Adaptable Healing Patient Room for Stroke Patients

A Staff Evaluation

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Adaptive systems, user experience evaluation, stroke, healing environments, patient room

Summary
Introduction: This article is part of the Focus Theme of Methods of Information in Medicine on "Pervasive Intelligent Technologies for Health".

Background: This paper addresses the evaluation with hospital staff of an in-patient environment that supports patients, family, nursing staff and medical specialists during the recovery process of neurology patients and especially patients recovering from a stroke. We describe the methods that were used to evaluate the Adaptive Daily Rhythm Atmospheres (ADRA), Artificial Skylight (AS) and Adaptive Stimulus Dosage (ASD) concepts.

Objectives: The goal of this evaluation was to gather qualitative and quantitative feedback from hospital staff about the usefulness, the usability and desirability of the Adaptive Daily Rhythm Atmospheres (ADRA), Artificial Skylight (AS) and Adaptive Stimulus Dosage (ASD) concepts that were implemented as different phases of a novel healing patient room. This paper reports the effects of these concepts with regard to 1) the healing process of the patient and 2) the workflow of the staff. These results are part of a larger R&D project and provide the initial feedback in an iterative user-centered design methodology.

Methods: After signing informed consents, the group of participants was taken to the laboratory environment where they were introduced to the Adaptive Healing Environment Patient Room and where they could also experience the room. Then, the participants were seated next to the patient bed so they had a similar viewing angle as the patients. The participants received a booklet with questionnaires. The items on this questionnaire addressed the influence on the healing process (i.e., the possible effect of such a concept/phase has on the healing process of the patient, meaning faster recovery, better sleep and enhanced well-being) and influence on the workflow (i.e., the possible effect the concept/phase has on the workflow of the staff in the ward). We presented every concept (AS and ASD) and all the phases of ADRA. After every presentation of the concept or phase of the ADRA system the participants rated the concept or phase anonymously on a 7-point Likert scale. In addition to rating the phase in the therefore designed booklets, they were also asked to motivate their ratings in writing. Subsequently, a focus group discussion took place. During the discussion the two note takers wrote down all the comments. Afterwards the quantitative results were analyzed with the non-parametric Kruskal-Wallis test. Significant effects were further analyzed in a post-hoc Mann-Whitney test.

Results: The results show that hospital staff expects a positive effect on the healing process of the patient for the Artificial Skylight, the Adaptable Stimulus Dosage concept and the different ADRA phases that provide a clear daily rhythm structure during the day. In fact the 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, also for the AS and ASD concepts. This is a very promising result as the phases were designed primarily with the healing effect of the patient in mind.

Conclusions: The hospital staff evaluation in the laboratory setting gave us an indication of the likely impact of the Adaptive Healing Environment Patient Room on the healing progress of patients. 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. In addition, we generated feedback from different departments from different institutions, which suggest that they all see similar added values for the patient room.
1. Introduction

This paper addresses the evaluation with hospital staff of an in-patient environment in which pervasive computing technologies are utilized to design a healing environment that supports patients, family, nursing staff and medical specialists during the recovery process of neurology patients and especially patients recovering from a stroke. We describe the methods that were used to evaluate the Adaptable Healing Patient Room (AHPR) with hospital staff and present the quantitative and qualitative results. Two objectives were considered for these evaluations: 1) to improve the patient’s recovery process and 2) to support the hospital staff in stroke care units. The evaluation results are used to further improve the design of the Adaptive Healing Patient Room (AHPR).

The concepts that are implemented in the Adaptive Daily Rhythm Atmospheres system were derived from findings in the literature on effects on the healing and recovery process and from our user requirements gathering work. It is well known that the healing process is affected by various environmental stimuli in the hospital. For example, there is clear evidence for a positive effect of nature on healing. From literature [1–5], we know that access to (rendered) nature views, as well as the presence of indoor plants, helps to increase the tolerance for pain and reduce the use of pain medication. Contact with nature also has, to a certain extent, a positive effect on short-term recovery from stress and mental fatigue [1–5], and may accelerate the physical recovery from, for example, elective cervical and lumbar spinal surgery [5, 6]. 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 [7]. Bright (artificial) daylight exposure during daytime and avoidance of too much light exposure during nighttime helps patients to sleep better at night [8] and to feel more energized during the day [9]. Especially a deep restorative and undisturbed sleep is of high importance for a fast recovery process in patients. Lately, a great number of hospitals have chosen to provide more single bedded rooms to patients because there is growing confidence and evidence that these rooms have a positive effect on patients. Private patient rooms have become the industry standard in the United States because they better facilitate patient care and management, afford greater therapeutical benefits for patients [10, 11], and may reduce the rate of hospital-acquired infections, although conflicting results have been found. Also in Europe, there is a tendency to provide only single rooms to patients for these reasons.

Today, most hospital patient rooms remain highly institutionalized environments that confine patients to an artificial and largely alien world and provide little opportunity to adapt the environment to individual patient requirements. To gain more insight into the actual needs of patient healing rooms, we conducted contextual research at several hospitals.

The object for this contextual research was to gain knowledge about stroke patients, their medical environment, and the neurology ward by addressing questions like: What do these patients and clinical stakeholders experience? What are their feelings and emotions? What do we know about the neurology ward? To answer these questions, we carried out contextual research in two neurology departments and rehabilitation centers. These visits provided us a way to gather first-hand knowledge on how care is currently delivered and experienced by all involved stakeholders, i.e., everybody with a task in and around the patient’s bed, and on the context in which these activities take place. These visits focused on the environment of single patient hospital rooms and on all relevant aspects that could be instrumental to enhance the healing process by means of context-related adaptations in the environment. For this, we started with a guided tour, followed by the main field research methods: shadowing stakeholders, doing observations, environmental analysis, and interviewing stakeholders. Immediately after each activity, the data were analyzed and visualized in an experience-flow [12]. We concluded both field studies with a multi stakeholder session where we confronted all the stakeholders with the initial user requirements that were derived as outcomes of our analyses. This knowledge and understanding resulted in a collection of initial user needs and requirements that can be used to develop potential solutions addressing the needs of both patients and staff. This process and the methods that were used to collect these initial user needs and requirements are reported in [12].

A major finding after observing patients and talking to medical staff (neurologists and nurses), was that stroke patients are at high risk to suffer from disorientation, confusion and delirium. This implies that they have a strong need for orientation in time and place. Furthermore, they need a clear and strict daily structure and support to maintain a healthy sleeping pattern. These observations are confirmed by the medical staff of neurology departments and rehabilitation centers for stroke, brain injury, and brain infection. However, the current conditions in hospitals are static regardless of the patient’s needs or care activity schedule. Another finding was the importance of establishing the right balance between a clinical environment and a personal environment for all people involved. For example, patients and their family need personal spaces for privacy purposes and to escape, re-energize, and relax from all invasive and emotional draining activities, but the room should also provide a clinical environment whenever a medical action is to be performed. These issues are particularly relevant given that stroke patients typically stay longer in the hospital than many other patient groups. Furthermore, patient rooms also need to facilitate an optimal working environment for the hospital staff.

These findings from the site visits combined with the established healing effects from literature provided the base for the generation of concepts that could potentially be applied to improve the healing process. From a total of 21 concepts that were further worked out for internal evaluation, a subset of about ten concepts was proposed to the staff of four hospitals. Based on their input four concepts were selected for further development. These adaptive healing room concepts have now been prototyped and are installed in our laboratory environment for further evalu-
2. Adaptable Healing Room Concepts

The Adaptable Healing Room consists of three main components: Artificial Skylight (AS), Adaptive Daily Rhythm Atmosphere (ADRA) and Adaptable Stimulus Dosage (ASD). We created a patient room in our laboratory environment and have installed a light cove behind the patient bed, electrically operated window curtains, and a Patient Wall (PW) in front of the patient containing two RGB light coves, two sound boxes integrated in the panel and three multi-media screens. The Patient Wall consists of an Orientation Screen (OS), Artificial View Screen (AVS) in the middle and Connectivity Screen (CS) on the right. The OS is displaying a digital or analog clock depending on the patient capability to read digital or analog, date, name of hospital, and welcoming word towards patients e.g. “Good morning Mrs. Smith.” The AVS is displaying nature views tailored towards the condition of the patient during the day and the CS is displaying pictures and drawings that family members and friends have uploaded. Figure 1 gives an illustration of the set-up.

2.1 Adaptive Daily Rhythm Atmosphere

The Adaptive Daily Rhythm Atmosphere (ADRA) supports the daily rhythm of the patient during the different phases throughout the day by generating dedicated multisensory atmospheres through manipulating light, audio, and video parameters. Where needed, the atmosphere can adapt to specific interrupts and visits, for example, when a doctor is visiting or a cleaner starts working. It is assumed that by using ADRA, the potential negative effects of the rigid environmental conditions in the healing room will be alleviated, because the system provides a daily rhythm atmosphere that is in sync with and optimized for the patient’s needs and the care agenda, and that intelligently adapts to deviations thereof. To implement this ADRA concept, we created a context-aware system based on sensor input concerning person location information, patient activities, and time of day. For more details, please refer to [14].

Many research efforts have focused on providing staff members with the right information at the right time. What constitutes ‘right’ information is determined based on the activity the staff member is carrying out. For example, the CISESE institute in Mexico has carried out a number of workplace studies in a public hospital, an overview of which is given by Favela et al. [15]. Based on the workplace studies, Sanchez et al. [16, 17] describe different methods for classifying activities of the hospital workers to enable context-aware communication between staff members. Bardram [18 –20] discuss a context aware hospital bed that displays relevant information for the nurse when administering medication by e.g. displaying the medication scheme, patient record, lighting the proper medication container, when the nurse and the medication container are close to the bed. Siewe et al. [21] show how this application can be formulated using context-aware calculus. Kjeldskov et al. [22] describe a prototype to support morning procedure tasks in a hospital ward by showing patients lists and patient information based on the location of the nurse and time of day. Weal et al. (23) and Cassens et al. [24] discuss the annotation of staff activities on a patient ward to facilitate further development of context-aware systems. The ADRA approach is fundamentally different compared to previously proposed systems, which focus on providing the hospital staff with the proper information. ADRA focuses on the patients by providing them with the proper healing environment based on their changing needs throughout the day during their stay at the hospital. In this way, ADRA goes beyond previous patient-focused work in the hospital, which mostly aims at patient monitoring, and handling of electronic medical records or personal health records, see for example [25–30].

Although the focus of our system is different from previously proposed systems, some of the technologies developed for other systems can be utilized. For example, existing person tracking technology, patient monitoring techniques, and context aware system design principles can be applied. The challenge is to create a robust yet flexible system that achieves our stated objectives while taking advantage of existing technology.

2.1.1 Details ADRA Concept

The goal of the Adaptive Daily Rhythm Atmosphere (ADRA) is supporting the daily rhythm of the patient. Therefore ADRA will generate dedicated multisensory atmospheres (e.g., light, audio, and video) for different phases throughout the day.

The following eight phases are identified in the system: 1) Waking up, 2) Breakfast, 3) Clinical care, 4) Lunch, 5) Rest, 6) Visitors, 7) Going to Bed, and 8) Sleep. Each phase has a defined time frame during which it is active. Note that the used times are determined based on the actual timing used by one of the hospitals we visited. Hospitals can of course adjust the scheduling to their needs. For a video showing the different phases, please consult [31]. We will now shortly describe the scenario for the different phases. These phases are based on the existing phases a patient goes through during the day in the hospital.

1. Waking up (07:30 – 08:00): At the start of the waking up phase the room is still dark and all lights, video, and audio are turned off. The room slowly prepares the patient for a gentle wake up by slowly increasing the light intensity in the room, such that it mimics a sunrise. When the light intensity is at its final level, a nature view slide show appears on the screen in front of the patient and an audio file with singing birds is played. Just a few minutes before eight o’clock, the window curtain furthest from the patient’s head will automatically open to allow natural outside daylight entering the room to light up the room without shining directly in the face of the patient. One minute later, the other window curtain follows. By the end of the waking up phase, the patient should be awake and be ready for breakfast and personal care.
2. Breakfast (08:00–10:00): Because stroke patients sometimes have trouble with swallowing, a still picture of a nature view replaces the video content to avoid distraction. For the same reason the audio is muted. Because light is such an important factor in the recovery of patients and to gently prepare the patient for the clinical care phase to come, we slowly increase artificial light intensity during breakfast. The light is also designed to be suited for personal care activities like washing and getting dressed.

3. Clinical Care (10:00–12:00): During clinical care the light intensity reaches its maximum level. This light in the room allows the doctors to examine the patient and the therapists to give therapy (Figure 1). The light is also beneficial to the patient as it increases their concentration and gives an activating feeling which should enable them to better remember the doctor’s instructions and complete their therapy. Furthermore, sufficient light exposure during the day can reinforce a healthy sleep rhythm. During this phase nothing will be shown on the screens and the privacy glass on the patient wall is turned on.

4. Lunch (12:00–13:00): Just like during breakfast, a still picture of a nature view is shown and the audio is muted, to allow the stroke patient to fully concentrate on eating. The light intensity is slowly reduced from its maximum level to a level similar to that during breakfast.

5. Rest (13:00–15:00): During rest one curtain closes to darken the room. The other curtain remains open to make a clear distinction between the afternoon rest and sleeping at night. During rest, the patient wall displays a video of a river with a mountain view with additional river sounds. The sound helps to mask noises in the corridor; the relaxing nature video should make the patient feel relaxed and reduce pain perception.

6. Visitors (15:00–20:00): In contrast with the clinical care setting, the visitor setting is cozy. We achieve this by creating colored light from the light coves and generating a nature picture on the screen. We know from other studies, that visitors tend to stay longer in patient rooms with a pleasant and cozy atmosphere. In general, patients benefit from social contacts (Figure 1).

7. Going to Bed (20:00–22:00): The room slowly prepares the patient to go to sleep by slowly reducing the light intensity and removing most blue light from the room, as blue light especially has an activating effect. A movie of a sunset is shown and again restful sounds are played to mask the sounds of the hallway (Figure 1).

8. Sleep (22:00–07:30): All the lights and the screens are turned off. Sufficient darkness during the night reinforces a healthy sleep pattern. When a nurse enters the room she is automatically detected and a dimmed light condition is created that just allows the nurse to visually inspect the patient and check medical parameters if necessary. The lights automatically turn off after the nurse has left the room. For a doctor, a higher light intensity condition is used because the presence of a doctor in a patient room at night indicates the patient has a severe medical problem.

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**Figure 1** Illustration of the laboratory set-up from left to right: Clinical Care Phase, Visitors Phase and Going to Bed Phase

**Figure 2** Adaptable Stimulus Dosage

<table>
<thead>
<tr>
<th></th>
<th>Low Stimulus Room</th>
<th>Medium Stimulus Room</th>
<th>High Stimulus Room</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Lighting</strong></td>
<td>Low contrast</td>
<td>Medium contrast</td>
<td>High contrast</td>
</tr>
<tr>
<td><strong>Patient Wall</strong></td>
<td>Orientation screen, Relaxation theme, family photos</td>
<td>Orientation screen, Relaxation Theme, Family Photos (with richer content)</td>
<td></td>
</tr>
<tr>
<td><strong>Daylight from Window</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Exterior Window View</strong></td>
<td>No</td>
<td>Diffused</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Skylight</strong></td>
<td>Off</td>
<td>On (75%) (selected times)</td>
<td>On (100%)</td>
</tr>
</tbody>
</table>
2.2 Adaptable Stimulus Dosage

From the context studies we not only learned that a patient room should be adaptive throughout the day, but also throughout the recovering process of a stroke patient. Patients that just got a stroke cannot handle noise and bright light. The patient room is adapted such that the contrasts and brightness are minimal, but to minimize the risk of delirium, the patient is exposed to a gently but clearly structured day/night rhythm with the ADRA system. For a patient later in his stay, stimulation is important for recovery.

Therefore the patient room electronically adjusts sensory load to the recovery state of the patient. Therefore we created a low, medium and high stimulus room (▶Figure 2). The medical staff needs to indicate in which state the patient is. By giving indication of patient status and condition the room will adapt according to that. The Adaptable Stimulus Dosage concept is an adaptable ambiences creation with optimal sensory load for healing including adjustable daylight, patient wall with adjustable colors and artificial nature view on hide able screens, noise damping and adjustable sounds. Low stimulus is designed for patient who can’t handle stimuli; the atmosphere provided has a low intensity light setting. Medium stimulus is designed for patients who can handle a few stimuli and high stimulus is designed for patient who can handle many stimuli and are often in the last period of their stay in the hospital.

2.3 Artificial Skylight

Daylight is known to be important for people’s health and wellbeing and has been associated with many positive effects, including improved mood, enhanced morale, lower fatigue, and reduced eyestrain [32]. Previous studies show that patients lacking sufficient daylight and appropriate views (e.g., at north sides or without nature views) have increased length-of-stay, pain medication use, or even higher morbidity rates [33–36]. Since in typical hospital environments it is not possible to give all patients sufficient daylight and appropriate nature views, we created an Artificial Skylight (AS) that provides supplementary sunny white light and blue sky views where and when needed.

The AS gives the impression of daylight entering the patient room through a skylight in the ceiling. It is an electric ceiling lighting solution that provides a unique combination of sunny white light and an infinite blue sky view in a window frame structure. Through angle-dependent spectral filtering of the light, the skylight appears blue.

3. Evaluation by the Hospital Staff

The goal for the evaluation of the different phases of the Adaptive Daily Rhythm Atmosphere (ADRA), the Artificial Skylight (AS) and the Adaptable Stimulus Dosage (ASD) with the hospital staff was to obtain qualitative and quantitative feedback to determine if the different phases of the ADRA, the AS and the ASD are useful, usable and desirable for the healing process of the patient and workflow of the hospital staff. This test was not a technical evaluation of the system. These evaluations were set-up as pilot tests in a laboratory setting to refine the concepts and to prepare the healing environment for a clinical trial. Since, clinical trials are very time consuming and labor intensive, it is important and extremely valuable to pre-test all the concepts in the laboratory to optimize the procedures for the clinical trial and to ensure that all aspects for the trial are valid. In addition, by conducting this laboratory study we also could obtain feedback from different hospitals and departments that are involved in the overall project, whereas with a clinical trial we would only get results from staff and patients from one particular hospital department and setting. Hence this laboratory study allows us to judge the differences between departments and hospitals. And above all, it enables the implementation of this user feedback in the iterative design cycle.

3.1 Set-up of the Laboratory Hospital Room

▶Figure 3 shows the set-up of the laboratory hospital room that was used for the evaluation. The task of the moderator was to lead the session. Two note takers participated to write down all the spoken feedback the participants gave. A maximum of four participants took part in each session of the evaluation process. Participants had to take place next to the patient bed, so they had a similar view as the patient. The moderator was standing on the left side and two note takers took place at the table on the right. At this position they were not blocking the view of the participants.

3.2 Participants

We invited medical staff from different departments from different hospitals, being neurology, rehabilitation and geriatric departments to our laboratory environment. They came in groups of 2–4 persons per session as a single group for each hospital department. The group session was selected because we hoped to learn from the discussion and interaction between the different staff members that are responsible for different functions in the care process (e.g., nurses, doctors, managers). Furthermore, since the entire evaluation session takes on average about 3 hours, the staff members were more willing to participate as a group than they were individually. The participants came from four neurology departments (9 nurses, 5 neurologists and 3 department managers), three rehabilitation departments (4 nurses, 2 rehab specialists, 1 department manager and 2 therapists), and one geriatric department (2 nurses, 1 geriatric specialist, 1 department manager). We had 30 participants in total who had on average 13 years of experience.

3.3 Methodology

After signing the informed consent, the group of participants was taken to the laboratory environment where they were introduced to the Adaptive Healing Environment Patient Room and where they could also experience the room. Then, the participants were seated next to the patient bed so they had a similar viewing angle as the patients. The participants received a booklet with questionnaires. The items on this questionnaire addressed the influence...
on the healing process (i.e., the possible effect the concept/phase has on the healing process of the patient, meaning faster recovery, better sleep and enhanced well-being) and influence on the workflow (i.e., the possible effect of such a concept/phase on the working activities of the staff in the ward). We presented every concept (AS and ASD) and all the phases of ADRA. After every presentation of the concept or phase of the ADRA system the participants rated the concept or phase anonymously on a 7-point Likert scale. In addition to rating the phase in the therefore designed booklets, they were also asked to motivate their ratings in writing. Subsequently, a focus group discussion took place. During the discussion the two note takers wrote down all the comments. Afterwards the quantitative results were analyzed with the non-parametric Kruskal-Wallis test. Significant effects were further analyzed in a post-hoc Mann-Whitney test.

3.4 Quantitative Findings

First we looked at the data per department. In Table 1 and Table 2 the mean scores of the Impact on Healing and the Impact on Workflow per department as well the overall means scores are depicted. As can be seen, the overall means range between 5.07 and 6.00 indicating that the three different departments (neurology, rehabilitation and geriatrics) rated all the implemented ADRA phases, the Artificial Skylight and the Adaptable Stimulus Dosage as having a positive impact on Healing and Workflow. No difference in scoring behavior was found between the three departments, except for the Impact on Healing in the phase Visitors ($\chi^2(2) = 7.169; p < .05$). Post-hoc Mann-Whitney tests revealed that the significant effect was caused by the fact that the neurology departments rated this phase significantly higher than the rehab centers ($Z = -2.571; p = .010$).

Next we looked at the data per function. Table 3 and Table 4 show the mean scores of the Impact on Healing and the Impact on Workflow of all different functions, i.e. department manager, geriatrician, neurologist, nurse, rehabilitation specialist, and therapist. Overall, the impact of the implemented ADRA phases, the Artificial Skylight and the Adaptable Stimulus Dosage on Healing and Workflow was rated as positive with mean scores ranging from 5.07 to 6.00. The scoring behavior was found to be equal between the six different functions, except for the Impact on Workflow in the phase Lunch ($\chi^2(5) = 16.264; p < .01$). Post-hoc Mann Whitney tests revealed that this significant effect was due to the fact that nurses rated this phase significantly higher than dep-

Table 1 Mean scores of Impact on Healing per department

<table>
<thead>
<tr>
<th>Organization</th>
<th>Skylight</th>
<th>ADRA Waking up</th>
<th>ADRA Breakfast</th>
<th>ADRA Clinical Care</th>
<th>ADRA Lunch</th>
<th>ADRA Rest</th>
<th>ADRA Visitors</th>
<th>ADRA Sleep</th>
<th>ADRA Sensing</th>
<th>ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurology</td>
<td>5.82</td>
<td>5.87</td>
<td>5.47</td>
<td>5.59</td>
<td>5.56</td>
<td>5.69</td>
<td>6.00</td>
<td>6.00</td>
<td>6.12</td>
<td>6.09</td>
</tr>
<tr>
<td>Rehab</td>
<td>5.78</td>
<td>6.00</td>
<td>5.29</td>
<td>4.89</td>
<td>4.86</td>
<td>5.75</td>
<td>5.33</td>
<td>5.83</td>
<td>5.83</td>
<td>5.88</td>
</tr>
<tr>
<td>Geriatrics</td>
<td>6.00</td>
<td>5.75</td>
<td>5.25</td>
<td>4.50</td>
<td>5.00</td>
<td>5.75</td>
<td>5.25</td>
<td>6.00</td>
<td>5.75</td>
<td>6.00</td>
</tr>
<tr>
<td>Overall</td>
<td>5.83</td>
<td>5.89</td>
<td>5.38</td>
<td>5.29</td>
<td>5.30</td>
<td>5.71</td>
<td>5.67</td>
<td>5.96</td>
<td>6.00</td>
<td>5.96</td>
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<tr>
<td>$\chi^2(2)$</td>
<td>0.297</td>
<td>0.380</td>
<td>0.248</td>
<td>1.543</td>
<td>4.893</td>
<td>0.179</td>
<td>7.169</td>
<td>0.467</td>
<td>1.190</td>
<td>0.594</td>
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<tr>
<td>P-value</td>
<td>0.862</td>
<td>0.827</td>
<td>0.884</td>
<td>0.462</td>
<td>0.087</td>
<td>0.91</td>
<td>0.028*</td>
<td>0.792</td>
<td>0.551</td>
<td>0.743</td>
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</table>

* P < 0.05
Table 2  Means scores of Impact on Workflow per department

<table>
<thead>
<tr>
<th>Organization</th>
<th>Skylight</th>
<th>ADRA Waking up</th>
<th>ADRA Breakfast</th>
<th>ADRA Clinical Care</th>
<th>ADRA Lunch</th>
<th>ADRA Rest</th>
<th>ADRA Visitors</th>
<th>ADRA Sleep</th>
<th>ADRA Sensing</th>
<th>ASD</th>
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<tbody>
<tr>
<td>Neurology</td>
<td>5.00</td>
<td>5.82</td>
<td>5.40</td>
<td>5.53</td>
<td>5.25</td>
<td>5.53</td>
<td>5.64</td>
<td>5.50</td>
<td>6.06</td>
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<tr>
<td>Rehab</td>
<td>5.78</td>
<td>5.63</td>
<td>5.38</td>
<td>4.88</td>
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<td>5.33</td>
<td>5.50</td>
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<tr>
<td>Geriatrics</td>
<td>4.75</td>
<td>5.00</td>
<td>4.75</td>
<td>4.00</td>
<td>5.00</td>
<td>5.50</td>
<td>4.75</td>
<td>5.25</td>
<td>6.00</td>
<td>6.00</td>
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<tr>
<td>Overall</td>
<td>5.20</td>
<td>5.66</td>
<td>5.30</td>
<td>5.14</td>
<td>5.07</td>
<td>5.54</td>
<td>5.42</td>
<td>5.46</td>
<td>5.96</td>
<td>5.79</td>
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<tr>
<td>χ²(2) =</td>
<td>3.242</td>
<td>3.131</td>
<td>2.098</td>
<td>4.199</td>
<td>2.156</td>
<td>0.123</td>
<td>3.177</td>
<td>0.682</td>
<td>0.214</td>
<td>0.255</td>
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<tr>
<td>P-value</td>
<td>0.198</td>
<td>0.209</td>
<td>0.350</td>
<td>0.123</td>
<td>0.340</td>
<td>0.940</td>
<td>0.204</td>
<td>0.711</td>
<td>0.899</td>
<td>0.880</td>
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Table 3  Mean scores of Impact on Healing per function

<table>
<thead>
<tr>
<th>Role</th>
<th>Skylight</th>
<th>ADRA Waking up</th>
<th>ADRA Breakfast</th>
<th>ADRA Clinical Care</th>
<th>ADRA Lunch</th>
<th>ADRA Rest</th>
<th>ADRA Visitors</th>
<th>ADRA Sleep</th>
<th>ADRA Sensing</th>
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<tr>
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<td>5.30</td>
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<td>0.876</td>
<td>0.659</td>
<td>0.076</td>
<td>0.259</td>
<td>0.272</td>
<td>0.525</td>
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</table>

department managers (Z = –2.344; p = .019) and rehab specialist (Z = –2.533; p = .011). Finally, although it was tested not to be significant, the negative impact scores of the therapists on Healing (mean score 2.50) and Workflow (mean score 3.00) in the phase Clinical Care need some additional elaboration. The therapists indicated that they preferred a warmer atmosphere to build up a relation with their patients, however, note that only two therapists took part in the study.

3.5 Qualitative Findings

The qualitative feedback of the participants was further elaborated in the focus group sessions.

The hospital staff members indicated that the Artificial Skylight would stimulate the day and night rhythm for patients. Extra daylight will help to lower depression certainly at the rooms located at the North side of the hospital. One of the neurologists described it like this: “There is a feeling with contact with the outside world. This will have an effect on the patient.” According to them this will have a positive effect on the psyche of the patient and when patients feel better, in general they will react more peaceful and therefore the nurse will have a better contact with the patient. The patient will work together with the nurse faster; will be more cooperative because he can deal with more stimuli. According to the participants the AS would also create a better work environment, because the effect of the AS is the same for the nurse as for the patient, as one of the nurses described it: “Gives a nice feeling to work in this environment ...”

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, and patients will not be woken abruptly anymore when nurses enter their room. Therefore the participants and especially the group of nurses believed that the waking up process with ADRA would cause the patient to be less aggressive, angry and grumpy. Furthermore, it would also be beneficial for the workflow because nurses don’t need to wake patients anymore and patients are expected to be more cooperative. As one of the department managers formulated it: “With this phase you are patient friendly without doing anything. It is like saying ‘good morning’ without saying it.” The par-
participants indicated also that the 30 minutes might be too long to wake-up, but that this needs to be tested with patients in a clinical trial.

The participating hospital staff members believed that the tight schedule imposed by ADRA would have a positive effect by giving more structure in the day for the patients. They assume that it allows the patient to identify the rhythm of the day and therefore they will 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. As one of the neurologists said: “The patient is stimulated to stay awake in the morning, this is good for his day and night rhythm”. Therefore the detection of the presence of the nurse during the night was also liked. Such a ‘night light’ will not wake the patient and is enough to assist the nurse. Staff thought the light was quick, effective and workable. One of the department managers said: “The nurses are assisted by the automatic light – no fumbling with the buttons and accidently turning on the wrong light therefore the patient is not disturbed and will not be woken.” Staff saw many more opportunities for the sensing of the presence of staff and patients: an option to track patients where they are in the ward combined with a nurse alert system or detecting when patient goes out of bed and wants to go to toilet – in which case they suggested automatically turning on the light.

Hospital staff also indicated that the room was giving the right number of stimuli over the day. For example, while eating concentration is needed, so staff believed that the breakfast and lunch phase were ideal for patients because there was no audio or video distraction and therefore patients can better perform their eating task. Also in the clinical care phase we provided a distraction free environment with a light boost of the artificial skylight. Staff believed that the light would 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 takes too long and therefore becomes boring, and that the atmosphere is too cold. Staff members suggested activating the phase only when the doctor and/or therapist are present in the room, and show a nature image and photos only when staff is not present. The two therapists indicated that they would like to have a cozier atmosphere to enable building a trustworthy relationship with the patient.

Hospital staff also believed that the ADRA concept would result in a behavior change on their part and that the system would help them to keep track of the time of day. As one of the nurses indicated: “As a staff member you are been made aware by the atmosphere that this is for example resting time, so you will also adapt your behavior to this.” They also indicated that at some moments such as in an acute situation, they should have the possibility to overrule the system and brighten the light.

According to the participants the room would not only be beneficial for the patients but also for the family members. One of the nurses indicated: “A lot of family members think a hospital is scary – this will reassure them and make them stay longer. This is beneficial for the patient.” The Visitors phase will also evoke visitors to be more calm by presenting this serene atmosphere this will also be beneficial for the wellbeing of the patient, for example, as one quotes: “It is like a home atmosphere in the room – cozy and enjoyable light.” The participants also suggested that the time of visiting hours could be adapted to the severity of the condition of the patient. If the staff could shorten the visiting hours could be adapted to the severity of the condition of the patient. If the staff could shorten the visiting hours in this way, then visitors stay less long when a patient is very ill. They also indicated that it would be nice if the room could know when there are no visitors present and could show a nature view on the screen or even provide an opportunity to give therapy via the screens.

The hospital staff, however, 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, in order to give them control over the pa-

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Table 4  Means scores of Impact on Workflow per function

<table>
<thead>
<tr>
<th>Role</th>
<th>Skylight</th>
<th>ADRA Waking up</th>
<th>ADRA Breakfast</th>
<th>ADRA Clinical Care</th>
<th>ADRA Lunch</th>
<th>ADRA Rest</th>
<th>ADRA Visitors</th>
<th>ADRA Sleep</th>
<th>ADRA Sensing</th>
<th>ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department manager</td>
<td>5.62</td>
<td>5.75</td>
<td>5.25</td>
<td>4.71</td>
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<tr>
<td>Neurologist</td>
<td>5.40</td>
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<td>Rehab specialist</td>
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<td>5.00</td>
<td>5.00</td>
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<td>6.00</td>
</tr>
<tr>
<td>Overall</td>
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</table>

*P < 0.05
The Adaptable Stimulus Dosage was also liked by the clinical stakeholders. They saw the added value of being able to provide few stimuli to the patient. They indicated that for agitated, confused and acute patients the low stimulus mode is perfect, because they need as few stimuli as possible. The hospital staff however, commented that in addition we also had to take into account noise form the hallway, because this can also be very disturbing for the patient. In addition they indicated for the low stimulus modulus providing a good day and night rhythm was still a need so opening the curtains would be necessary to follow the rhythm of the day. They also indicated that one picture of family members could work calming and give security to the patient. In addition they indicated that this ADS concept would also have a very positive effect on the way of working. This again enhances the well-being of the patient, so it will enhance the workflow as well. Nurses were indicating that this would create time to do other activities. In addition staff claimed that the room has many more opportunities. It would be beneficial in the future to show rehab training as Burdea [37] suggested in his research or to make contact with the home situation via Skype or other communication tools.

4. Conclusion and Discussion

These results show that hospital staff expects a positive effect on the healing process of the patient for the Artificial Sky-light, the Adaptable Stimulus Dosage concept and the different ADRA phases that provide a clear daily rhythm structure during the day. In fact the 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, also for the AS and ASD concepts. This is a very promising result as the phases were designed primarily with the healing effect for the patient in mind.

The hospital staff evaluation in the laboratory setting gave us an indication of the likely impact of the Adaptive Healing Environment Patient Room on the healing progress of patients. 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. In addition, we generated feedback from different departments from different institutions, which suggest that they all see similar added values for the patient room. In contrast, with a single-site clinical trial we would only obtain feedback from one hospital department and we would not be able to generalize the findings to other institutions. In addition the laboratory evaluations helped to make hospitals enthusiastic to participate in a clinical trial because they could experience the concepts first hand and see the added value.

As mentioned in the introduction, the goal of the evaluation was to evaluate the Adaptable Healing Environment Patient Room with hospital staff. With regard to future work, the other important stakeholder of the Adaptable Healing Environment Patient Room, the patient, needs to be involved. For this clinical trials are required. To prepare for a comprehensive clinical trial, we will first evaluate the concept with patients in a laboratory setting. Considering the medical condition of stroke patients, and the typically long-term rehabilitation process, we will conduct this test with former stroke patients and their family. The goal of this test then is to assess their opinions, feelings and attitudes towards the Adaptive Healing Environment Patient Room in order to gain understanding of their expectations and determine whether the Adaptive Healing Environment Patient Room could improve the experience and wellbeing of patients during their hospital and rehabilitation period.

Acknowledgment

We thank all patients, medical staff, researchers and designers that have contributed to defining and validating the issues, concepts, and solutions proposed in this work. Furthermore, we thank all who have contributed to improving this paper.

References

8. Bringslmark T, Hargit T, Patil GG. The psychological benefits of indoor plants: a critical review of

Pervasive Health