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A.1. Human centred design solutions

A NEW AND IMPROVED LIVING ENVIRONMENT FOR ELDERLY WITH DEMENTIA

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SUMMARY

The amount of people with dementia will more than double in the next 25 years, which makes the need to improve their living environment urgent. The aim of the study was to design an improved living environment with a focus on light, that meets the need of elderly with dementia, and thus improve their quality of life.

It was shown that, in line with the outcome of the desk research, both inadequate design and poor lighting conditions played an important role in the behavioral aspects of elderly with dementia. Not only the amount of light (artificial and daylight), but also the view outside is an important aspect.

Freedom, clarity and recognition are important keywords for the design guidelines for people with dementia. Based on these guidelines an ideal living environment for people with dementia was established, where the connection with the outdoor environment and (smart) way finding with natural light was taken as basis of the design.

INTRODUCTION

Dementia is a progressive disease. This means that the structure and chemical properties of the brain keep on damaging. The extent to which a person is able to remember, understand, communicate and reason will gradually decline.

At virtually any brain damage, including dementia, the higher levels of the brain are affected [Verdult, 2003]. People with dementia therefore act more unconscious, reflexive and impulsive (the first two levels of the brain). More complex actions are at risk, such as preparing meals. In addition, more people express in the course of their disease behavioral and mood problems. This can be a direct result of brain damage, which means that there is no longer control of his own impulses (this happens at level 3 of the brain). Also the sense of time is lost, and conscious planning and conscious making is no longer (level 4 of the brain).

People with dementia are most of the time 'locked' in wards that restrict their living environment. These living environments may confuse people with dementia, which can lead to uncertainty and fear. As a result people with dementia can express more behavioral and mood problems, which are only a result of a bad and unhealthy environment [Van der Plaats, 2008].

In this study a new building was designed for people with dementia, to improve their quality of life. In order to understand the needs of the focus group an extended desk research was performed in three stages. First, a literature review of the needs and perception of elderly with dementia and the influence of light on elderly and demented people. Second, a survey in three care facilities in the Netherlands, to get an indication of the current lightning conditions of the care facilities. And third, interviews with people with dementia were held. The outcomes were translated into design guidelines, which are used to design a living environment for people with dementia.

THEORY

If there is already a disease, stress can cause an increase in symptoms associated with the disease [Van der Plaats, 2008]. It appears then as if the disease is worsening, but actually is the cause of the environment. That is why a good and healthy environment is very important, particularly in brain diseases. People with dementia that cause behavioral problems are often bothered by something what they cannot convey to the environment [Stroobants, 2012]. Causing behavioral problems is most of the time a way to get rid of this frustration. A healthy environment can decline these behavior problems.

According to information prepared by nurses for care takers people with dementia need to experience an amount of freedom [Omgevingspsycholoog, 2015]. People with dementia have sometime a tendency to run away from the care facility. If the person with dementia is stopped (by an employee or a closed door) the situation that he is locked up will become extra clear. Therefore, the person with dementia experiences that he or she has no control over his own environment. We find this as humans in generally very annoying. For a person who slowly loses control of their lives, this is more than an unpleasant experience. As a result people with dementia experience stress which can result in the expression of behavioral problems.

People with dementia need recognition and clarity. Most important in a room are the edges, these ensure that the room is easy to read and understand. Once a window begins at floor level the edges of a room become unclear, which makes the room harder to understand. A balustrade will help for a good overview of a room. Contrast is another aspect to help the clarity of a room. Contrast between floor and wall ensures that the edges of the space will be immediately clear [Van der Plaats, 2008]. Also, by using landmarks the people with dementia can better orient where he is in the care facility [Verdult, 2003].

For people with dementia, a clear routine is very important. Separation between the living room and bedroom are the most important. Each room has only one function, so there is no misunderstanding what to do in that specific room [Van der Plaats, 2010]. By creating different interior designs a person with dementia can connect with

its environment. This is usually done by dividing residents of a care facility in living groups.

Rooms with difference in stimuli ensure that each type of person with dementia can find his or her place in the house [Van der Plaats, 2008]. People with zen-dementia require minimal stimuli, while wanderers and balance seekers are in need of a lot of stimuli.

At all times it is important that at people can give meaning to stimuli. When this is not the case people with dementia will not know, for example where sound is coming from, and therefore panic. The background noise in a room should be kept as low as possible. The speech intelligibility of the elderly is a quarter lower than in adolescents. This is a difference of 5dB in background noise [Hoof, 2008].

Light is probably the most important aspect for us to understand the environment.
But due to aging the functioning of the eye deteriorates. The vision in the dark will get worse by the decrease in pupil diameter [Boyce, 2003]. In addition, older people have more trouble getting used to abrupt changes in luminance [Boyce, 2003]. The adaptation of the eye with an abrupt movement from light to dark is very slow so it can take up to 40 minutes before an elder sees something in the dark.
Due to aging of the lens the sight nearby and the sharpness of the view decline [Boyce, 2003]. The low wavelengths are poorly absorbed by yellowing of the lens, so blue light will be less seen by elderly. By biomedical and anatomical degradation of the retina, it is possible that the signals are not well transferred to the brains [Boyce, 2003].
Glaucoma is a disease that damages the optic nerve which results in decreased contrast sensitivity, poor night vision, delayed adjustment of the eye and even blindness. Glaucoma is five times more found in people with dementia than in healthy elderly [Wu, 2007].

Light can affect the atmosphere in the room, and therefore also how we experience the room. The living room needs a lot and bright light, while task focused light is more important in the bedroom [Aarts, 2011].

Light is not only important to perform tasks but also for the control of various processes and hormones at a rhythm of 24 hours (circadian). The main process for people with dementia is the sleep / wake cycle. Because of dementia this rhythm is affected and operates a lot less [Someren, 1997]. People with dementia are therefore often awake in the evenings and nap during the day.

The biological clock is particularly sensitive to blue or bright light [Someren, 1997]. As mentioned earlier blue light isn't absorbed properly due to the yellowing of the lens. Therefore it is better to use bright light (>2000 lux) instead of blue light. The mean exposure to 2000 lux is for residents in a 'closed' care facility less than 2 minutes, in comparison to 1 hours for elderly living at home [Campell, 1998]. In order to maintain a working sleep / wake rhythm, it is important to receive a minimum 2 hours of 2000 lux in the morning. When the resident is exposed to bright light in the evening the rhythm will even be more distort, because of the lack of production of melatonin.

According to the literature review the following requirements are established.

Table 1. Requirements of illuminance at different task for people with dementia.

Task	**Minimum illuminance (lux)**
Living room (general orientation)	300
Living room (>60%)	500
Reading	500
Fine crafts	1500
Diner table	500
Kitchen	500
Preparing food	800
Hallway	200
Bedroom	300
Bathroom	300
Orientation at night	50

There are no maximum requirements established for the different tasks. High illuminance levels are desired, as long as no glare occurs.

When care complexes are designed there is often one place for the table, but in practice there are many tables through the entire living room. The design must take this into account. Therefore, a minimum illuminance of 500 lux which should cover at least 60% of the living room is required.

METHOD AND RESUILTS SURVEY CARE FACILITIES LIGHT

A survey was carried out in three care facilities in the Netherlands; Boswijk in Vught, Hogeweyk in Weesp and Rietvinck in Amsterdam. In each care facility two living rooms are measured to get an indication of the current lightning conditions of the care facilities in the Netherlands. The measurements were taken around November during the daytime.

Using a grid, lightning conditions are measured in the living rooms with and without artificial light. See figure 1 for the results. The measurements less than 0,5 meters from the window are dismissed.

Figure 1 shows that more than 75% of the measurements in each living room are below 300 lux. With artificial light a few care facilities exceed the requirement, but the median of each living room is still below 300 lux.

Care facilities home 5 of Boswijk and home 22 of Hogeweyk have the best values. They have a light colored interior and windows at at least two sides of the room. Home 22 of Hogeweyk is also on the first floor with no obstacles around the windows, such as trees or balconies.

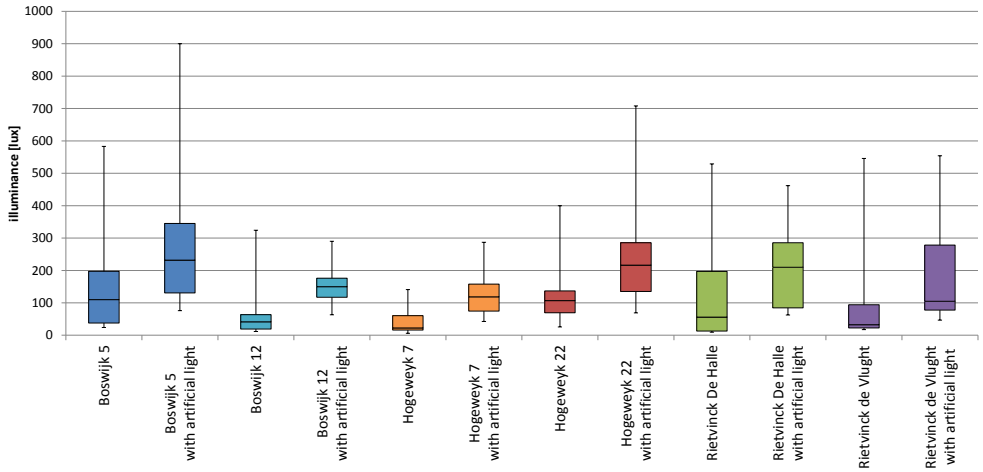

Figure 1. Light conditions in care facilities with and without artificial light.

METHOD AND RESUILTS INTERVIEW PEOPLE WITH DEMENTIA

An interview was held with 17 residents on 5 wards in care facility Glana in Geleen. The people with light dementia were interviewed. An interview with people with dementia must be done slightly different. The answer may come through something I've said or something they sow at the time. Therefore, the questions are repeated three times in the conversation in different sentences. Between same questions the subject was changed, so thought about something else. If they answered three times the same the answer was used.

It showed that the living environment of residents in large-scale care facilities (more than 8 people at one ward) is smaller than residents in small-scale care facilities. In large-scale facilities the living environment of the residents doesn't exist beyond their own chair, it's their safe spot. It is more difficult for people with dementia to overlook the whole home in the bigger care facilities. They have no idea what's around a corner, which is frightening for them. In smaller care facilities this overview is easier to comprehend. Most of the residents choose a place in a corner in the hallway (so they can see both ways) or face to the entrance of a room (so they can see who enters). Therefore they can keep easier overview of the space, and they will more likely understand what is happening in a room.

All residents like to watch an activity, in contrast to a view were nothing happens. Outside is a view to a busy stress wished for. In the living room the kitchen is the hot spot during the day. There are a lot of things to see (and participate with), such as food preparation.

An interesting outcome of the interview was that the residents find it cold inside when it looks like it's cold outside (clouds, windy, less light). This has nothing to do with the temperature inside the home. The nurses indicate that the residents take more naps during the day in wintertime than in summertime.

DESIGN

Design guidelines

The guidelines for this study are a result of the literature review and the research. They are the basis of the design. The design is primarily made from large to small. So will also the design guidelines be explained.

The ‘care neighborhood’ should be a neighborhood on its own. The threshold to go outside is kept as low as possible, low-rise buildings are recommended. The use of a garden can stimulate the senses (sight, hearing, touch, smell, taste, etc). A garden is seasonal so it can contribute to the reduction of disorientation in time and space. In addition, it also increases the contact with the reality and it can help in maintaining social contact.

The clarity and visibility of a care facility are increased by making a axis with landmarks. The axis has to run through the entire care facility. By making use of a axis, the person with dementia will always arrive on this path. Along the axis should be placed landmarks.

The wake / sleep rhythm of people with dementia is distorted, confusion of the function of the bedroom on top of this is not desirable at all.

In the second stage of dementia the person will no longer recognize today things as such, as a result they panic. Therefore it is recommended to divide the care facility in different living groups.

There must be different spaces with a diverse stimulus, for the different needs of stimuli for people with dementia.

The use of contrast and a balustrade can help people with dementia to understand the layout of a room in one quick look.

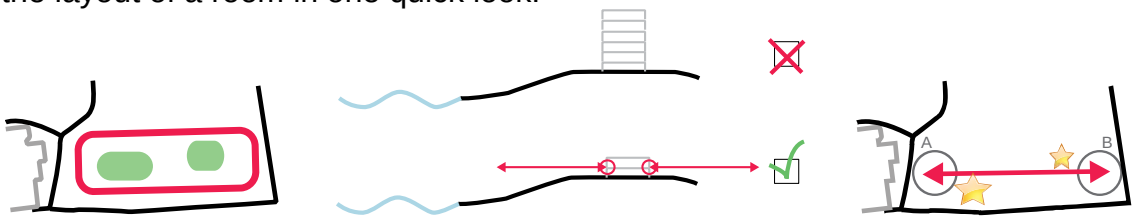

Figure 2. A ‘care neighborhood’ with a low threshold to the outside. An axis with landmark should be used to increase clarity and visibility of the ‘care neighborhood’.

Figure 3. Create a separation of functions (especially sleeping and living), living groups, and rooms with and without stimuli.

Figure 4. Contrast and a balustrade can help with a clear overview of a room.

Light is important for orientation in a room. In the living room a minimum of 300 lux is required for general orientation, for more requirements see Tabel 1.

The differences between two adjacent rooms should not exceed 300 lux (daylight factor of 3%). Older people have more trouble getting used to abrupt changes in luminance.
Rooms with windows only on one side should be carefully designed. When they are too deep, the light won't penetrate the whole room. There should also be ensured that there are not too many obstacles that prevent light penetration, such as trees, overhangs or even closed.
Artificial light should not be given any unnecessary contrast in the visual field. Therefore it should preferably be designed in line with the ceiling. The use of blue light for artificial light should be avoided due to the yellowing of the lens. To control the circadian rhythm in the 24-hour rhythm people with dementia should be exposed to bright light (>2000 lux) in the mornings.

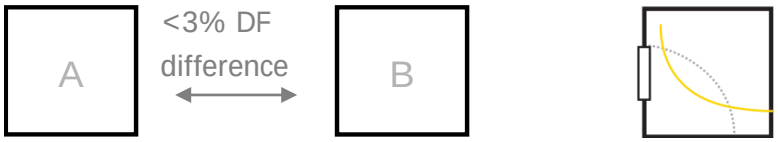

Figure 5. The difference between two adjacent rooms should not exceed a daylight factor of 3%. Rooms with windows at only one side should be wide but not deep.


Figure 6. The artificial light should be in line with the ceiling and the use of blue light for artificial light should be avoided.

The neighborhood
In the design we have chosen to make an open care, allowing the residents a lot of freedom. The residents can easily and independently walk in and out the home. To ensure safety it's a closed premise. This is done by the houses, winter gardens (greenhouses) and incrementing the dune. The closed premise is design as a real neighborhood or small town. Thereby keeping the demented in contact with the outside world. To ensure it is recognized like a small town certain elements are used. A city is made by streets, squares, parks and homes. In addition, each city has a center with offices and shops. At the center is also a large landmark of the city, such as a church. Besides the big landmark a city has several smaller landmarks, such as special buildings, artwork e.d. The care facility is designed with the same elements, making the care facility a 'care neighborhood'.

The dune has a key role in the design. The dunes provide a degree of security and tranquility. It indicates places where people can retreat or clearings for encounters. To preserve the dunes the houses are placed under the dune. This also gives a certain degree of security in the home. From outside the resident has limited view of the house, making it seem as if they are in an untouched dune landscape. Dunes can also be formed manually creating focused view. Thus there can be determined what is seen from certain points.

Landmarks
There is one big landmark in the care neighborhood and four smaller ones. They are all made of the same material which makes it one unit with the same function; creating clarity and recognition for the residents.

The big landmark is the centre of the care neighborhood, and seen from far. It contains shops, a supermarket, different group clubs, a hairdresser, offices and medical services. There is also a small hotel for overnight guests and a restaurant.
The four smaller landmarks are located between two houses. The houses are designed so that the landmark is seen from every room inside the house. Because the resident has a constant view to this landmark it remains in the subconscious. The landmarks in the dune gardens are quite large and therefore quickly visible from the axis of the care neighborhood.

Houses
The houses consist of a head and a tail. In the head is the living room, and in the tail are 6 bedrooms. All the 6 bedrooms are in one hallway. This means there is only one door in the living room, which provides clarity for the residents. In addition, the hard separation of living and sleeping give the residents a clear pattern.
The houses are designed towards the landmarks. The direction of the house is emphasized by beams in the direction of the landmark that remain visible. These beams are made of wood and are made larger than is actually needed, making them notable elements in the room.

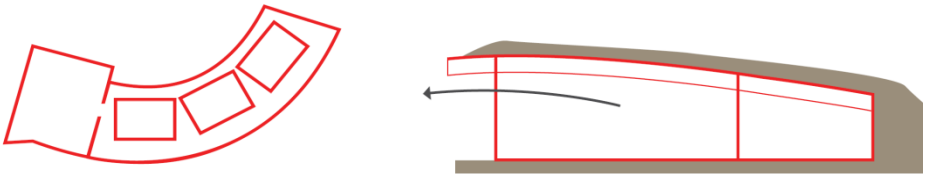

Figure 7. The houses consist of a livingroom and 6 bedrooms with beams towards the landmarks.

Solar chimney
Because the residents benefit from clarity and brightness they are manipulated with light in the home. People are instinctively attracted to light, this is a mechanism for survival. This is also called the `photoytopism'. People can be guided by a path of light.

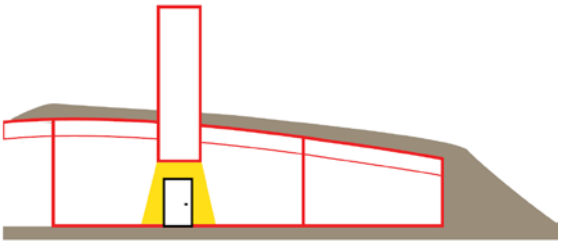

Figure 8. Solarchimney to guide people with natural light

A solar chimney is placed above each door in the homes. Because of this the area around the door had a higher illuminance. As a result the resident is automatically drawn here, and therefore do not have to wonder where the exit or entrance of the room is.

DISCUSSION

As an graduate program a 'care neighborhood' with wayfinding with light is presented. It showed that by combining different aspects people with dementia can experience freedom with guidance through natural lightning. Therefore giving them a new and improved living environment. This study, did not result in a real-life design

and this proposal for a 'care neighborhood' with (smart) wayfinding with light was not actually built and tested. Therefore, it cannot be concluded that this study resulted in designing solution. Potentially, this study can hand out pointers and design aspects that can be included in a real-life design.

CONCLUSION

A new building for improving quality of life for people with dementia is presented. People with dementia can express more behavioral and mood problems due to a bad environment . A combination of measures was defined to improve the quality of the indoor environment. This list of design guidelines are taken as the basis of the new design. The overall goals of the study was to design an improved living environment with a focus on light, that meets the need of elderly with dementia, and thus improve their quality of life. Potentially, his study can hand out pointers and design aspects that can be included in a real-life design.

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REFERENCES

Aarts, M, et al (2011) Lighting design for institutionalized people with dementia symptoms. Symposium Proceedings Light & Care 2010, 20-24. 2011. Eindhoven. 2010.

Boyce, P.R. (2003). Lighting for the elderly. Technology and disability. (2003)165-180

Campbell, S., et al. (1998). "Exposure to light in healthy elderly subjects and Alzheimer's patients", Physiology & behavior. (1998)42: 141-144

Hoof, J., et al. (2008). "The indoor environment in relation to people with dementia"

Plaats, van der A. (2008). De wonderlijke wereld van dement zijn. Amsterdam, Elzevier Gezondheidszorg.

Stroobants, E., Verhaest, P. (2012). Architectonica. Een thuis voor mensen met dementie. Bechem, Epo uitgevers.

Someren, E. et al. (1997). "Indirect Bright Light Improves Circadian Rest-Activity Rhythm Disturbances in Demented Patients". Society of Biological Psychiatry. (1997)955-963

Verdult, R. (2003). De pijn van dement zijn. Amersfoort, ThiemeMeulenhoff bv.

Wu, Y-H, Swaab, D.F. (2007). "Disturbance and strategies for reactivation of the circadian rhyth system inaging and Alzheimer's disease", Speel Medicine (2007)8:623-636

http://www.omgevingspsycholoog.nl/dementie-nep-bushalte (Found: 02-01-2015)