

Towards adaptive patient rooms

Co-creation with stroke patients

Currently, most hospital patient rooms are highly institutionalized environments that confine patients to an artificial and unfamiliar environment. They provide little opportunity to adapt this environment to individual requirements although it is well known that the healing process is affected by environmental stimuli in the hospital. For example, from literature we know that access to (rendered) nature views helps to increase the tolerance for pain (Grinde & Patil, 2009; Ulrich et al., 2004; Ulrich, 1984), has a positive effect on short-term recovery from stress and mental fatigue (Ulrich et al., 2004; Ulrich, 1984) and can accelerate the physical recovery from illness (Velarde, Fry & Tveit, 2007).

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Not only nature views, but also exposure to daylight is found to be an important factor in the recovery process. Patients exposed to sufficient daylight are less stressed and seem to need less pain medication (Walch et al., 2005). Bright daylight exposure during daytime and avoidance of too much light exposure during night-time helps to sleep better at night (Wakamura &



Figure 1. Waking-up phase, Doctor's visit during Clinical-care phase, Visitors phase and Going-to-bed phase

and staff

Tokura, 2001) and to feel more energized during the day (Bringslimark, Hartig, & Patil, 2009).

Our research concerns the design and development of patient healing environments and especially for patients who are recovering from a stroke. A stroke event has a large impact on a patient physically, cognitively as well as psychologically (Hafsteinsdóttir & Grypdonck, 1997). To obtain insight into the needs and requirements of stroke patients and their medical environment, a contextual research in two neurology departments and rehabilitation centers was conducted (Daemen et al., 2011). From these findings we could generate a substantial number of potential modifications to the patient environment that could have a positive impact on the healing process of the patients and the work environment of the staff. Several concepts were developed and evaluated with the staff of four hospitals to select the most promising and viable ones for further development and prototyping. These Adaptive Healing Room concepts have now been prototyped and are installed in Philips Experience Lab for further evaluation and iterative design and development. One of these concepts is the Adaptive Daily Rhythm Atmosphere (ADRA). The evaluation of this system with hospital staff and former patients is presented in this paper.

Adaptive Daily Rhythm Atmospheres

The ADRA system provides a daily rhythm atmosphere that is optimized for the patient's needs, is in sync with the care

agenda, and can adapt intelligently to deviations thereof. ADRA supports the daily rhythm of the patient by generating dedicated multisensory atmospheres for different phases throughout the day that consist of controlled light, audio, and video parameters. The total room can be set in a high, medium or low stimulus mode, with dedicated daily rhythm atmospheres for each mode. It is hypothesized that by using ADRA the rigid environmental conditions in the patient room will be alleviated; thereby better supporting the healing process of the patients. We established that the day of a patient in a neurology ward typically consists of 8 distinct phases: Waking up, Breakfast, Clinical care, Lunch, Rest, Visitors, Diner and going to bed, and Sleep. Each phase has a special combination of light, sound and view settings designed to optimally support the patients circadian rhythm and current activities, and a defined time frame during which it is active.

For a video showing the different phases, see Philips Research, 2011.

The ADRA system is a context-aware system based on time of day as well as sensor input about person location and patient activities. It consists of electrically operated window curtains, and a PatientWall in front of the patient containing two RGB light covers and three multi-media screens. The left multi-media screen is used to provide orientation information, such as day of the week and time, the middle screen is used to show specially designed nature



images and movies, and the right screen is used to support connectivity with the outside world, by showing personal photos and drawings. Furthermore, the ceiling of the room contains an Artificial Skylight. This gives the impression of daylight entering the patient room through a skylight in the ceiling. It is a novel lighting solution that provides a unique combination of sunny white light and an infinite blue sky view in a window frame structure. Figure 1 gives an illustration of the active room. Note that this configuration has been designed for single patient rooms, in view of the strong trend towards applying such rooms in new built hospitals, particularly in the US. However, it can be reconfigured to suit, for example, double patient rooms. For technical details on the context-aware ADRA system and its implementation, we refer to Flinsenberg et al., 2011. This system was evaluated with former patients as well as with hospital staff.

Hospital staff and patient evaluation

The goal for the evaluation of the different phases of the ADRA concept was to obtain qualitative and quantitative feedback to determine if the conditions in the different phases are useful, usable and desirable for the healing process of the patient and workflow of the hospital staff. We conducted separate sessions with hospital staff and former patients. Because we tested the patient room in the hospital laboratory setting and not in a real hospital, it was paramount to find a group of participants that could represent the hospitalized stroke patients. In cooperation with the national stroke center of the Netherlands a group of six stroke patients was recruited to participate in the evaluation of the patient room. In addition we invited medical staff from different departments from different hospitals, being neurology, rehabilitation and geriatric departments, to our laboratory environment. In total 35 hospital staff members participated with different functions, incl. neurologists, nurses and therapists. These evaluations were set-up as pilot tests in a laboratory setting to refine the concept and to prepare for a clinical trial.

After signing informed consents, the staff groups were guided to the Adaptive Patient Room where they could experience it themselves. Then, the participants were seated next to the patient bed so they had a similar viewing angle as actual patients would have. The participants received a booklet with questionnaires addressing the expected influence on the healing process of the patient and the expected influence on the staff workflow. All concepts and ADRA phases were then presented, and anonymously rated on a 7 point Likert scale. In addition, participants were asked to motivate their ratings in writing. Subsequently, a focus group discussion took place, recorded by two note takers. Sessions took about 3 hours in total. Quantitative results

were analyzed for significance with the non-parametric Kruskal-Wallis test.

The evaluation with former patients and their spouses was similar. The main differences were joint scoring by each patient and his or her accompanying spouse, and the use of a 10 point Likert scale specially designed for stroke patients. The patient sessions lasted 1 hour. In interpreting the results, we have to take into account that former patients after a traumatic experience are probably likely to respond positively due to the attention and special circumstance of being invited to a research laboratory. For details on the experimental setting, see (Daemen et al., 2013b).

Findings from hospital staff evaluation

The results show that hospital staff expects a positive effect on the healing process of the patient of the different ADRA phases. Staff members from different healthcare institutions and with different professional roles agreed on most aspects. In addition, the staff also expected a positive effect for almost all phases on the efficiency of the clinical workflow. This is a very promising result. It shows that careful consideration of both patient and staff needs emerging from context studies enables the design of patient centered solutions that may prove not to negatively impact staff workflow, or even improve it (Daemen et al., 2013b).

According to the hospital staff members the ADRA phases were a good example of a patient centric approach. For example, one of the participants expressed it as follows: 'It is tailored around the patient. In the past we tailored everything to the doctor, but it is very important to tailor it to the patient.' To illustrate this, consider the waking up phase. From the context studies we learned that nowadays when nurses enter the room in the morning, patients are often still asleep and nurses need to wake them. Patients are thus woken up very abruptly, and feel their privacy is invaded and therefore can be grumpy and even aggressive. According to participants the ADRA waking up phase will prevent this. Furthermore, it would also be beneficial for the workflow because patients are expected to be more cooperative

The participating hospital staff members believed that the consistent schedule imposed by ADRA would have a positive effect by giving more structure in the day for the patients. They expect that it allows the patient to identify the phase of the day and therefore to be able to anticipate what is coming, for example, breakfast or lunch. As one of the nurses mentioned: 'I believe it is nice that the patient gets the time to prepare – now he doesn't get that time...' According to the staff the use of an imposed rhythm would reduce the likelihood that patients reverse their day and night rhythm.

Hospital staff also indicated that the room was giving the right number of stimuli over the day. For example, in the clinical care phase we provided a distraction free envi-

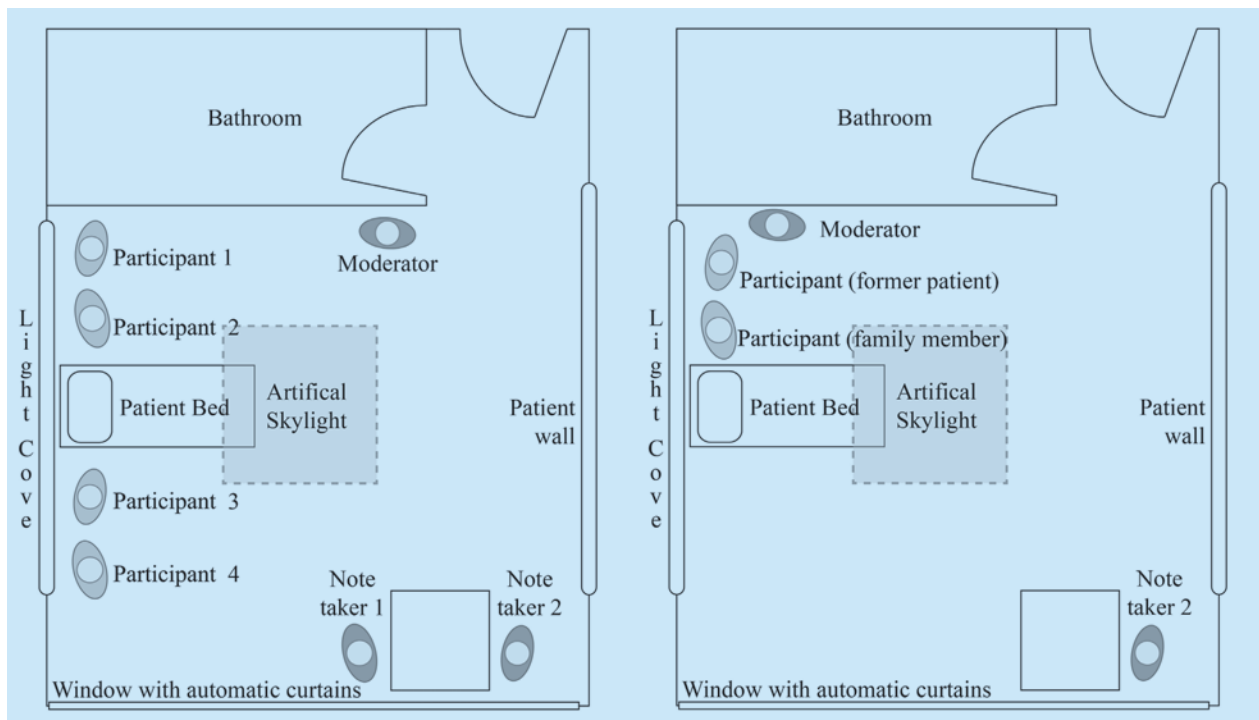


Figure 2. Set-up for study with hospital staff (left) and former patients (right)

ronment with a light boost of the artificial skylight. Staff expected that the light will work as an activating agent and that this is beneficial for the therapy. As one of the department managers mentioned: 'Clinical examination and nurse activities are enhanced by a patient that is more awake.' On the other hand staff indicated that the clinical phase lasts too long and therefore becomes boring, and that the atmosphere is too cold. The two therapists indicated that they would like to have a cozier atmosphere to enable building a trustworthy relationship with the patient.

The hospital staff was missing options for personalization and the possibility for patients to control certain settings of the room. According to them, patients had to be able to choose the images, sound and light settings, albeit to a limited extent. The amount of control should be tuned to the patient capabilities, because depending on the severity of the stroke and their recovery progress, patients may or may not be able to handle certain control options. They also believed it was important to give patients the possibility to watch tv on the screen in front of the patient. Furthermore, the staff indicated that the system should be designed around the hospital program and not the other way around. As one of the neurologists said: 'My hospital is not a hotel.' So a good balance between personalization and generalization is necessary.

Findings from former patient evaluation

The waking up phase was appreciated the most with a mean score of 8 (on a 10-point Likert scale) and a standard deviation of only 1,09. Patients indicated that it would be nice to be woken like this. 'I like nature – such a nice idea to

show nature views in the morning – When you are a little bit better when you like nature this is really fantastic – It gives the feeling that life is still worth fighting for.' Some participants indicated that if they are woken they need to go to the toilet, so half an hour would be too long. In addition participants indicated that the nature views should be adaptable towards the preferences of the patients.

The visitor phase scored the lowest with a mean score of 5,3 and a relatively high standard deviation of 2,65. Two patients scored 8, but also two patients gave a score of 1 and 4 to this phase. The reasoning for that is that the participants who scored low didn't have good family contact, so for them a visitor phase would not be beneficial and would even have a negative effect by letting them think of family not visiting. In addition these participants mentioned that visitors might look more at the screen than pay attention to them. They indicated that the PatientWall should work in the background. As one patient was indicating: 'When I was in the hospital I found too many visitors often too busy. This room might have the effect that visitors stay too long.' Patients who scored high had a good family contact and therefore would appreciate this atmosphere.

The results show that overall former patients are positive about the different ADRA phases that provide a clear daily rhythm structure during the day, but some changes should be made. In general participants appreciated the patient room. They all indicated that this would have helped them during their stay. As one patient mentioned it: 'When I was in the hospital ... I didn't see anything positive ... the only focus was on me, to get me better again. This room

is positive and will help me to be positive.' Some patients mentioned that the room would help them in the end of their hospitalization, but for the initial days in the hospital it would create too many stimuli. 'A patient is really away the first days ... light can be very disturbing in the beginning ... you want peace of mind the first days.' Another remark was that when you are in the hospital you don't have much control over the environment. It would be nice to get more control over the environment.

Conclusion and discussion

The hospital staff and former patient evaluation in the laboratory setting gave us an indication of the likely impact of the Adaptive Patient Room. Both user groups saw the possible positive effects of the ADRA system. Furthermore, this laboratory evaluation of the concepts was an important step that enabled to improve the shortcomings of the current concept before starting clinical trials. For example, both former patients and hospital staff expressed the need for personalization of the room.

An evaluation by actual patients requires a clinical study. Also, the laboratory setting is an approximation for the actual setting, but lacks aspects such as crowdedness and stress, which participating staff has to factor in from own experience. However, setting up the laboratory study proved very valuable, as it helped to identify expected effects and shortcomings in a much earlier research phase. It also enabled generating feedback from different departments from different institutions, that all expect similar added values of the ADRA concept. This allowed generalizing the findings to other institutions, which would not have been possible when moving directly into a clinical trial, which typically provides feedback from a single site only.

In addition, the laboratory evaluations helped to make hospitals enthusiastic to participate in a subsequent clinical trial because they could experience the concepts first hand and anticipate the added value.

We have to state that this was only a pilot study because of the low number of participants. With regard to future work, the adaptive patient room will be tested with patients in a hospital setting, after implementing the lessons learned.

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References

- Bringslimark, T., Hartig, T., & Patil, G.G. (2009). The psychological benefits of indoor plants. *Journal of Environmental Psychology*, 29(4), 422-433.
- Daemen, E.M.L., Cuppen, R., Flinsenberg, I., Loenen, E. van, & Rajae-Joordens, R. (2011). Contextual Research for Healing Patient Rooms Design. In: *Proceedings of the First European Conference on Design4Health 2011*, Sheffield, 95-110.
- Daemen, E.M.L., Cuppen, R., Flinsenberg, I., Loenen, E. van, & Rajae-Joordens, R. (2013a). Adaptive Daily Rhythm Atmospheres for stroke patients: A staff evaluation. In: *Proc. Pervasive Health 2013*, Venice, 121-128.
- Daemen, E.M.L., Behere, S., Cuppen, R., Facey, J., Flinsenberg, I., van Loenen, E., & Rajae-Joordens, R. (2013b). Creating an adaptive healing room for neurology patients. *World Health Design* Jan.2013, 72-77.
- Flinsenberg, I., Cuppen, R., Loenen, E. van, & Daemen, E. (2011). Context-Aware System for Neurology Hospital Wards. *Lecture Notes on Computer Science*, 83, 366-373.
- Grinde, B., & Patil, G.G. (2009). Biophilia: does visual contact with nature impact on health and well-being? *International journal of environmental research and public health*, 6(9), 2332-43.
- Hafsteinsdóttir, T.B., & Grypdonck, M. (1997). Being a stroke patient: a review of the literature. *Journal of Advanced Nursing*, 26(3), 580-588.
- Loenen, E. van (2012). Towards smart healing environments. Presentation at the 1st Int. Conf. on Optimal Healing Environments, Rotterdam, 28-11-2011.
- Philips Research (2011). Adaptive Healing Room. <http://www.youtube.com/watch?v=1edIODuCXes>. Retrieved 31-1-2014.
- Ulrich, R., Quan, X., Zimring, C., Joseph, A., Choudhary, R. (2004). The Role of the Physical Environment in the Hospital of the 21st Century The Center for Health Design, 2004.
- Ulrich, R. (1984). View Through a Window May Influence Recovery from Surgery. *Science*, 224(21), 420-421.
- Velarde, M.D., Fry, G., & Tveit, M. (2007). Health effects of viewing landscapes, *Urban Forestry & Urban Greening*, 6(4), 199-212.
- Wakamura, T., & Tokura, H. (2001). Influence of bright light during daytime on sleep parameters in hospitalized elderly patients. *Journal of physiological anthropology and applied human science*, 20(6), 345-51.
- Walch, J.M., Rabin, B.S., Day, R., Williams, J.N., Choi, K., & Kang, J.D. (2005). The effect of sunlight on postoperative analgesic medication use: *Psychosomatic medicine*, 67(1), 156-63.

Abstract

This article describes research into a new type of patient room, designed to be adaptable to the changing needs of patients during their hospital stay. We initially focus on stroke patients. The concept is being developed through a fully user centered design process, whereby patients and hospital staff are involved in all phases, from the early insight generation research up to the final clinical tests. To analyze as early as possible in the process if the concept will adequately address the needs identified in the insight phases, a fully functional prototype of this Adaptive Healing Room has been built in a laboratory setting, and evaluated with staff from different hospitals and with former stroke patients. The results of these evaluations are presented here. They show that the concept is very promising: staff as well as patients expect positive effects of virtually all features designed to support patients orientation and recovery. They also provide unexpected new insights, which will be used to further improve the concept.