

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/276973904>

Design Considerations for Adaptive Lighting to Improve Seniors' Mood

Conference Paper · June 2015

DOI: 10.1007/978-3-319-19312-0_2

CITATIONS

3

READS

356

5 authors, including:



Alina Huldgtren

Hochschule Düsseldorf

48 PUBLICATIONS 1,106 CITATIONS

[SEE PROFILE](#)



Christina Katsimerou

Delft University of Technology

9 PUBLICATIONS 70 CITATIONS

[SEE PROFILE](#)



André Kuijsters

Eindhoven University of Technology

9 PUBLICATIONS 181 CITATIONS

[SEE PROFILE](#)



Judith Redi

Delft University of Technology

87 PUBLICATIONS 1,386 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



insideDEM [View project](#)



Nutzerwelten [View project](#)

Design Considerations for Adaptive Lighting to Improve Seniors' Mood

Alina Hultgren¹, Christina Katsimerou², Andre Kuijsters¹, Judith A. Redi², Ingrid E.J. Heynderickx¹

¹ Human-Technology Interaction Group, Industrial Engineering and Innovation Science, Eindhoven University of Technology, PO Box 513, 5600MB Eindhoven, The Netherlands
{a.hultgren, a.kuijsters, i.e.j.heynderickx}@tue.nl

² Multimedia Computing Group, Intelligent Systems, Delft University of Technology, Mekelweg 4, 2628CD Delft, The Netherlands
{c.katsimerou, j.a.redi}@tudelft.nl

Abstract. The advance of LED technologies allows for new design opportunities in the area of lighting for psychological health. Research has shown that lighting in various colors and intensities can be used to improve people's moods, e.g. through its effects on melatonin levels. This is especially interesting in the context of ambient assisted living and care environments where people are less mobile and spend long hours indoors. The presented work aims at creating a technical system that can detect an older resident's mood and consequently adapt the lighting in the room to either calm or activate the person. As part of the system's design process we conducted interviews with caregivers in different care settings (day care, stationary care and home care) to gather requirements for the system. The study provides insights into moods of seniors and their detection, which is formulated in a preliminary mood model, as well as design considerations for different living- and care-settings.

Keywords: Mood, Ambience, LED-lighting, Seniors, Requirements.

1 Introduction

Lighting can impact (psychological) health and wellbeing positively [4,9,12,14]. With the advance of LED technologies the design space of lighting for health and wellbeing has been broadened significantly. The large range of intensities and color variations that can be achieved with LEDs today offers vast possibilities to create lighting atmospheres tailored to specific settings. This has already been utilized in urban settings, public institutions and office buildings. Although the low costs of LEDs allow for use in the home context as well, application of LEDs for ambient lighting atmospheres and lighting for wellbeing is not widespread yet in this context. Some commercial products such as the Philips Livingcolors¹ or Hue² exist, and although the

¹ www.livingcolors.philips.com

² www2.meethue.com/

Hue system comes with a smartphone app allowing people to adapt the lighting settings, human computer interfaces have to be developed more specifically to support people in making use of the health benefits and easy creation of relaxing or activating atmospheres in their homes. Especially for older people, who are less mobile, spend long hours indoors and are prone to negative moods, intelligent lighting systems could provide health benefits. With the advance of ambient assisted living (AAL) and smart homes, it becomes feasible to install lighting systems that react to users and automatically adapt to their needs. Research in this area is still rare.

We aim at designing a system that can detect seniors' negative moods and create pleasant affective atmospheres through lighting (and possibly sound and smell). The light settings, e.g. activating lights counteracting depression, are based on the psychological effects of lighting found in earlier research (see related work) and the effects of different lighting scenarios have been tested extensively in experimental studies in this project [11]. Besides finding light settings that positively impact a senior's mood, another important aspect of the project is the recognition of negative mood states. Also overall requirements of the system with regard to user perceptions, needs and wishes need to be taken into account to design the system to maximize user acceptance. The latter two aspects (moods in seniors, user requirements) were the focus of a set of interviews we conducted with caregivers in different care settings. We present data from these interviews and provide requirements and design considerations for an ambient lighting system for seniors.

2 Related Work

2.1 Impact of Lighting on Mood

Lighting of different intensities and colors has been found to influence biological and psychological processes in humans that impact people's moods. We will focus on major findings that are relevant for the project at hand.

Disruptions to circadian rhythms can cause mood disorders [1]. Biological effects of bright light on melatonin levels, which influence people's circadian rhythm, are well documented [4,9,13,15]. Research has shown that bright blue light "increases alertness during the night, improves sleep quality, may significantly reduce the symptoms of depression for seasonal mood disorders, and even for people with non-seasonal affective disorders, and may positively impact the treatment of patients with dementia" [10].

As we are interested in the improvement of seniors' moods, psychological effects of lighting are in the focus. Illuminance and correlated color temperature play an important role in influencing emotional wellbeing. However, results from previous research with younger target groups have been controversial. In separate studies in the work context Knez and colleagues [7,8] found different effects of warm (3000K) and cool lighting (4000K) on males and females. Other studies have focused on psychological effects of color on mood and found positive effects. Office workers, for

instance, who judged their offices as colorful, experienced better moods than workers who judged their offices as neutral or colorless [12]. Furthermore, blue color is more often perceived as calming [2], while red as arousing [5]. The effects of illuminance and color on mood have so far mostly been studied disjoint. However, advanced LED technologies now allow combining these two aspects and creating lighting atmospheres that combine functional lights with ambient colored lighting. In our studies [10] we focused in particular on how to create lighting atmospheres that would be perceived by seniors as cosy or activating and whether such atmospheres have indeed the desired effect of improving the seniors' mood. We found that seniors preferred functional, reddish white lighting in combination with orange colored accent lighting for cosy ambiances and bluish white light with cyan colored accents for activation. More than one colored accent light should be avoided.

2.2 Lighting in Ambient Assisted Living

AAL³ is a vibrant research field aiming to improve health, wellbeing and quality of life for seniors living independently. AAL comprises many technologies. "Among AAL/telecare solutions and service offerings, there is huge diversity in the different configurations of technologies and in the degree of involvement of health care professionals. However they all tend to encompass some or all of the following features: monitoring of safety and security, e.g., to detect water left running, via sensors that operate in isolation and generate alerts when events are detected; monitoring of activities of daily living (ADL) and lifestyle monitoring via a network of sensors in the home, again with some alerting function, e.g., for falls detection; and physiological monitoring, which usually involves some direct participation of the users e.g., in taking blood pressure measurements" [3].

Ambient lighting is rarely considered in AAL research. In [6] lighting was utilized for temporal and spatial orientation, which differs from our focus. We could only find one similar project, i.e. the ALADIN project [14], in which researchers focused specifically on developing an adaptive lighting system for seniors. However, several aspects differ from our work: (1) only white lighting was used and no accent lights, (2) lighting was focused stronger on supporting activities in the household and (3) the system was developed as an app for a television, that comprised not only lighting, but also recommendations for wellbeing and exercise. The latter makes it difficult to assess the impact of the lighting to the reported beneficial effects of the system.

3 Project Context

Researchers with expertise in psychology, human-computer interaction and artificial intelligence collaborate in this project with Philips to develop an intelligent lighting system that can automatically recognize the mood of a senior user and adapt several

³ www.aal-europe.eu

lamps in the room to provide an atmosphere with positive impact on the mood. When the project was initiated, we focused on care homes as the setting for the system because seniors often experience negative moods in the phase of relocation from home to a care home. However, in light of the current demographic developments and changes in the care system, we expanded our focus to also take into account the possibility of installing the system in private flats.

The system will be designed to classify moods either as negative with low arousal (e.g. depression), in which case an activating light will be chosen or as negative with high arousal (e.g. unrest), in which case a calming light will be chosen. To detect the mood of the resident the system uses input from cameras. While research on emotion recognition has focused on younger populations, and short affective states rather than longer mood states, we aimed to understand: (1) the difference between mood and emotion, (2) the recognition of seniors' moods, and (3) factors influencing the mood. Furthermore, we asked about the general attitude towards the envisioned system and its application to different care contexts. To get answers, we conducted interviews with caregivers in different senior care settings, who have extensive experience in recognizing and dealing with moods of the residents.

4 Interviews

We conducted two initial rounds of exploratory interviews with (1) six caregivers working for a senior daycare center in Delft, The Netherlands, where some seniors have been diagnosed with dementia, and a focus group of (2) three caregivers in a care home for people with dementia in The Hague, The Netherlands. Based on a qualitative content analysis of these initial interviews we learned about different features that help detecting a senior's mood and were able to categorize these into physical (facial expression and posture) and behavioral aspects (interactional and non-interactional, verbal and non-verbal). We realized, however, that in the context of daycare or care homes, a lot of interaction between residents can be observed and that physical features are also closely tied to this context. Considering our expanded project focus on independent living, we decided to run an additional interview study with caregivers from an organization offering independent living units as well as a care home to study how the requirements for the system would differ in these settings.

4.1 Study Set-up

We interviewed caregivers of an extra-mural care unit of a large apartment building that is administered by a care organization in Eindhoven, The Netherlands. Senior residents live independently in bought or rented flats. The average age of people receiving care is 92 and the care levels range from household help to daily physical care. Some residents suffer from first to third stage dementia. Interviews were conducted on two days in a meeting room inside the apartment building, where caregivers worked, and took between 40 and 60 minutes.

4.2 Participants

We recruited eight participants through a manager at the Vitalis WoonZorg Groep. We specifically recruited participants with a range of ages (24-59), work experiences (2-37 years) and work times (15-32 h/week). All participants were Dutch and female, as there is only one male caregiver in the institution, who was not fluent in Dutch.

4.3 Materials



Fig. 1. Examples of lighting in the room used in the interviews: (a) cosy, (b) activating.

During the interviews we showed participants example photographs of cosy and activating lighting settings (Fig1). We used a smartphone for audio recordings.

4.4 Data Analysis and Results

The interview data was transcribed verbatim and coded (according to a coding manual derived from the first interviews). We looked for recurring ideas, which were then categorized into the higher level themes elaborated in the following.

Mood and Emotion

We found that both moods and emotions were seen as generally related. *“If someone is in a bad mood, then the emotions are, of course, also negative. (P1)”* Mood is long-term, and emotions are reactions to events and therefore short-term. *“Emotion is often a snapshot, for example, something funny happens and I laugh. That’s an emotion. Moods are something longer, a longer period. (P3)”* Depending on the event, however, it is possible that people experience emotions with different valence from the mood. *“I think they are different, because you can be in a gloomy mood, but I think you can still laugh about a joke every now and then... So, I think that mood is something longer term and that different emotions can play a role in there. (P5)”* As spontaneous reactions, emotions can sometimes also be irrational. *“An emotional reaction, that is often when something intense happens,... or something they cannot accept...[Emotions] are not thought through, not rational. (P4)”* Considering mood duration, we were told that moods range between single days and weeks. When people are depressed or in a gloomy mood it usually takes longer. However, when it

exceeds several weeks, caregivers would consult a doctor. *"I think if something holds on for several weeks, an alarm has to ring. (P5)"* Overall, the duration of mood is strongly influenced by external events and circumstances. *"There are people, who are sad the whole day... the mood stays. Also depends on what has happened (P1)"*.

Mood in seniors with and without dementia

Caregivers also referred to differences in mood duration related to dementia. Closely linked to the progression of the disease people either experience negative moods more often (mild dementia), or moods change more quickly (severe dementia). *"Sometimes it goes by fast, when the forgetfulness begins to work. When you are in the beginning phase then you don't forget it ... but people in the last phase forget it immediately (P8)."* *"Most demented people are a bit gloomy, because they know [what happens to them] or it depends in what phase they are... another resident is so far... after half a minute he forgot it already (P5)"*

In old age emotions can appear milder than in younger people. According to one participant *"overall people are generally more conscious about emotions and moods ... to some extent they are more relaxed ... I have the impression that they are milder when they become older (P3)"* In people with dementia this can lead to apathy *"The emotions are less and then they are in a state where they have this emotionless expression on their face (P8)"*. While we have to consider such findings with great care, because the caregivers are talking about single cases, it is important to consider that an automatic mood recognition system may fail in these cases. Generally, individual differences have to be taken account by the system.

Mood Recognition

Mood recognition is a common caregiver task that is done when entering the room. It gives the caregiver room to adapt the interaction. A prevailing theme of the interviews was the familiarity with the resident to be able to judge the mood. All caregivers mentioned that when knowing the residents well, it is very easy to recognize the current mood state, whereas this is almost impossible with new residents. *"Well, you know the residents, so you know what behavior they show normally. If someone is usually very cheerful, while when you come in, he does not say anything or just mumbles something. Yes, I definitely notice that someone is not feeling well. (P5)"* *"I cannot see it on her, because I don't know her ... because maybe it always like that. You have to be able to compare. (P6)"* Regular contact is important. *"Then you can keep track of their progress, how is someone, and that someone is not getting worse (P5)"* *"When you work a few nights, you know how it went earlier. (P4)"* Another aspect is that knowing a person's background could help to assess why a person is in a certain mood. *"If you know the life story of people, then you understand more (P4)."* *"Someone you know for a long time, you know the background. Then you also know why they are depressive (P3)."*

To get a first impression of the mood state two features were mentioned by all interviewees: the facial expression, most dominantly the eyes, and the voice of the person. *"When I come inside, I see immediately whether I am welcome or not. I see it*

on her, how she looks at you, the corners of the mouth downwards ... I often see it in her eyes or from the expression on her face. (P6) “Usually yes, you see it immediately in their faces. ... Actually even before you see them. Then it is often the way they say good morning (P3)”

Recognizing negative moods is key in our application, since we would like to provide an intervention in such cases. Therefore, the interviews focused specifically on negative mood states, such as being depressed, aggressive or sad.

Gloomy/depressive. We found that the prevailing negative mood in residents was being gloomy, which is to be distinguished from being depressed. When talking about depression, caregivers referred to a medical condition that could be diagnosed and treated. Being gloomy describes similar mood states, which are not connected to a medical condition. Features for the recognition are facial expression, posture and social behavior. “*You can see it in the facial expression. I think they would be staring. You can see it in the eyes, the way they are standing, no smile on the face. (P5)*” “*Most of the time you see it in their faces. Expressions, they don’t look happy, not awake, gloomy, the corners of the mouth down, and then they sit like this [puts her shoulders forward.] (P8)*” “*You see it from their posture. Yes, that is a bit collapsed. Contacts with other people they don’t want then. (P2)*” Similar facial expressions were described for depression, but people were much more withdrawn. “*They are more focused on the inside, introverted. (P3)*” “*Depressed, ‘crawling’ away and this withdrawal and not wanting anything (P4)*”

Scared/nervous. Being nervous or scared is mainly observed with people suffering from mild dementia due to memory loss or disorientation. Features signaling nervousness are mainly behavioral, either non-interactional, such as wanting to move, or in interactional, such as not being able to focus on a conversation with another person. “*There are different types of unrest. For example, people want to get up from the chair ... they want to do certain things that they can’t (P4).*” “*They want to begin an activity, but cannot finish it. (P3)*” “*I think that they want to walk a lot or they don’t dare to (P5).*” “*When someone is very nervous, I think they cannot have a relaxed conversation or listen or they lose the red thread. (P5)*”

Caregivers reported that residents are rarely scared. Significant features are facial expression, in particular the look in people’s eyes, a tense posture and vocal reactions like screaming. “*You often see it in the eyes, and the posture, that someone is very tense. (P2)*” “*Yes, and in the look in their eyes... If someone is really scared, then you see it in their look, like looking fast, looking around, suspicious I would say (P3).*” “*Also, how someone lies in the bed, clinging, cringing, and tensing up. That is then pure fear, and then screaming. (P2)*”

Other moods. Other negative moods are rarely observed on a regular basis. Two caregivers reported about a resident who suffered from Korsakoff syndrome, a neurological disorder linked to alcoholism and showing symptoms of dementia. This

resident became aggressive when being drunk. He forgot that he had drunk and asked for more. Features were an angry look on the face, being loud and being physically aggressive to others. Sadness was another mood that was mentioned but did not occur regularly. Shedding tears was the most obvious sign. Otherwise the body language is similar to being gloomy.

Influences on Mood

Internal and external influences impacting a resident's mood are important for the context modeling of the system to make the mood recognition more accurate or help predicting the mood. In the interviews many external factors surfaced, including loneliness, weather, time of day, sound, light and smell and two internal factors, i.e. illnesses and memories of events (e.g. death day of relative).

External Factors. Loneliness was reported as a crucial factor leading to gloomy moods. *"Yes, there are people here, that sit alone the rest of the day [after caregiving] four days a week (P4)" "Surely because they live there alone, ... the family is busy, then they become lonely and gloomy. (P5)" "They are alone a lot. They cannot walk, because they have no one ... children live far away. (P8)"* Also the time of day has an impact on the residents' mood. Caregivers observed that many people have problems with the start of the day. *"I realized with older people, in the morning, starting the day, having the day ahead, ... while in the evening they can retreat, that is important for people between 80 and 90. (P4)" "I noticed that most depressing feelings are experienced in the morning, when starting the day ... later, people are calmer. (P3)" "With that one person it was the care in the morning, He did not like it, and at lunchtime it was fine again (P2)"*

Weather has a mediating role in that it does not affect the mood directly, but the mobility of the person. If people cannot go outside for several days they experience negative moods. *"People cannot go outside, cannot go for a walk... you get gloomy from that. (P4)" "When the sun shines at nine in the morning then the day is very good. Then they can go outside. That makes a big difference (P2)."* Different types of weather can play a role, since they influence the mobility in different ways. *"They don't like it too cold, then they cannot go outside (P6)" "Many people walk with a walker or cane and it gets really windy around these buildings and then they cannot go outside. (P2)"*

We specifically asked about light, sound and smell as they are directly relevant to the system. Light was seen as a positive factor by all caregivers. Sounds and smells were seen as playing a smaller role. Music is very personal, depends on the individual's preferences. Generally, residents like sounds that give the impression of 'life in the house', but too much noise can impact the mood negatively.

6 Discussion and Design Considerations

6.1 Mood model derived from the data

Figure 2 presents an initial model derived from the interviews. On the left side, influencing factors impacting the mood are shown, divided into internal and external ones. On the right side the features for detected the mood are listed. It should be noted that behavioral factors are strongly influenced by a person's habits, which should be taken into account to accurately detect the mood.

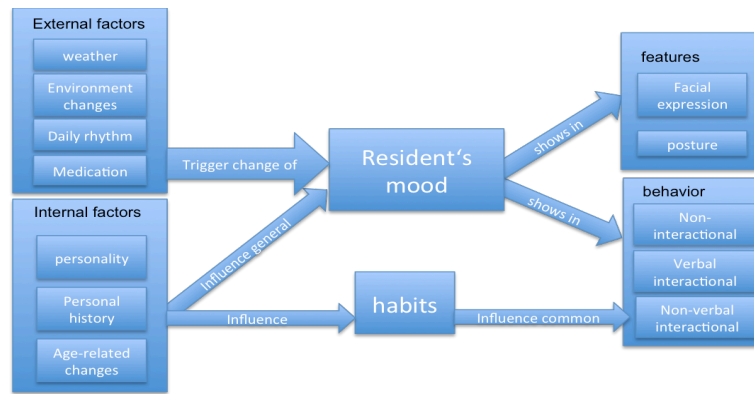


Fig. 2. Senior Mood Model.

6.2 Considerations based on Insights about Mood

Gloominess is the most observed mood in seniors living independently. It occurs due to few social contacts and resulting loneliness as well as compromised mobility, especially in bad weather conditions. Anxiety and connected nervous behaviors are mainly observed in people with mild dementia, who feel lost. People with extreme dementia, can experience rapid mood changes due to forgetfulness. Depression and aggression were moods that were rarely experienced and linked to medical conditions. Consequently, an AAL system intending to improve seniors' moods should be optimized to recognize gloomy moods and provide activating ambiances. In case of mild dementia, nervous behaviors should be detected and a cozy atmosphere used to counteract. To recognize moods the mood model above can provide guidance. Our system is trained on a few subjects and tested on new unseen ones. This makes it able to deal with unseen data, in the same way as the nurse judges the mood of a new resident. In particular, the system requires a user model that contains information about the personality (introverted, outgoing), diseases (dementia, depression) and behavior patterns in order to notice deviations from the normal state. In addition, a context model providing information about the current situation (time of day, weather, etc.) supports the prediction of residents' mood. Combined with real-time input from sensors on facial expression, posture and movement, the mood can be analyzed.

6.3 Overall Attitude and expected Effects

The reactions to the system were diverse. Overall, the caregivers were positive towards the use of lighting to improve moods. Some doubts, however, were apparent towards the automatic sensing and adaptation of the lamps. The most beneficial effects were seen for people suffering from depression or gloomy moods. *"I think it could work very well, because light works very positively on people that are depressed. (P3)"* For anxious people, caregivers were not sure about the effects. Generally for *"people who are scared, ... if the light is cozy, it would probably give them a feeling of safety (P3)"*, but for people with dementia doubts were mentioned. *"So, the light changes, but how that would be experienced by someone with dementia ... I think that it can also bring feelings of anxiety to the surface (P3)"*

6.4 Use of Camera and Sensors

Three themes emerged in the interviews: keeping control, privacy and suspicion. A common statement of the caregivers towards the installation of the system as such and specifically the use of cameras to recognize and automatically adapt the lighting, was that people live independently in the apartments and therefore, wish to be in control. *"Well, I think with people with dementia you can place anything, but here it is explicitly about people that want to keep control themselves (P4)"* In any case the system would have to be agreed upon with the residents and the family. As expected, privacy was one of the factors, which could hinder the use of the system. *"I think that more than half the people would not agree ... Privacy, I think. (P2)"* *"No that is always so sensitive, such things, all the privacy is gone (P7)." Privacy is a general concern in AAL systems that monitor the users. For our system it is crucial to store some data about the users' behavior and therefore, a solution with high data security needs to be implemented. In addition, we will explore in interviews with seniors what the exact privacy concerns are. An aspect we had not considered before, is that people with mild dementia could react with suspicion towards the cameras, unobtrusive sensors may be a better option in this case.*

6.5 The right Setting for the System

As hypothesized after the first rounds of interviews we found differences in how caregivers perceived the use of the system in different care contexts. Several interviewees immediately stated that the system should be used in a care home. Four reasons were named for this. Independence of the residents (also linked to stage of dementia) and rebuilding their flats to install the system was seen as obstacles. *"See, in a care home on a floor with dement people you can install it, but in people's homes would you not do it so easily. (P8)"* *"Here people live independently, would you do this whole refurbishment here (P7)." In care homes two aspects were seen as beneficial circumstance, i.e. more extreme moods that need to be handled and more supervision by caregivers in care homes. "I think it is better in a care home, because aggression is occurring more often there. I think that the moods are more extreme there. They are together with more people and have more stimuli and obstacles there. (P5)" "Look, in care homes it is different, the doors are open and in the corridor there*

are caregivers (P6). “Because it is easier to handle. You can monitor people more (P2).” Closely linked to the living setting for the system was the aspect of automatic adaptation of the lights, which was perceived as opposing the idea of keeping control in independent living. *“People live independent, so you have to strive for them having control (P3).” “[Controlling the system themselves] would be very good, I think, because then they have the feeling that they are involved (P7).”* Another comment showed the importance of knowing the intended effect of a certain light setting: *“Then it is a lamp with a remote control ... if it also says from high to low it is activating or calming, then I think it is better (P6).”*

Despite the concerns about compromising the independence with an automatic system, several caregivers emphasized that residents may have difficulties being aware about their negative mood state or would not take initiative to change it. *“I will put on another light, because I don’t feel so happy. People would not do that (P8)” “I think that if someone needs to get calmer, they often don’t have it under control and would turn on [the system] (P2).” “If someone is gloomy or depressed, then they are often in denial (P5).”*

Given the above a good solution could be to detect the mood automatically and provide a choice to the user to change the light in order to improve the mood. In this case the user would be involved and be in control, but at the same time issues with not taking initiative may be overcome.

7 Conclusions and Future Work

Insights obtained in interviews with caregivers working in different care settings were presented in form of a mood model as well as design considerations for an adaptive lighting system for the care context. The presented model can be used by others as a starting point in designing systems affecting the mood of seniors and can be applied to other design contexts than lighting. Overall, we can conclude that in the independent living context, control by the users is an important factor for acceptance of the system, whereas the automatic features dependent on cameras and sensors are more relevant in the institutional context. We have to distinguish situations in the home context, in which residents experience affective disorders, for instance, depression. Caregivers highlighted that depressed individuals would rarely initiate a lighting change to improve their moods. A combination of automatic sensing to detect a negative mood and a notification of lighting change would be an option. Generally, in the home context gloomy and anxious moods occur, while aggression or extreme nervousness is rare. The latter are more common in day care and care home context where several people were together. Depending on the context the system could be targeted to detect certain moods.

Currently we are interviewing seniors to get a first person perspective on the attitudes towards our system, which will be integrated into the design as well.

Acknowledgements

We are grateful to the Vitalis WoonZorg Groep for supporting us in our research. Furthermore, we would like to thank Philips to enable this project, and, in particular, Boris De Ruyter for valuable discussions.

References

1. Boyce, P., Barriball, E.: Circadian rhythms and depression. *Aust Fam Physician* 39, 307–310 (2010)
2. Elliot, A.J., Maier, M.A., Moller, A.C., Friedman, R., Meinhardt, J.: Color and psychological functioning: The effect of red on performance attainment. *J. Exp. Psychology* 136(1), 154–168 (2007)
3. Fitzpatrick, G., Hultgren, A., Malmberg, L., Harley, D., IJsselsteijn, W.A. Design for Agency, Adaptivity and Reciprocity: re-imagining AAL and telecare agendas. In Randall, D., Schmidt, K. & Wulf, V. (Eds.) *Designing Socially Embedded Technologies: A European Challenge*. Springer Publishing Company (2015)
4. Golden, R.N., Gaynes, B.N., Ekstrom, R.D., Hamer, R.M., Jacobsen F.M., Suppes, T., Wisner, K.L., Nemeroff, C.B.: The efficacy of light therapy in the treatment of mood disorders: A review and metaanalysis of the evidence. *Am. J. Psychiatry* 162, 656–662 (2005)
5. Kaya, N., Epps, H.H.: Relationship between color and emotion: A study of college students. *College Student Journal* 38, 396–405 (2004)
6. Kempter, G., Ritter, W., Künz, A.: *Guiding Light for the Mobility Support of Seniors. In Ambient Assisted Living*. Springer, Berlin Heidelberg (2014)
7. Knez, I.: Effect of indoor lighting on mood and cognition. *J. Environ. Psychology* 15, 39–51 (1995)
8. Knez I, Enmarker I.: Effects of office lighting on mood and cognitive performance and a gender effect in work-related judgment. *Environment and Behavior* 30, 553–567 (1998)
9. Kobayashi, R., Fukuda, N., Kohsaka, M., Sasamoto, Y., Sakakibara, S., Koyama, E., Nakamura, F., Koyama, T.: Effects of bright light at lunchtime on sleep of patients in a geriatric hospital. *Psychiatry Clin Neurosci.* 55, 287–289 (2001).
10. Kuijsters, A., Redi, J., de Ruyter, B., Seuntjens, P., Heynderickx, I.: Affective ambiances created with lighting for older people. *Lighting Res. Technol.* 0, 1-17 (2014).
11. Kuijsters, A., Redi, J., de Ruyter, B., Heynderickx, I.: Improving the mood of elderly with coloured lighting. *Constructing Ambient Intelligence* (pp. 49-56). Springer, Berlin Heidelberg (2012).
12. Küller, R., Ballal, S., Laike, T., Mikellides, B., Tonello, G.: The impact of light and colour on psychological mood: a cross-cultural study of indoor work environments. *Ergonomics* 49, 1496–1507 (2006)
13. Lieverse, R., Van Someren, E.J., Nielen, M.M., Uitdehaag, B.M., Smit, J.H., Hoogendijk, W.J.: Bright light treatment in elderly patients with nonseasonal major depressive disorder: A randomized placebo-controlled trial. *Archives of General Psychiatry* 68, 61–70 (2011)
14. Maier, E., & Kempter, G. (2010). ALADIN-a Magic Lamp for the Elderly?. In *Handbook of Ambient Intelligence and Smart Environments* (pp. 1201-1227). Springer US.
15. Riemersma-van der Lek, R.F., Swaab, D.F., Twisk, J., Hol, E.M., Hoogendijk, W.J.G., Van Someren, E.J.W.: Effect of bright light and melatonin on cognitive and noncognitive function in elderly residents of group care facilities: A randomized controlled trial. *JAMA* 299, 2642–2655 (2008)