuum cleaner
- Wake up light
- Light therapy

**Privacy**
- Camera's public places
- Share mood/health

**ACE-system**
- Explain the ACE-system (Susan/John)
  - Ambiences
  - Camera
- Opinion about the ACE-system

**Trust**
- Measuring mood with a camera
- Improve mood with light

**Privacy**
- Camera in home environment
- Visibility of mood

**Control**
- Control ACE-system on iPad
- Choose tabs

**Attitude**
- Do you think the system was easy to use?
- Do you think the system can help you?
- Do you want to have the system yourself?
- Would you recommend the system?
- Do you think the system can help others?

**End**
- Thank
- Ask if there are questions?
### Appendix C: Coding scheme

The coding frame which was based upon the first interviews, built in Nvivo, and used to code the interviews.

<table>
<thead>
<tr>
<th>In general</th>
<th>ACE-system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Privacy</strong></td>
<td><strong>Privacy</strong></td>
</tr>
<tr>
<td>Considers public cameras as a problem for his/her privacy</td>
<td>Wants wristband instead of camera</td>
</tr>
<tr>
<td>Thinks public cameras are necessary, because of crime/safety</td>
<td>Wants ability to turn off the camera</td>
</tr>
<tr>
<td>Has nothing to hide, so does not see public cameras as a problem</td>
<td>Wants that nobody can access the videos</td>
</tr>
<tr>
<td>Thinks public cameras are fine</td>
<td>Finds cameras acceptable for people in worse conditions</td>
</tr>
<tr>
<td><strong>Trust (in technology)</strong></td>
<td><strong>Trust (in technology)</strong></td>
</tr>
<tr>
<td>Does not always follows GPS system</td>
<td>Is not sure that cameras can measure mood</td>
</tr>
<tr>
<td>Follows GPS system always</td>
<td>Thinks cameras can measure mood possible</td>
</tr>
<tr>
<td>Never used a GPS system</td>
<td>Thinks cameras can measure mood, because there are many innovations</td>
</tr>
<tr>
<td>Thinks automatic vacuum cleaners clean not as good as humans do</td>
<td>Does not know what to think about cameras</td>
</tr>
<tr>
<td>Thinks automatic cleaners clean well</td>
<td><strong>Trust (in light)</strong></td>
</tr>
<tr>
<td>Thinks light therapy helps</td>
<td>Does not believe that light can improve mood</td>
</tr>
<tr>
<td>Does not know whether light therapy helps</td>
<td>Believes that light can improve mood</td>
</tr>
<tr>
<td>Thinks wake-up lights do not work</td>
<td>Does not know whether light can improve mood</td>
</tr>
<tr>
<td>Thinks wake-up lights work</td>
<td><strong>Control</strong></td>
</tr>
<tr>
<td>Does not need wake-up light to wake up</td>
<td>Prefers no change in the amount of options on systems</td>
</tr>
<tr>
<td>Prefers no change in the amount of options on systems</td>
<td>Prefers only the automatic tab</td>
</tr>
<tr>
<td>Prefers fewer options on systems</td>
<td>Prefers only the semi-automatic tab</td>
</tr>
<tr>
<td><strong>Ambience change</strong></td>
<td><strong>Ambience change</strong></td>
</tr>
<tr>
<td>Thinks that mood becomes worse when remembered to mood</td>
<td>Prefers the automatic and manual tab</td>
</tr>
<tr>
<td>Thinks that he/she would feel betrayed when remembered to mood</td>
<td>Prefers the semi-automatic and manual tab</td>
</tr>
<tr>
<td>Thinks it is not fine to be remembered to his/her negative mood</td>
<td>Prefers a combination of all three tabs</td>
</tr>
<tr>
<td>Thinks it is fine to be remembered to his/her negative mood</td>
<td>Prefers the ambience tab</td>
</tr>
<tr>
<td>Sees the ambience change as a reminder to improve his/her mood</td>
<td>Wants not be able to change the ambiances</td>
</tr>
<tr>
<td><strong>Worse conditions</strong></td>
<td><strong>Worse conditions</strong></td>
</tr>
<tr>
<td>Thinks the system is for people who are gloomier</td>
<td><strong>Already satisfied</strong></td>
</tr>
<tr>
<td>Thinks the system is for people who are lonelier</td>
<td>Does not want changes anymore</td>
</tr>
<tr>
<td>Thinks the system is for people who are needier</td>
<td>Does not want to learn to work with new systems</td>
</tr>
<tr>
<td><strong>Already satisfied</strong></td>
<td>Likes new technologies, but not in his/her house</td>
</tr>
</tbody>
</table>
Appendix D

The remote control presented to the participants in the interview is shown below. I asked them to indicate the buttons they use and the buttons they do not use. I used colored pencils to color the buttons. I colored the buttons they use green, the buttons they do not use red, and the buttons they rarely use orange. After that, I asked how their ideal remote control would look like.
The sheet below was presented to the participants to initiate the discussion about systems they use.
Below, the print screens of the interface are shown. They were shown to the participants on an tablet. The buttons on the interface worked, but the ambience in the model living room was controlled externally using a smartphone.

The participants were asked to start the system, which was possible by pressing the start-button.

The participants were asked to explain what they saw.

The participants were asked to activate the neutral ambience. This was possible by pressing the picture of the neutral ambience in the manual-tab (dutch: handmatig).
Participants were asked to tap the semi-automatic-tab (dutch: semi-automatisch) and were asked how they thought this tab would work. I made sure that in the end, the advised (dutch: advise) ambience was touched.

The participants were asked to make the blue ambience a bit greener. This could be done in the ambiances-tab (dutch: sferen).