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Improved quality of life for resident dementia patients: St. Katharina research project in Vienna

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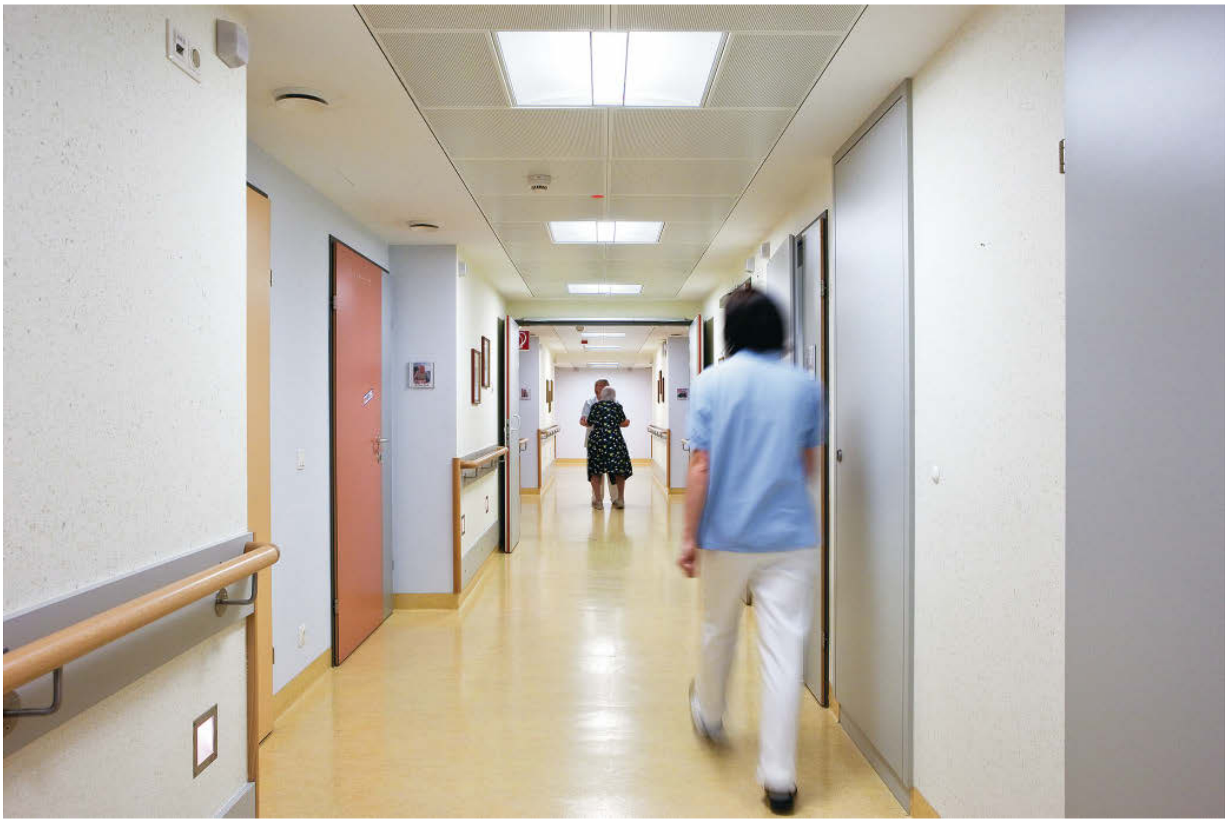

In various old-age homes where experiments have been carried out with "luminous ceilings" (for instance "Haus im Park" in Bremerhaven, "Haus Ruhrgarten" in Mülheim), positive effects on the well-being and social behaviour of residents were observed. In spite of the initial scarcity of available data, there was sufficient evidence to suggest that a positive development might be initiated by using adequate lighting: increasing social activities during the day result in greater fatigue in the evening, providing in turn for more restorative sleep at night and accordingly favourable effects on the residents' mental and emotional state.

Summary

In a residential ward for dementia patients in the St. Katharina old-age home in Vienna, controllable lighting was installed in the course of refurbishment, allowing for different lighting intensity levels and light colours to be implemented and their effects on the well-being of residents to be examined systematically. Various lighting situations, two of them static and one dynamic (simulating daylight transitions) with varying lighting intensity levels and light colours, were created. Measurements were carried out during a period of almost two years (at least 8 weeks for each lighting situation respectively) and were completed in autumn 2009. Each lighting situation was repeated once in order to take account of seasonal effects.

Not only the residents' emotional and mental states as well as their social activities were investigated, but also the effects on nursing staff, both regarding their own well-being and their assessment of the nursing situation. This strongly interdisciplinary research project is subsidised and supported by the national 'Kompetenznetzwerk Licht' (Lighting Competence Network).

Problem definition

Light as a partial aspect of electromagnetic radiation is visible for human beings in the range between 380 and 780 nm. Within this range, it allows for the perception of the environment reflecting the light and of its colours.

Light, however, is not only essential for visual perception, it also has a biological effect by influencing people's day/night rhythm - the so-called circadian rhythm – through the corresponding receptors (Brainard 2001; Ehrenstein 2008). In this context, insufficient amounts of light during the day may impair people's circadian rhythm, which may cause sleeping disorders or even depressive disorders. In case of elderly persons, the probability of an insufficient daily amount of light is higher because the transmission of the lens of the eye, i.e. the passage of light, is reduced. Accordingly, the probability of impairments and disruptions of the circadian rhythm is higher.

It was found out in initial feasibility studies in various old-age homes that a higher amount of light provided by modified, brighter lighting results in positive effects on well-being and social behaviour among the residents. This fact was systematically exploited, for instance, in Mülheim/Germany ("Haus Ruhrgarten") or in Bremerhaven/Germany ("Haus im Park") by installing luminous ceilings. In Mülheim, moreover, it was possible to investigate these effects more thoroughly during an observation period of approx. 4 weeks (Brach et al. 2004, Bieske et al. 2006). In spite of the unsatisfactory amount of data available, however, it is justified to assume that a series of positive effects was started using adequate lighting: increasing social activities during the day result in greater fatigue, providing in turn for more restorative sleep at night and accordingly beneficial effects on the patients' mental and emotional state. Overall, the day/night rhythm is reinforced: more activity during the day, better sleep during the night.

So if positive effects like those observed in Mülheim were achieved, it is worthwhile to analyse them more thoroughly and especially on a longer term basis. In this context, dementia patients are an interesting target group as, apart from other impairments, a disruption of the circadian rhythm may be assumed for many of them, typically characterised by daytime fatigue on the one hand and nighttime activity on the other (Förstl & Schweiger 2007; Kastner & Löbach 2007).

With a view to demographic trends and the prevalence of dementia drastically increasing with age (cf. Bickel, 2005), investigating the factors that might promise an improvement or maintenance of the status quo is important. While the progression of the disease is not likely to be stopped, there is yet justified hope to mitigate it.

The examinations were carried out at the St. Katharina old-age home in Vienna. The home is managed by the order of the Sisters of Mercy. It accommodates 94 residents in five wards.

The complete refurbishment of the building that had become necessary due to the usual wear and tear was used to furnish the first floor especially for a residential group of dementia patients – a concept already successfully applied in similar ways in a series of buildings in Germany (e.g. Kasten et al. 2004). That means, apart from the seven single and two double rooms, a spacious living room and dining area was newly furnished, with an integrated kitchen. This architectural modification is meant to create a family-like situation and support the newly introduced nursing concept of maieutics (person-centred, experience-oriented nursing according to van der Kooij, cf. Kasten et al. 2004, van der Kooij 2006, Kitwood 2000, Lind 2007). At the same time, this also offered an opportunity to implement, within the scope of the so-called lighting project, a lighting concept in this residential ward that was to enable the systematic examination of different lighting scenarios and their effects on the residents' well-being and behaviour.

Scientific state of the art

On the biological efficacy of light
Light is not only essential for visual perception, but it also works as a physiological clock. It was discovered only at the beginning of this millennium (Brainard 2001) that apart from the receptors for colour vision (cone cells) and those for the perception of brightness/darkness (rod cells), there are also receptors that respond sensitively to the blue range of the daylight spectrum. While these melanopsin-containing ganglion cells are spread over the entire surface of the retina, the cells in the nasal and lower parts of the retina are more sensitive. The consequence of this is that light coming from the upper field of vision is more effective. The light causes the production of the hormone melatonin to be suppressed during the night. Melatonin is a product of the pineal gland (corpus pineale) and controls the circadian rhythm through the suprachiasmatic nucleus. That means melatonin promotes fatigue. Accordingly, light is not only a social but also a physiological conductor of circadian rhythm (cf. Brainard 2001). During the day, again via the suprachiasmatic nucleus, light directly impacts cognitive centres in the brain, increasing activity (cf. Vandewalle 2007).

The circadian rhythm may be disrupted for a number of reasons (Ehrenstein 2008). A well-known example is the problem of shift working or the jet lag occurring after intercontinental flights. But dysfunctions of the circadian rhythm may also occur because the daily amount of light is insufficient to provide a sufficiently strong timer signal. This will cause fatigue during the day, possibly sleep disorders or even depression, e.g. SAD (seasonal affective depression).

The problem of insufficient amounts of light often occurs with elderly persons. On the one hand, this is due to the lower transmission of the lens, combined with a shift towards the yellow range, with the blue range being less effective. On the other hand, restricted mobility may lead to people spending less time outdoors, and accordingly making less use of natural light. This problem is aggravated in the case of the very elderly and/or dementia patients.

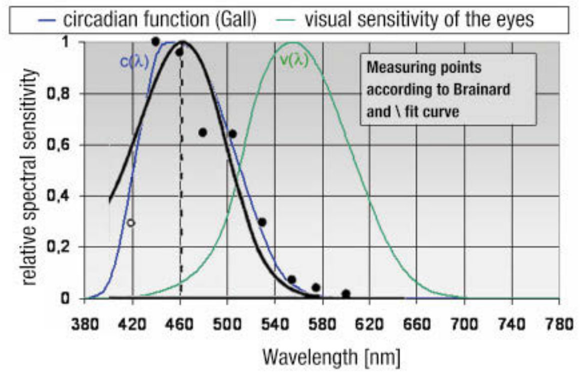

Fig. 2-1. The circadian effect curve as compared to the visual effect curve. The maximum of spectral sensitivity is at 460 nm, which corresponds to blue colour perception.

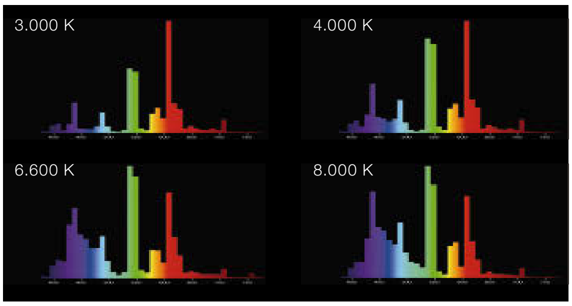

Fig. 2-2. Comparison of the spectra of LUMILUX fluorescent lamps (OSRAM) T5 (16 mm) with the colour temperatures 830 (3000 K), 840 (4000 K), 865 (6500 K) and 880 (8000 K).

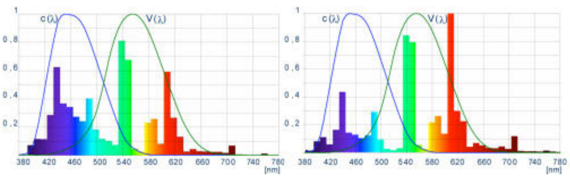

Fig. 2-3. The assessment of the light colours according to the circadian effect function shows that the SKYWHITE lamp (right) achieves a markedly greater effect as compared to the light colour 840 (left).

Biologically effective lighting in interiors

The biological effect of bright light on people causes an increase of their activity during the day and stabilisation of the circadian rhythm as described above.

In order to guarantee the biological effects of light also indoors, it is necessary for artificial lighting to be similar to daylight. At present, this is not possible using conventional lighting. In the case of warm or intermediate light sources – which are usually used indoors –, biological efficacy could only be achieved at dramatically increased levels of illuminance and thus considerably higher energy costs.

The circadian effect function was described by Brainard and others.

Therefore, a new fluorescent lamp with an increased colour temperature of 8000 K at a colour rendering index of Ra ≥ 80 was used for the luminous ceilings, in combination with the previously known fluorescent lamp colour temperatures of 3000 K and 6500 K. This allows a very wide range of colour temperatures and illuminance levels to be selected and dynamically controlled.

The biological effects of the SKYWHITE fluorescent lamp with a colour temperature of 8000 K, an increased blue component, and a light colour that is more similar to daylight at comparable illuminance and comparable energy efficiency, are 2 to 2.5 times higher than those of conventional fluorescent lamps.

A comparison of the spectra shows the differences especially in the blue range of the spectrum (Fig. 2-1.):
It must be taken into account that the perception of light and colours by the geriatric resident is different from that of the nursing staff or generally younger persons. This is due to the age-related cataract of the eye. The yellowish discolouration of the lens leads to a wavelength-related reduction of transmission, the short-wave blue components are thus reduced more strongly.

Apart from the light colour, also illuminance influences the biological effect of light. To achieve an illuminance level of 1000 lx, a wide-area source of light emanating diffuse light is required. This corresponds to the bright sky outdoors. The illuminance of this source of light should be able to produce some 3000 lx on a horizontal surface.

The corresponding lighting system allowing for adjustment of the colour temperature between 3000 K and 8000 K and of illuminance up to approx. 3000 lx was provided for the St. Katharina old-age home.

According to preliminary estimates, the extra costs of energy consumption of a biologically efficient lighting installation might thus be kept below €0.20 per day and resident.

Photobiological safety

The use of light sources with increased blue components requires careful assessment of potential risks of eye damage (blue light hazard). Therefore, the lighting situations with the highest illuminance levels and largest blue components were evaluated according to the provisions under European standard DIN EN 62471 (Photobiological safety of lamps and lamp systems, 03-2009).

The maximum photobiologically effective beam density assessed according to the blue light hazard was less than 5 W m^{-2} sr^{-1} at the maximum horizontal illuminance implemented of 2200 lx and a colour temperature of 8000 K.
This is less than 5 % of the threshold for risk category 0, which is considered safe under DIN EN 62471 (exempt group).
Accordingly, it may be assumed that lighting situations with high illuminance levels and large blue components are also without any photobiological risk for the residents or the nursing staff.

Dementia

There is a number of different types of dementia, the most common by far being Alzheimer's dementia (approx. 80 %). It is a primary, neurodegenerative form of dementia characterised by memory deficits as well as further cognitive impairments (e.g. reduced judgement, decreased ability to make plans, to process information) and also by changes in behaviour and in the affective sphere (e.g. emotional lability, irritability, apathy). It is caused by deposits in the brain (plaques) and/or changes in the neural cells (neurofibrils, cf. Förstl & Schweiger, 2007, Kastner & Löbach, 2007); it is still contested whether the plaques are a remedial response of the body to the neurofibrils. As for the vascular forms of dementia - also primary and neurodegenerative -, impairments occur due to dysfunctions of perfusion. Degenerative forms of dementia are progressive, that means they can be observed to aggravate through several stages depending on the extent of the impairments. It is the increasing occurrence of behavioural problems, e.g. sundowning (Schröder 2006): restlessness in the evening/at night, daytime fatigue, disorientation - that suggests that hormonal processes are involved, and that the circadian rhythm is disrupted. This is thought to be due, among other things, to insufficient exposure to light (Kastner & Löbach, 2007). The main aspect in the project that is going to be presented in this brochure is to compensate such deficits through adequate lighting and to find out which lighting concepts have a positive impact on dementia patients – especially regarding circadian rhythm. This should lead to stabilisation of sleep, and recreative sleep should lead to an improvement of cognitive orientation and emotional well-being. Moreover, a positive effect on the quality of life of dementia patients is expected.

Biological effect of light on dementia patients

Due to the biological efficacy of light - control of melatonin balance and accordingly circadian rhythm -, a positive effect on the well-being, especially of dementia patients, is expected. Starting from the consideration that the circadian rhythm of dementia patients is disrupted among other things by the fact that due to restricted mobility exposure to daylight is reduced and the transmission of incident light is reduced due to age-related cataract, it is assumed that there is no or only insufficient melatonin suppression, causing daytime fatigue and drowsiness, while sleep during the night is insufficient and/or disturbed.

With daytime melatonin production suppressed by providing appropriate lighting, chances are that residents will have a better night's sleep on the one hand and be more active in the course of the day on the other, so that they should be more inclined and motivated to take part in social and/or household activities. In other words, it was expected that the activation of the residents' resources intended by the nursing concept would be facilitated. Increasing activity during the day should in turn have a supporting effect on circadian rhythm, leading to corresponding fatigue at night. By stabilising the residents' circadian rhythm, a positive trend should thus be triggered, which is meant to result in improvement of their cognitive orientation and have a positive influence on their emotional state so that, as a whole, their well-being and their quality of life should be enhanced by providing restful sleep at night and activation by day. In a study carried out by von Riemersma-van der Lek et al. (2008), which, however, was realised with older residents in institutions of supervised living, the beneficial effect of exposure to biologically effective lighting was demonstrated.

Since, as mentioned above, the circadian rhythm of Alzheimer's dementia patients is often impaired (daytime fatigue, nighttime activity), there is hope that an adequate lighting concept may contribute to normalising the circadian rhythm, which is likely to cause positive effects on the psycho-mental state of the residents and have a positive influence on their well-being.

Based on these conditions, the questions of the investigation were initially formulated in a very general manner:

- Which lighting concepts applied during the day have an effect on sleep, on the well-being, the cognitive orientation and emotional state of residents suffering from dementia?
- Which parameters of the lighting concept prove to be particularly effective?
- What kind of effects can be observed in the nursing staff? Are there any interactions between nursing staff and lighting concept, and if so, how can they be classified?

Research hypotheses

The lighting concept

When conceiving the lighting installation that was meant to be investigated with respect to its effects on the well-being, behaviour, cognitive orientation and emotional state of the residents of the dementia ward, the general conditions required by the old-age home had to be taken into account apart from purely investigative aspects. That means the comfort of the ward that is also based on adequate lighting had to be guaranteed. Any laboratory-type situation had to be avoided.

The study-relevant lighting situation was essentially implemented in the common area of the ward - for two reasons. On the one hand, it was possible to rely on the experience gained in Mülheim ("Haus Ruhrgarten"), which had shown that brightness will attract the residents, so that they liked to frequent the bright places. On the other hand, the residents were meant to be motivated under the nursing concept to spend time in the common area in order to get into contact with other residents and/or to participate in social or household activities. Moreover, in this area it was easiest to install large bright panels in the form of luminous ceilings that would ensure an adequately effective amount of incident light.

As an independent variable, the lighting was set to operate within the scope of the existing conditions such that apart from the standard situation (standard-based lighting; Baseline BL, cf. chapter "Technical implementation"), a total of three clearly distinguishable lighting situations were to be implemented by way of reference, with clearly different characteristics and accordingly different expectations regarding their effects.

The idea was to investigate whether and to what extent the effect of the lighting – regarding the control thresholds of illuminance and light colour (spectrum) - on the dependent variables would be achieved

- through illuminance alone (lighting situation 1),
- or additionally through light colour (lighting situation 2)
- or alternatively through dynamic changes similar to daylight (lighting situation 3), and whether there would be any seasonal differences.

Lighting situation 1 includes a static increase of intensity (from 300 lx to 2200 lx), lighting situation 2 includes a static change of light colour (from 3000 K to 8000 K), and lighting situation 3 includes a dynamic change of illuminance (from 300 to 2200 lx) and light colour (from 3000 to 8000 K) depending on the time of day. All lighting situations were applied twice within one year.

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The lighting situations do not represent any binding requirements for ideal lighting characteristics in nursing homes, but are meant to provide for clearly distinguishable, measurable lighting situations whose analysis will supply additional information and basic data for improved lighting in nursing homes. This refers to lighting that provides a higher quality of life to the residents through its effects on the non-visual system (e.g. by consolidating fragmented sleeping patterns or by supporting fragile day/night rhythms) - clearly renouncing any lighting-based manipulation of the residents.

The effect of light on the well-being of the residents

If biologically effective lighting has positive effects on circadian rhythm and is able to trigger the positive development described, this should be reflected by the residents' well-being as a dependent variable. The concept of "well-being" is considered a unity of mental, physical and social well-being, constituting a sort of umbrella term relating to a number of positive experiences; aspects like absence of strain, joy – a short-term component, contentment – as the rational assessment of the relation between positive and negative experiences under a longer term perspective, and happiness – as its emotional assessment - are all part of this (Mayring 2000). Well-being is part of the assessment of quality of life (Oppikofer 2008) and/or overlaps with this concept. This is due to the fact that quality of life as a theoretical concept is complex, multidimensional and dynamic, as it is greatly influenced by age and environment (for the assessment of quality of life cf. Edelman et al. 2005, Ivemeyer & Zerfaß 2006, Oppikofer 2008, Rieckmann et al. 2009).

Providing for the well-being especially of the very elderly proves highly problematic per se, because the absence of physical strain and impairments is hardly ever achievable from a purely objective point of view, so it will ultimately depend on the extent to which the individual concerned is able to put things into perspective. It is precisely in the early to medium stages of dementia that the perceived reduction of cognitive abilities and accordingly the experience of losing essential characteristics of one's own identity puts a special strain on dementia patients, thus greatly influencing the experience of contentment or happiness and impairing quality of life. When trying to promote daily well-being, as is the case here, the residents should be provided with opportunities to have positive experiences - as is also the intention of the maieutic nursing concept. This can be combined with the flow theory of Csikszentmihalyi (2007). In other words, "flow" in the sense of "being completely absorbed in an activity" will occur in case there is a balance between requirements and abilities. So if, on the one hand, the prerequisites are created to strengthen the residents' abilities - by stabilising the circadian rhythm, and consequently providing for restorative sleep and improved vitality - and on the other hand, the available resources are activated successfully, it should be possible to enable even dementia patients to experience "flow" and accordingly contribute to improving their well-being. As this cannot be observed directly, aspects of both vitality and communication are used to analytically assess well-being. Aspects of vitality are both a necessary prerequisite and a source of positive feedback regarding one's own abilities. By way of conversations and social activities, communicative features convey the experience of one's own abilities by interacting with others.

Taking the experiences from “Haus Ruhrgarten” in Mülheim into account (Bieske et al. 2006, Brach et al. 2004), and cooperating with the nursing management of the St. Katharina old-age and nursing home as well as with an expert in the palliative care of the very elderly, the individual study criteria regarding vitality and communication have been worked out:

Vitality/mobility:
Finding one’s way about the ward without any help (go to common area, terrace, room in a targeted manner and independently);
Situation-based, independent conduct during the palatable preparation of food as well as when eating and drinking; appropriate participation in household activities;

Communication:
Appropriate reactions when interacting with nursing staff (for instance complying with requests from the nurse); appropriate participation in social activities (ball games, handicrafts etc.);

The tools of observation used in the “Haus Ruhrgarten” project (Bieske & Dierbach, 2004, Brach et al. 2004) were accordingly adjusted to the present purpose with a few modifications and prepared for electronic data capture. The use of these tools was also meant to promote the widening of the database. The tools themselves are aimed at investigating dimensions that are considered as indicators of quality of life (Oppikofer 2008).

The collection of data was effected both via external observers and through estimates made by the nursing staff, and additionally by means of technical tools.

Apart from these directly collected data, information was collected from the nursing files, especially by analysing special events (for instance falls) and interventions (evaluation of eating/drinking balance records), as well as changes in medication.

The effect of light on nursing staff
The work of nursing staff in old-age and nursing homes involves two particular strains. On the one hand, the care of very elderly and/or immobile persons requires great physical effort (lifting and carrying loads), on the other hand this work includes a high degree of emotional involvement, that is showing positive emotions under unfavourable conditions. This is especially true of the nursing of dementia patients who need a great amount of help, but may react in an irritated or even aggressive manner due to their disease. For the care of dementia patients, different nursing concepts have been developed, the respective benefit of which, however, is supported by only a minor amount of empirical data (cf. Rieckmann et al. 2009, ANAES 2003). It is only for occupational therapy, music/massage as well as aroma therapies that any positive effects with a view to the respective target criteria have been demonstrated.

As for the maieutic nursing concept developed by van der Kooij (2003), this is an emotion-oriented, person-centred concept showing many overlaps with the validation concept by Naomi Feil (2007). It is aimed at activating the resources of the residents and requires understanding and a respectful attitude on the part of the nursing staff. It requires a person-oriented approach combined with appropriate social behaviour and speech patterns. Both concepts are essentially based on empathy and intuition; with respect to the definition of criteria - assessment of various stages of dementia, approaches - they are hardly based on theory and not very transparent, so that evaluating the nursing approach appears difficult (Lind 2007).

The corresponding further training of nursing staff at the dementia ward was carried out in the form of one-day seminars at the beginning of the introduction phase. Supervision of progress in nursing conduct based on specific examples was not carried out. It must be assumed, however, that the introduction of a new nursing concept as described above might result in considerable stress and accordingly strain on the nursing staff due to its genuine lack of transparency, which makes it hard to convey the concept.

Upon furnishing the dementia ward, the lighting project was also presented to the nursing staff, especially regarding the question of how they would be affected by it in their daily work. One important aspect was the completion of questionnaires and another the presentation of the methodology (presence of one observer and installation of the sensors). Two nurses expressed reservations in this respect insofar as technology would be used instead of personnel. It was not possible - or only to a minor extent - to eliminate these reservations - although they were not based on facts - in the course of the project.

As the influence of this attitude on the other nursing staff, who had initially expressed a neutral or positive attitude, could not be assessed, any meaningful formulation of hypotheses was hardly possible. It was rather suspected that group dynamics will have a greater influence than the respective situation.

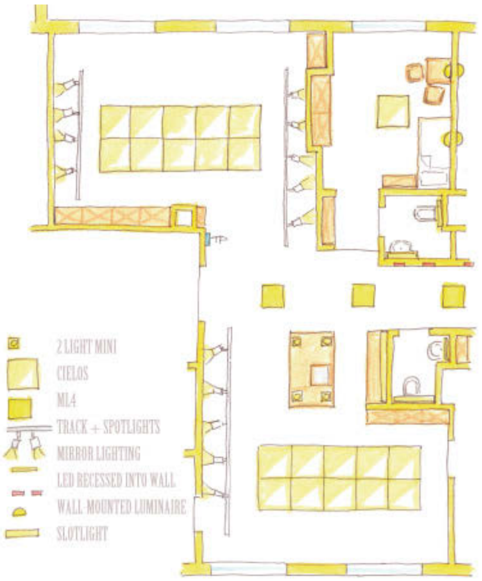

Fig. 4-1. Preliminary design sketch of common area with both luminous ceilings (bottom right – eat-in kitchen; bottom left – living room)

Fig. 4-2. One element of the light fields in the common area with the “CIELOS special” luminaire

Research methods and implementation

Lighting concept
The lighting comprised the luminous ceilings in the common area, the selection and arrangement of spotlights and downlights, as well as the corridor lighting.

Luminous ceilings
As mentioned already, luminous ceilings were installed in the common area of the ward, in the middle of the living room and the eat-in kitchen in each case (cf. Fig. 4-1.).

Both luminous ceilings in the common area consist of a multiple arrangement of square wide-area luminous ceiling modules, type CIELOS 3C (three channels for three light colours) with a side length of 90 cm and 12 lighting outlets each (cf. Fig. 4-2.). Each of the two luminous ceilings consists of 10 luminaires, with the individual luminous ceiling modules arranged in a closed field consisting of 2 rows of 5 luminaires each, accordingly forming an actively illuminated area 1.8 x 4.5 m in size.

The CIELOS 3C luminaire was chosen as the starting point, because it has three separately controllable lamp groups with 4 lamps each and has been optimised with a view to maximum uniformity and good colour mixing across the entire light emitting area, including peripheries, by being designed as an RGB luminaire. Instead of the 21 W T16 fluorescent lamps provided for in the standard (RGB system with red, green and blue fluorescent lamps for colour mixing) including additional coloured filter tubes for colour saturation, the CIELOS luminaires were fitted with fluorescent lamps of different colour temperatures.

Three groups of fluorescent lamps, consisting of four lamps in each case, with colour temperatures of 3000 K, 6500 K and 8000 K. Even in case of white light, instead of mixing 3000 K and 8000 K to achieve colour temperatures of 5000 K or 6000 K, it makes sense to use a third lamp type somewhere in between. Otherwise the mixed light will appear slightly coloured, which may impede acceptance. Since the standard luminaire is designed for FH lamps, while the 8000 K lamps by Osram were only available as FQ at the time of commencement of the study (in this dimension 39 W with FQ lamps instead of 21 W for T5 FH), the luminaire had to be modified for thermal reasons due to the higher installed load.

Fig. 4-3. Layout and reflected ceiling plan of the residential ward for dementia patients in the St. Katharina old-age home, position of the luminaires in the corridor area.

Fig. 4-4. Luminous ceiling in the living room area. The colour temperature and illuminance can be modified as described.

Fig. 4-5. Corridor lighting

Other lighting

Beyond that, a holistic lighting concept was developed. The arrangement of the luminaires and luminous ceilings described in the following text is shown in the layout and the reflected ceiling plan (cf. Fig. 4-3.), the lamps used are listed in the following table (4-1.):

Number of luminaires	Luminaire type	Lamps per luminaire	Supplied by
20	Zumtobel CIELOS 900 Special	4x FH 21 W, 830	Osram/Zumtobel
		4x FH 21 W, 865	Osram/Zumtobel
		4x FH 21 W, 880	Osram/Zumtobel
		+ Tridonic electronic ballasts	Zumtobel
4	Zumtobel 2LIGHT Mini Cardanic	1x 75 W QT-LP 12 flood	Zumtobel
		+ electr. transformer	Zumtobel
14	Zumtobel VIVO S CR-CBC 51	1x 50 W QR-CBC 51	Zumtobel
11	Zumtobel KAVA LED 24 V RGB	Integrated light source	Zumtobel
14	Zumtobel MELLOW LIGHT IV	2x FQ 24 W, 865	Zumtobel
		+ 2x FQ 24 W, 830	Osram/Zumtobel
2	Bega 6610	1x QT 18 100 W	Zumtobel

Table 4-1. Lamps of the luminaires in ward 1 of the St. Katharina old-age home

In the corridor, MELLOW LIGHT IV ceiling-recessed luminaires were installed, with two lamp groups consisting of 2 x T5 24 W fluorescent lamps of different colour temperatures (4000 K, 840; 2700 K, 827). In the wall, KAVA LED RGB were installed close to the floor; they additionally serve as guidance, night and atmospheric light. In the area of the kitchen, 4 2LIGHT Mini ceiling-recessed spotlights were installed, fitted with 75 W halogen lamps (QT 12 75 W/12 V). The combination of directional light via the reflector and an additional diffuse component produces a gentle yet lively lighting atmosphere. Brightening and accentuation of the wall surfaces is achieved through VIVO S spotlights installed on a track. The flexible spotlights fitted with 50 W QR-CBC lamps in each case also serve as a design feature, creating a snug, cosy atmosphere on account of their warm directional light.

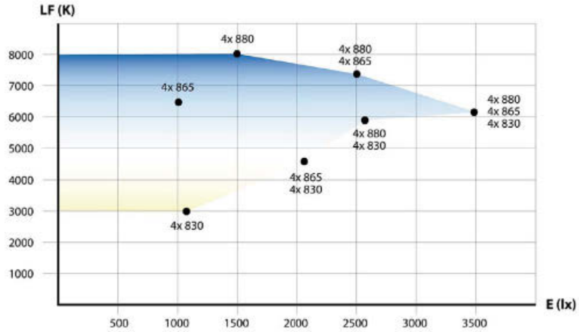

Fig. 4-6. Control thresholds for light colour and illuminance in the lighting system in ward 1 at St. Katharina for non-dimmed lamps in each case

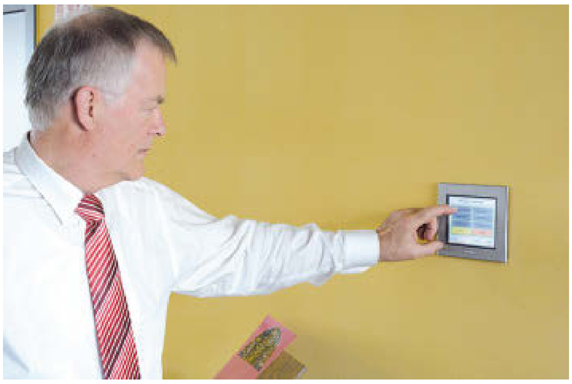

Fig. 4-7. Operating the touch panel is possible upon entering a code

Fig. 4-8. CIRCLE control point. ON/OFF key (centre key), three lighting situations, dimming function. Blinds control is not active.

Implementation and control of lighting situations

Based on the lamps defined, the luminous ceiling installation described allows for horizontal illuminance (Eh) of up to 3500 lx (maximum) in the task level area below the luminous ceiling (corresponds approximately to vertical illuminance of Ev of up to 2300 lx) and an effective colour temperature range of 3000 K to 7800 K, as shown in the figure (3-4.) where the light colour and illuminance control thresholds are represented.

The individual lamp groups are controlled and dimmed independently from each other in each case, which produces light colour mixes. By means of lighting control, the individual lighting scenes or situations that were to be investigated were programmed to test them over a prolonged period. These lighting scenes may be called up via a touch panel (table 4-2.). A demo version is also available, calling up the L3 situation in a ten-minute demonstration. Operation is only possible if a four-digit code is entered. This is to avoid unwanted changes of the lighting situation, e.g. by the residents.

Lighting situations touch panel
Lighting situation Baseline 1
Lighting situation Baseline 1a (without downlights)
Lighting situation L1
Lighting situation L2
Lighting situation L3
Demo program L3

Table 4-2. Lighting situations programmed and available on the touch panel, may be called up at any time

Moreover it is possible to preset a maximum of three situations on a CIRCLE control point. The following are the standard settings of the control point (table 4-3.).

Lighting situations CIRCLE control point
1) Baseline with 4x downlights (100 %) above the kitchen ensemble
2) Baseline without 4x downlights (0 %) above the kitchen ensemble
3) empty
6:00 a.m. to 6:00 p.m.: no intervention (switch-off/dimming) possible
6:00 p.m. - 6:00 a.m.: switch-off is possible
KAVA (corridor)

Table 4-3. Overview of the standard settings of the CIRCLE control point

The lighting situations taken into account during the investigation are described below:

1. Lighting situation Baseline
2. Lighting situation L1
3. Lighting situation L2
4. Lighting situation L3
5. Night
6. Demo program

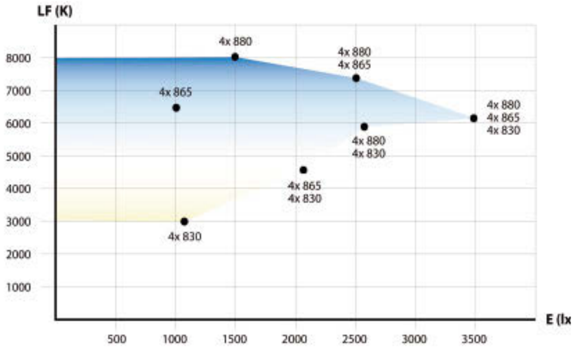

Fig. 4-9. Description of the Baseline setting (BL1, BL2; light grey point) with illuminance levels of 300 lx and light colour of 3000 K, static

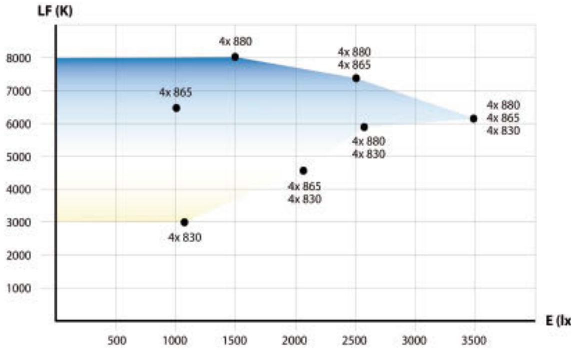

Fig. 4-10. Description of lighting situation 1 (light grey point) with an illuminance level of 2000 lx and light colour of 3000 K, static

1. Lighting situation Baseline

The Baseline lighting situation as reference situation corresponds to the standard situation (BL1 for the first run in the winter semester, BL2 for the second run in the summer semester, cf. Fig. 4-9.). The CIRCLE control point has the same settings as in the standard situation (table 4-4.).

Parameter	Description
Duration	6:00 a.m. to 6:00 p.m. daily (static)
Light colour	3000 K throughout
Illuminance	Living room area 300 lx (as-new value 400 lx) Corridor 150 lx (as-new value 200 lx)
KAVA light colour	orange/beige
Spotlight (wall)	to 7 %

Table 4-4. Overview of key lighting control parameters of the Baseline setting (BL1, BL2)

2. Lighting situation L1

Lighting situation L1 (table 4-5., Fig. 4-10.): In this first trial situation, the illuminance level was increased to 2200 lx and kept static. The light colour remains unchanged at 3000 K.
The lighting situation was preset appropriately at the CIRCLE control point (table 4-6.).

Parameter	Description
Laufzeit	6:00 a.m. to 8:00 a.m. daily (increase to lighting situation L1: from 300 to 2000 lx)
	8:00 a.m. to 4:00 p.m. static at 2200 lx
	4:00 p.m. to 6:00 p.m. static at 300 lx
	From 6:00 p.m. static at 300 lx
	From 7:00 p.m. night ambiance and switchable
Light colour	3000 K throughout
Illuminance	Living room area 2200 lx Corridor 100 % (6500 K lamp can be added if required)
KAVA light colour	orange/beige
Spotlight (wall)	to 15 %
Downlights above the kitchen ensemble	100 %

Table 4-5. Overview of key lighting control parameters of lighting situation L1

Standard settings lighting situation L1
1) Lighting situation L1
2) empty
3) empty
7:00 a.m. to 7:00 p.m.: no intervention (switch-off/dimming) possible
7 p.m. to 7:00 a.m.: switch-off is possible
KAVA (corridor)

Table 4-6. Overview of standard settings of control point during lighting situation L1

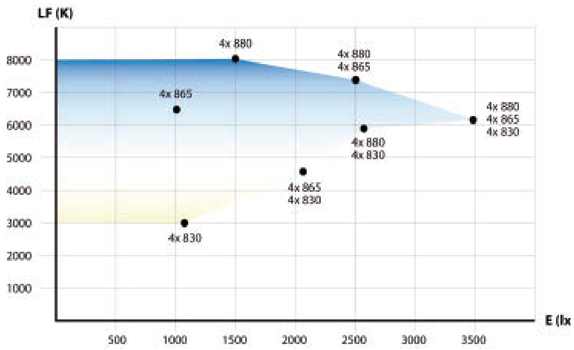

Fig. 3-11. Description of lighting situation L2 (light grey point) with an illuminance level of 1500 lx and light colour of 3000 K, static

3. Lighting situation L2

Lighting situation L2 (table 4-7., Fig. 4-11.): In addition to increasing illuminance to 1500 lx (the level at which the light colour may still be set to 8000 K), the light colour was changed to 8000 K static. The CIRCLE control point was adjusted correspondingly (table 4-8.).

Parameter	Description
Duration	6:00 a.m. to 8:00 a.m. daily (boosting to lighting situation L2: from 300 to 1500 lx, change of light colour from 3000 K to 8000 K)
	8:00 a.m. to 4:00 p.m. static at 2200 lx
	4:00 p.m. to 6:00 p.m. dynamic decrease from 2200 lx to 300 lx and from 8000 K to 3000 K
	From 6:00 p.m. static at 300 lx
	From 7:00 p.m. night ambiance and switchable
Light colour	CIELOS 8000 K Corridor 6500 K
Illuminance	Living room area 2200 lx Corridor 6500 K 100 %
KAVA Lichtfarbe	orange/beige
Spotlight (wall)	at 15 %
Downlights above the kitchen ensemble	100 %

Table 4-7. Overview of key lighting control parameters of lighting situation L2

Standard settings lighting situation L2
1) Lighting situation L2
2) empty
3) empty
7:00 a.m. to 7:00 p.m.: no intervention (switch-off/dimming) possible
7 p.m. to 7:00 a.m.: switch-off is possible
KAVA (corridor)

Table 3-8. Overview of the standard settings of the CIRCLE control point in lighting situation L2

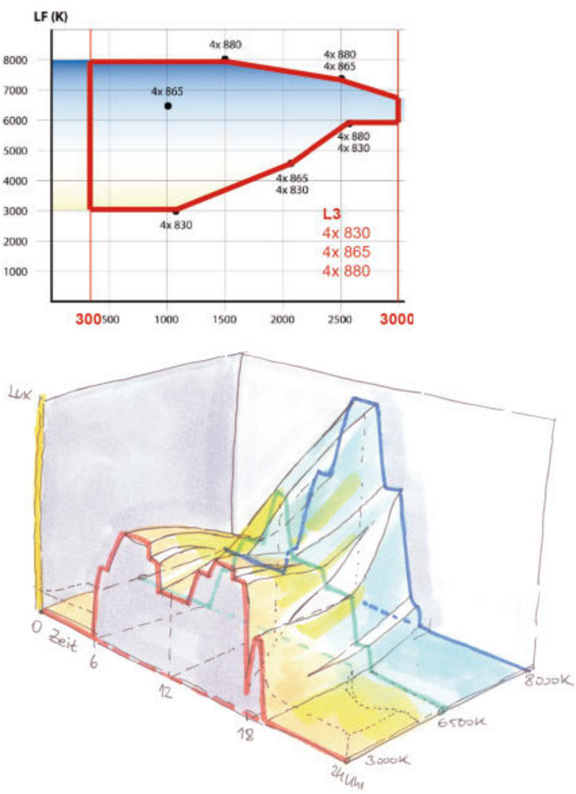

Fig. 4-12a/b. Presentation of lighting situation L3, parallel to L2, with daylight-based dynamics, and of the range within which the change is effected. Not the entire range is covered.

4. Lighting situation L3

Lighting situation L3 (table 4-9., Fig. 3-10.): This lighting situation essentially corresponds to lighting situation L2, but also includes dynamic changes similar to daylight.
The CIRCLE control point was adjusted correspondingly (table 3-10.). The dynamic changes are effected within the range presented in Fig. 4-12a/b. The corner marks from morning through noon to evening are described by the values in table 4-9.

Parameter	Description
Duration	6:00 a.m. to 6:00 p.m. dynamic (300 lx – 2200 lx – 300 lx at 3000 K – 8000 K – 3000 K)
	From 6:00 p.m. night ambiance and switchable
	4:00 p.m. to 6:00 p.m. dynamic decrease from 2200 lx to 300 lx and from 8000 K to 3000 K
Light colour	3000 K – 8000 K – 3000 K
Illuminance	Living room area 2200 lx Corridor 100 % (6500 K lamp can be added if required)
Dynamic changes in the common area CIELOS	Morning: 300 lx / 3000 K Midday: 2200 lx / 8000 K Evening: 300 lx / 3000 K
Dynamik im Sozialbereich Strahler	Morning: 7–15 % Midday: off Evening: 300 lx / 3000 K
KAVA light colour	orange/beige
Spotlights (wall)	at 15 %
Downlights above the kitchen ensemble	100 %

Table 4-9. Overview of key lighting control parameters of lighting situation L3

Standardeinstellungen Lichtsituation L3
1) Lighting situation L3
2) empty
3) empty
7:00 a.m. to 7:00 p.m.: no intervention (switch-off/dimming) possible
7 p.m. to 7:00 a.m.: switch-off is possible
KAVA (corridor)

Table 4-10. Overview of the standard settings of the CIRCLE control point in lighting situation L3

5. Night ambiance

The night ambiance corresponds to Baseline 1a, with downlight, and is sort of added to any lighting situation automatically without activating a separate switch.

6. Demo program

Demo program (lighting situation L3): to present the situation to interested parties and visitors, a demo version was developed that may be called up via the touch panel (table 4-11.). The setting of the CIRCLE control point corresponded to the standard situation (cf. table 4-2.).

Parameter	Description
Duration	5 to 10 minutes
Light colour	like L3
Illuminance	like L3
KAVA light colour	like L3
Spotlights (wall)	like L3
Touch panel	Only operable via touch panel
	approx. every fourth value of lighting scene L3 is addressed

Table 4-11. Overview of key lighting control parameters of the demo program

Colour temperature shifts and their cause

For the 8000 K lamp it should be noted that the light emanating from the luminaire only has a colour temperature of 7250 K. This is primarily due to the modulation of the light through luminaire components such as their diffuser.

This downward colour temperature shift is not critical in case of the lamps of other colour temperatures, as essentially only the blue components are concerned, and this effect will accordingly only apply in case of light sources with higher colour temperature. The interaction of the light with room surfaces causes a further shift of the spectrum towards the long-wave warm range. Vertically only 5000 Kelvin were measured along the periphery of the luminous ceiling. This is due to the yellow colour of the wall surfaces absorbing further blue components on account of their material reflectivity. In combination with the 8000 K lamp, the yellow wall colour also conveys a dissonant and unpleasant room impression. Unfortunately, however, the wall colour could not be discussed but had to be accepted as a fact. For optimal results, therefore, the properties of the room surfaces and the lighting scenes were to be harmonised, for the resulting overall room impression and the effective spectrum, taking into account all stages of modulation and all influences, are ultimately decisive. Depending on the season, the time of day and the weather conditions, external influences (windows, daylight) may also cause a shift in colour temperature.

Observation procedure, interviews and questionnaires

In parallel with testing the lighting, the procedures for investigating the dependent variables that are based on observation and interviews were selected and prepared for the present purpose.

Data collection and observation procedure
Observation or monitoring by observers was going to be the main source of information. In conceiving this procedure, corresponding experiences (Bieske et al. 2006; Brach et al. 2004) from other projects were used, namely the instruments or tools developed in Mülheim "Haus Ruhrgarten". This observation procedure was adapted for MS Excel so that the observation data could be recorded directly by electronic means. The observations were made in the common area in each case (eat-in kitchen, kitchen, living room area, corridor, terrace). Documentation was effected at ten-minute intervals respectively according to the prescribed list of parameters, daily from 9:00 a.m. to 1:00 p.m. and from 2:30 p.m. to no later than 6:00 p.m. in each case.

For the dependent variables vitality/mobility and communication, the following is recorded in detail:

Time spent at the ward, a distinction being made between the relevant person staying
- in his/her room,
- in the living room area,
- in the dining/kitchen area (eat-in kitchen),
- in the corridor, and
- on the terrace (with a further distinction being made as to on whose initiative the person went to the terrace – on the person's own initiative, more or less intensive mobilisation by relatives or nursing staff).

Moreover, the time when changes within an interval took place, i.e. when persons stayed in different places within an interval, was documented;

Time spent outside the ward (to the extent known): hospital stay, other stay outside the nursing home
Current activities and interactions:
- Conversation, differentiation according to participants in the conversation (co-residents, nursing staff, others, or several persons during an interval)
- Household activities, differentiation according to motor activity and type of activity
- Social activities, differentation according to the type of cooperation: in this context, it was also investigated who initiated the activities or how intensively the residents had to be motivated to cooperate.

Eating and drinking: the extent to which the residents were able to prepare their food in a palatable way on their own and how independently and proactively they were drinking and eating, as well as the appropriate handling of cutlery were documented.

Some parameters were meant to be recorded as applicable in each case, namely
- cognitive orientation (knowledge about one's own person, appropriate response to the respective situation, orientation as to place and time), and
- emotional well-being (oral expressions of fear, dissatisfaction or aggression, aggressive behaviour or even-tempered condition).

Observers
The behaviour and well-being of the residents was recorded by a physically present observer. Overall, eight observers were recruited (via the website of the Sisters of Mercy), all of them having completed (university) training in medicine, social, nursing and/or pedagogic sciences. The observers were trained for several hours on different days and then supervised on a random sample basis. One observer was excluded after one week, because she did not fulfil the requirements with respect to accuracy and reliability. One observer was involved in the examinations right from the start, except for the pilot phase.

From these raw data, various indices were determined per person in each case. Consequently, they were evaluated descriptively and/or by way of inferential statistics (cf. chapter "Results").

Data collection by way of structured interviews and analysis of nursing files
By analogy with the observation tools, the ward manager and/or the respective deputy were asked to provide an assessment of the status of the observed residents two weeks after implementation of a lighting situation in each case. That means, the nursing staff assessed

- the vitality/mobility of the residents;
- their ability to eat and drink on their own and/or to prepare their food in a palatable way;
- their participation in household and social activities;
- their cognitive orientation (assessing whether the residents are oriented with respect to place, time, situations, and whether they recognise themselves and other persons in different situations);
- their emotional state.

As a rule, the interviews were made at lunchtime, when most residents were in their rooms, and they lasted approximately one hour.

For each resident nursing files were kept by the nursing staff, that were regularly analysed beyond the observational and interview data, namely with respect to
- extraordinary events (fall, food and liquid balances, etc.),
- medication,
- indicators of sleeping pattern, to the extent documented by the night nurse.

Anticipating the description of the results (cf. next chapter), it must be noted, however, that the data from the nursing files can only be used for interpretation with great caution since they either

- reflect the style of documentation of the nurses rather than a neutral description of facts; this is especially true of the documentation of day and night shifts, for instance one night nurse systematically recorded every visit to the toilet, while another one classified this as “no special occurrence” with respect to the same residents;
- or the nursing files were incomplete, for instance biographical data, reports about falls were missing, only the hospital reports were available;
- or the presentation of the facts did not fulfil the prescribed criteria in the summary nursing instructions (e.g. required behavioural descriptions mixed with evaluative interpretations of sensations).

Data collection regarding the situation of nursing staff
Just like the residents, the nursing staff are also influenced by the lighting situation. Accordingly, the nurses were not only interviewed in relation to subjectively perceived effects on the residents, but questionnaires were also used to investigate how the lighting situations affected the staff.

The observers regularly distributed questionnaires to the nursing staff on a weekly basis and collected them again from the nurses.

Questionnaires with scales (cf. annex):
- for the working situation (scope of action, time pressure, complexity)
- for error handling
- for self-efficacy
- for emotion (frequency of pleasant/unpleasant emotions, dealing with emotions)
- for irritability / strain / burn-out / psychosomatic complaints
- for social support by superiors and colleagues
- for general and specific satisfaction at work

Due to the staff working in shifts and the refusal to participate on the part of individual nurses, especially in the second run, the response rate was fairly erratic, amounting to only 20 % in some cases.

Test procedure

Phases of the investigation

As it was difficult to estimate the extent to which the residents would respond in a stable manner to the respective modified lighting situation, the duration of the investigation phases for the first run was determined to be approx. eight weeks upon recommendation by nursing management and the palliative medical consultant, in order to obtain a sufficient volume of data.

The investigations started in August 2007 with the standard situation, with the first twelve weeks having a pilot character due to personnel and technical problems. From this period complete data are available for individual days only. The first run of lighting situation 1 (L11) was extended to 10 weeks, as no observations were carried out in the period from 20/12/2007 to 07/01/2008 due to the special situation during the holiday season.

Overall, the following sequence of lighting situations was implemented (cf. table 4-12.)

From...to	Description	Explanation
01/08/2007 to 13/11/2007	Baseline (BL1)	Standard situation
14/11/2007 to 31/01/2008	Lighting situation 1 (L11)	Higher intensity
01/02/2008 to 31/03/2008	Lighting situation 2 (L21)	Like L11 + modified spectrum
01/04/2008 to 31/05/2008	Lighting situation 3 (L31)	Like L21 + dynamic sequence
02/06/2008 to 19/07/2008	Lighting situation 1 (L12)	Higher intensity
21/07/2008 to 7/09/2008	Baseline (BL2)	Standard situation
08/09/2008 to 6/10/2008	Lighting situation 2 (L22)	Like L12 + modified spectrum
7/10/2008 to 23/11/2008	Lighting situation 3 (L32)	Like L22 + dynamic sequence

Table 4-12. Sequence of investigation phases.

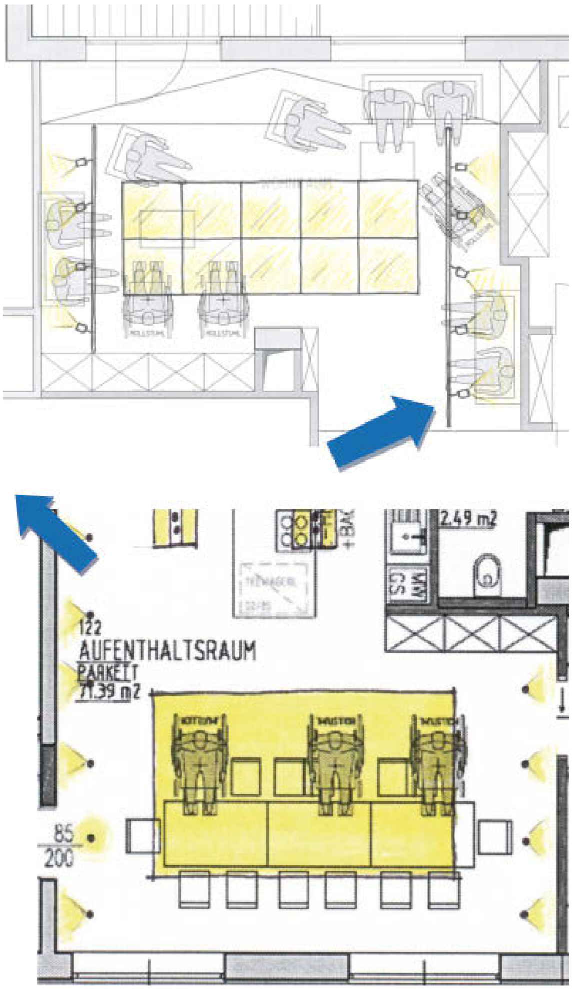

Fig. 4-13. Schematic presentation of the living room/dining area (common area) indicating the observers' positions (arrow).

Observation schedule

From August 2007 onwards, the residents were initially observed for half a day each, from no later than 8:30 a.m. until 1:00 p.m. or from 2:30 p.m. to no later than 6:00 p.m. in each case. From November 2007 onwards, observations were carried out by two observers throughout the day, i.e. both in the morning and in the afternoon, except for the half-days when the majority of the residents were staying in other areas of the building in each case (Wednesday mornings in the so-called energy therapy facility and Friday mornings in the chapel). As in the course of the investigation, the energy therapy initially attended by most residents was no longer attended, and as on the other hand Friday afternoon turned out to be the preferred day for visits by relatives, the observation focussed on the first four days of the week (Mondays to Thursdays, mornings and afternoons, respectively, cf. table 4-13.) from mid-2008 onwards.

Time	Monday	Tuesday	Wednesday	Thursday	Friday
No earlier than 8:30 a.m. to 1:00	Observation	Observation		Observation	Observation
Lunch break					
2:30 p.m. until 6:00 p.m. at the latest	Observation	Observation	Observation	Observation	Observation

Time	Monday	Tuesday	Wednesday	Thursday	Friday
No earlier than 8:30 a.m. to 1:00	Observation	Observation	Observation	Observation	
Lunch break					
2:30 p.m. until 6:00 p.m. at the latest	Observation	Observation	Observation	Observation	

Table 4-13. Observation schedule during the phases of the investigation until mid-2008 and until the end of the investigation

Course of observations during the day

The course of daily observations normally started between 8:30 a.m. and 9:00 a.m., when the majority of the residents came to the living room/dining area to have their breakfast. The observers would typically choose a position near the entrance that allowed them a good view of the major part of the common area and of the corridor. The necessity to change positions only occured if any residents stayed in the rear part of the living room area (cf. Fig. 4-13.).

Description of the sample

Selection and accommodation
The ward is designed to accommodate 13 persons. The selection of residents for the dementia ward was the responsibility of the nursing management. One essential criterion was a diagnosis of dementia and/or capacity deficits according to the facts on file. Moreover, the residents were meant to emotionally benefit from staying at this ward. Above all, this was made dependent on the fact that each of the residents showed some motivation to participate in social activities. Upon completion of refurbishment works, the residents gradually moved into the ward from April 2007 onwards. At the time of moving the first residents, the lighting system had already been installed, but trial operation had not started yet. The sensors were only installed in the course of August 2007.

In the pilot phase (August to October 2007), two residents died, the respective data were not taken into account. The successors were directly included in the observations. One resident had to be excluded from the pool of data during the first Baseline investigation, as she stayed in her room almost exclusively and was primarily mobilised by relatives. In the course of the project, two further persons died in different phases of the project. Overall fifteen persons were taken into account, but not with all trial phases. That means, fairly complete data are available from ten persons.

Code	BL1	L11	L21	L31	L12	BL2	L22	L32
1010a	yes	yes	yes	yes	yes	yes	yes	yes
1020a	yes	yes	yes	yes	yes	yes	yes	yes
1031a	yes	yes	yes	yes	yes	yes	yes	yes
1032a	yes	yes	yes	yes	yes	yes	yes	yes
1041a	incompl.; n.a.							
1041b		yes	yes	yes	yes	yes	yes	yes
1042a	yes							incompl.; a.
1042b								incompl.; a.
1050a	yes	yes	yes	yes	yes	yes	yes	yes
1060a	yes	yes	yes	yes	yes	yes	yes	yes
1070a	yes	yes	yes	yes	yes	yes	incompl.; a.	
1070b								
1080a	yes							
1080b		yes	yes	yes	yes	yes	yes	yes
1090a	incompl.; n.a.							
1090b	incompl.; a.	yes	yes	yes	yes	yes	yes	yes
1100a	yes	yes	yes	yes	yes	yes	yes	yes
1110a	yes	yes	yes	yes	yes	yes	yes	yes

Table 5-1. Observation schedule during the phases of the investigation until mid-2008 and until the end of the investigation

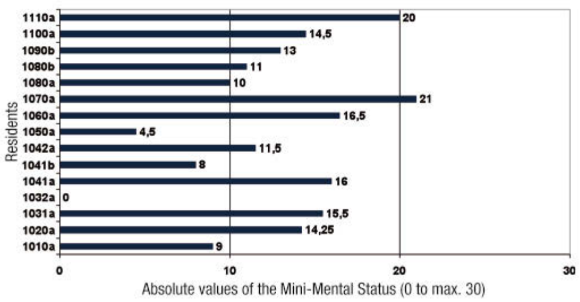

Fig. 5-1. Schematic presentation of the living room/dining area (common area) indicating the observers' positions (arrow).

Description of the sample according to demographic aspects

The sample ultimately consisted of fifteen persons, who can be described as follows, according to demographic criteria:

- Age and sex: at the beginning of the investigation, the sample consisted of eleven female and two male residents aged 88.6 years on average. At the end of the investigations, one of the male residents had died and the average age had reduced to 87.4 years on account of younger successors.
- Family status: 75% of the residents were widowed, the rest either single or divorced.
- Professional life: two thirds of the residents had been working, some of them (in senior positions) in their own business. All of them had completed vocational training.

Neuropsychological status

Based on the facts on file, it was found out that three residents had been classified as dementia patients (FS03 Alzheimer's dementia) according to a neuropsychological expert opinion (appointment of a guardian). One resident had been diagnosed with vascular dementia; dementia was noted as a secondary symptom (Parkinson) in the case of two other persons. For the rest, there was no diagnosis on the files. Since, however, a major part of the residents had moved to the old-age home due to their inability to live on their own, it is justified to assume some form of dementia. Three persons moved to the old-age home directly after a hospital stay. Due to the partly obsolete or missing information as regards diagnosis, all residents submitted to the Mini-Mental Status test during the pilot phase (August/September 2007). The residents who subsequently joined the group submitted to the test three to four weeks upon their respective admission. The results are shown in Figure 5-1.

Based on the MMS, all persons can be classified as dementia patients. The maximum value achievable is 30; from 20 to 25, pathological cognitive changes are assumed; in case of values between 10 and 20, experts talk about medium-grade to serious dementia. The relatively good values of persons 1070a and 1110a are due to their excellent calculating performance (in an MMS test component, where the test subjects must subtract 7 from 100 in each case).

Health status and medication

The nursing files showed that among the residents

- two persons had diabetes mellitus type 2,
- two other persons had Parkinson's disease,
- four persons suffered from hypertension (high blood pressure).

This source of information also shows that each of the residents received at least five, but for the majority more than five, medicinal drugs (dietary supplements not counting), with:

- five persons receiving antihypertensives,
- six persons receiving drugs reducing gastric acid,
- six persons receiving sleeping pills,
- ten persons receiving psychotropic drugs and/or antipsychotics, in five cases a drug that is not indicated in dementia, and in four cases a drug that is assessed unsuitable for elderly dementia patients.

To the extent assessable according to the nursing files, the medication was only slightly modified (for the treatment of headaches, wound management etc.). Neither the dosage of sleeping pills nor that of the psychotropic drugs or antipsychotics was changed depending on the lighting situation.

For individual residents, a liquid intake record was kept at times. This, however, does not show any connection with the lighting situation either. The same is true by analogy of other extraordinary events (falls, hospital stays, etc.).

Nursing situation

Overall, seven nurses were employed in the residential group for day care, among them three graduate nurses, two to three persons per day respectively, supported by trainees as applicable. In each case one nurse was explicitly instructed to act as "everyday life manager" and to stir the residents into action. 10 % more staff is used than in a standard ward.

The residents were classified in care levels three to six (of a total of seven). During the project (14 months), one person was reclassified to a lower care level; in case of nine residents the care level remained the same, and the remaining residents (five in total) were reclassified to higher care levels, one resident by three levels, the others by one or two levels.

Effects of the lighting situations

As indicated already, the effects of the lighting situations were determined on the basis of observational data. In the first run (BL1, L11, L21, L31), fairly comprehensive observational data were collected for almost all residents; in the second run, especially from July 2008 onwards (BL2 and L12), the state of health of several residents deteriorated quite massively, and accordingly due to frequent or lengthy hospital stays or the residents increasingly withdrawing to their rooms, the observational data are fragmentary. The data available are generally insufficient to allow for an evaluation of seasonal effects.

Vitality/mobility - results from observational data

As indicated already in the "Technical realisation" chapter, the vitality of the residents was made suitable for systematic evaluation by dividing this criterion into individual aspects such as time spent in and moving around the ward, including places and duration, participation in household activities as well as independent and appropriate eating and drinking. In this context, it was expected that the residents

- would generally frequent the common area more often and/or for longer periods than in the standard situation,
- would participate increasingly in household activities under the lighting situations created; this was expected in particular from the biologically effective lighting situations L2 and L3.
- would move around more often under the lighting situations due to the increased activation and improved cognitive orientation aimed at.

It also has to be examined, however, whether there are differential differences, that is whether the effect of light may possibly be dependent on the respective individual and/or is modified by other factors, for instance based on certain behavioural patterns and/or the nursing staff.

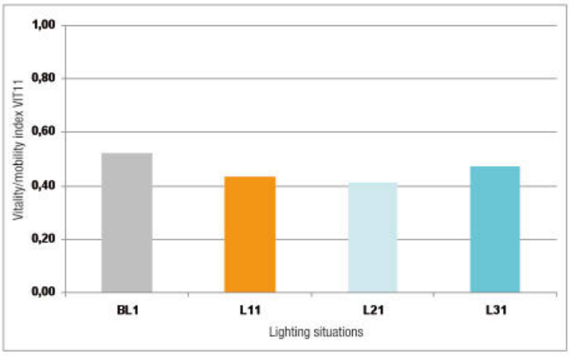

Fig. 5-2. Vitality/mobility index for staying in the common area, average of all residents for the entire day

Places frequented by the residents

It was investigated where exactly the residents spent their time in the various areas. In doing so, a differentiation was made on the basis of observational data according to the frequency of stays in the common area – i.e. living room, eat-in kitchen -, in the corridor, on the terrace and in the person's room. Based on this, an index was calculated (vitality/mobility index: frequency of staying in a certain place in relation to all places observed), which may assume a value between 0 (never frequented a certain place) and 1 (regularly frequented that place). The data from the first run were included, as in the phases of the second run the amount of data available was insufficient for an overall evaluation.

The overall result, i.e. taking the data of all residents into account, shows that in lighting situations L11 and L21, the residents attend the common area significantly less frequently than in BL1, there is no significant difference between BL1 and L31 (cf. Fig. 5-2.). This result is primarily based on morning data, while in the afternoon no differences between the lighting situations are observable. In total, however, the standard deviations in the lighting situations are lower.

Moreover, the result seems more differentiated if we consider the results for individual persons (only persons for whom data from lighting situations BL1 to L31 are available, Fig. 5-3.). It is evident here that

- three persons (1010a, 1031a and 1110a) stay more frequently in the common area in all or individual lighting situations (L11 to L31),
- three persons do not show any differences between lighting situations and/or the standard situation (1050a, 1060a, 1070a), and
- for the remaining five persons, the frequency of staying in the common area is higher under BL1 than in any lighting situation.

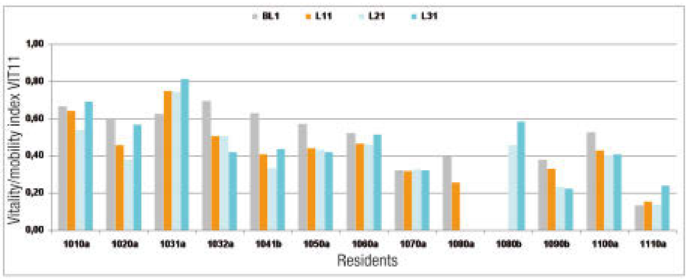

Fig. 5-3. Vitality/mobility index for staying in the common area, average of the entire day, differentiated by residents

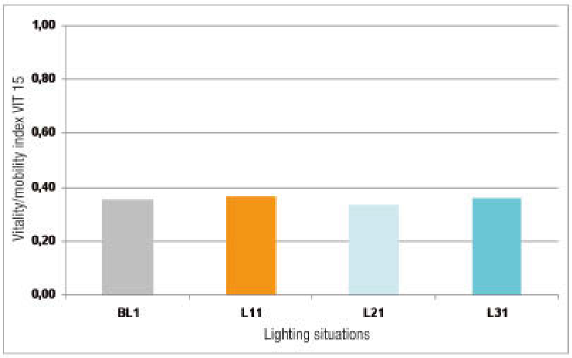

Fig. 5-4. Vitality/mobility index for staying in the room, average of all residents for the entire day

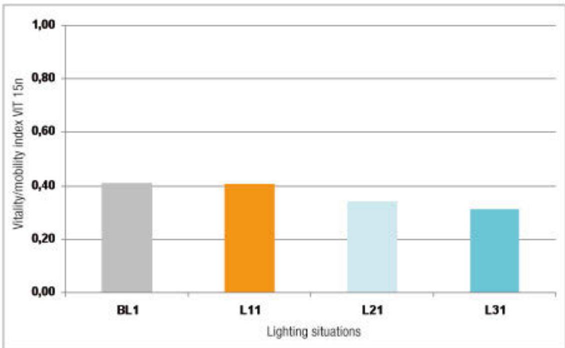

Fig. 5-5. Vitality/mobility index for staying in the room in the afternoon, average of all residents

If the residents are not staying in the common area, the question is where else they stay. The observational data allow to make a statement on whether the residents have rather stayed in their rooms, in the corridor or on the terrace. The volume of data regarding the frequency of staying in the corridor is insufficient for meaningful evaluation; the same equally applies to staying on the terrace, with a seasonal increase being observed during L31. The frequency of staying in the room was investigated. After all, it might be expected that residents will increasingly stay in their rooms, if they are not present in the common area. However, this is not confirmed by the analysis for the entire day (Fig. 5-4.).

The analysis of the afternoon data, however, shows that the residents tend to stay in their rooms less frequently in lighting situations L2 and L3 (Fig. 5-5.). Accordingly, it is interesting to check where the residents prefer to stay or whether they will move around rather than permanently stay in one place (cf. the following section).

Whenever the residents neither stayed in their rooms nor in the common area, this was primarily due to fact that the terrace is frequented more often in spring and summer, especially in situation L31. For lighting situations BL1 to L21, no or only fragmentary data are available.

Moving around different places within one observation interval
It was nevertheless examined if the lighting situations have an effect on the residents moving around. As indicated in the following figure (5-6.), the residents change their location significantly more often within one observation interval in lighting situations L11 and L21, while changes of location are equally frequent in lighting situations BL1 and L31.

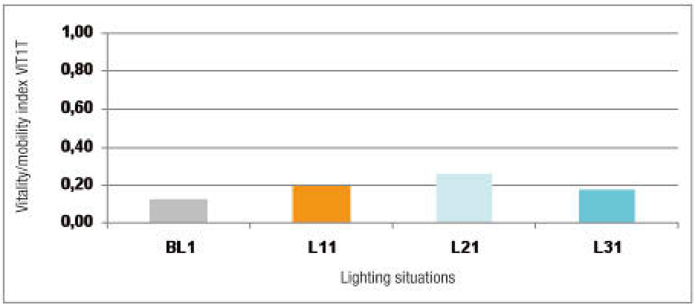

Fig. 5-6. Vitality/mobility index for changes of location within a period of observation of ten minutes, average of all residents for the entire day

Again, the individual differences are remarkable. Most residents respond with more frequent changes of location in situation L21, some only show minor differences, and only one person changes location most frequently in situation L31 (1032a; cf. Fig. 5-7.).

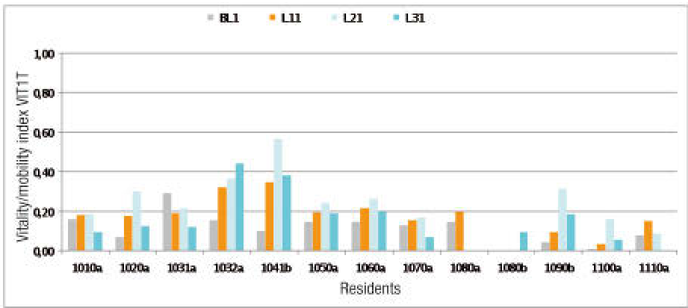

Fig. 5-7. Vitality/mobility index for changes of location within a period of observation of ten minutes, differentiated according to residents for the entire day

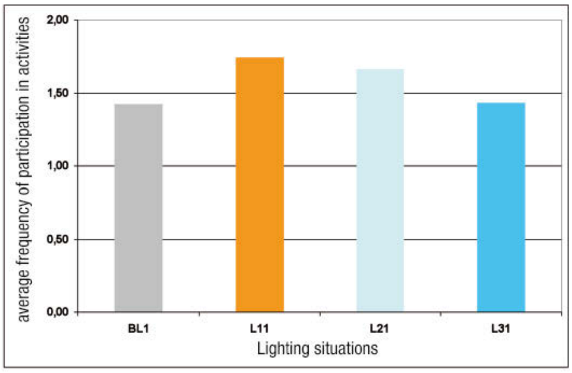

Fig. 5-8. Average frequency of participation in household activities in the first run

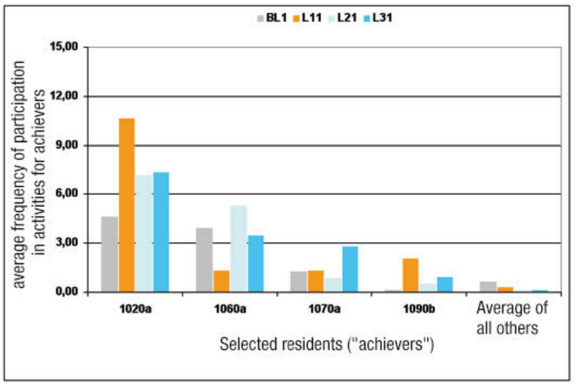

Fig. 5-9. Average participation of individual residents (“achievers”) in household activities in relation to all other residents

Participation in household activities

As another criterion for the residents’ vitality/mobility and a potential source of their well-being, it was investigated whether the lighting situations had an effect on the frequency of the residents participating in said activities. This includes, for instance, participation in the preparation of meals as well as participation in activities such as doing the laundry or arranging/sorting things etc.

The express goal of the nursing concept is to enable the residents to participate in daily activities by activating their resources and to provide them with a sense of achievement by mastering these activities. With a view to the lighting situation, it is assumed that biologically effective light initiates a cascade of positive events: successful melatonin suppression during the day promotes improved and accordingly restorative sleep at night, in turn leading to an improvement of cognitive orientation, a balanced emotional state and increased activation. Therefore, especially in lighting situations L2 and L3, increased participation in household activities should be observable.

As regards the result, it should be noted first of all that the evaluation of the data concerning the frequency of participation in household activities can only be effected in a descriptive manner, as the total amount of available data is insufficient. Accordingly, only cumulative values were formed for the respective lighting situation and the average per observation day calculated.

As is shown in the figure (5-8.), the rate of participation in household activities is higher in the respective lighting situations than in the standard situation.

This is essentially due to four “achievers”, who were primarily addressed and activated by the nursing staff, as indicated in the following figure (5-9.). What is remarkable in this context is the fact that two persons are particularly active in lighting situation 1, while the other two persons show increased activity in lighting situations 2 or 3.

In the second run of lighting situations, the rate of participation is highest in the second Baseline situation and lower in all special lighting situations. This is mainly due to the fact that the state of health of most residents had markedly deteriorated – in relation to the rest, especially in case of two “achievers”, and one person had died. Accordingly, the data from the second run is not significant.

Independent intake of food

As another vitality criterion, the extent to which the residents were able to eat and drink on their own was investigated. Carrying out a well-founded analysis is only possible to a limited extent in this respect, as the frequency of eating is subject to high intrapersonal and interpersonal variation. This means that there are times when all the residents eat together, especially at lunch. Then again, there are residents who tend to go to the dining room at times, or insist on eating alone in their room, or those who want to eat their meals together with relatives in their room. Finally, there are persons who regularly only eat [...], while others regularly eat four meals, and again others who only eat four meals sporadically. Therefore, these data are subject to influencing factors that do not allow for any conclusive statement to be made regarding eating and drinking patterns. There seems to be a tendency to the effect that independent eating is more readily observable in L11 than in any other lighting situation.

Communication – results from observational data

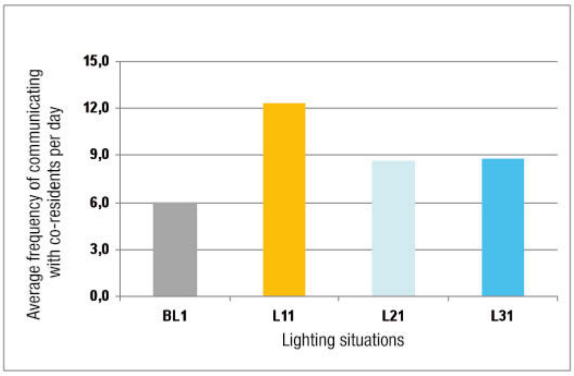

Fig. 5-10. Average frequency of conversations – average of all residents per day in the various lighting situations

Conversations

It was observed whether and with whom the residents were conversing - with one or several of their co-residents, with the nursing staff or with visitors. Overall the database was too small to allow for a separate analysis of conversations with visitors; they are included in the evaluation of conversations with several persons.

Under a quantitative perspective of the total frequency of conversations - measured according to the average frequency of conversations per day -, an increase is obvious in all lighting situations, but especially in lighting situation L11 (Fig. 5-10.).

Incidentally, this is true for all the residents observed (cf. Fig. 5-11.).

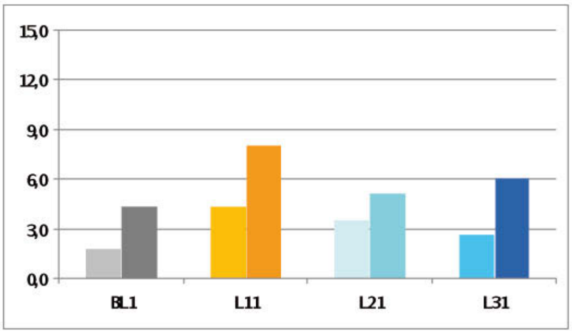

Fig. 5-12. Comparison of average frequency of conversations among residents per day in the various lighting situations in the morning and afternoon (light = morning; dark = afternoon)

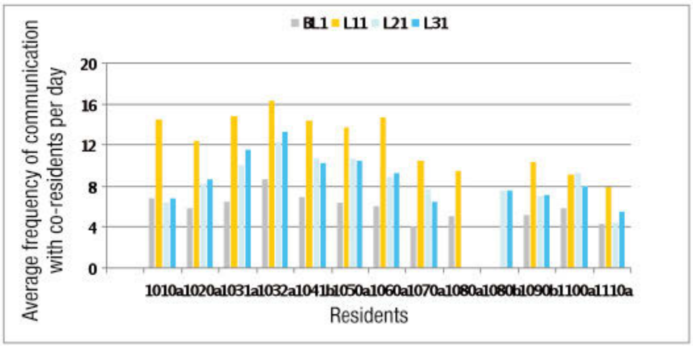

Fig. 5-11. Average frequency of conversations among residents per day in various lighting situations, broken down by resident

Moreover, there is an effect based on the time of day: the frequency of conversations increases in the afternoon, which is also due to the fact that in the morning, more residents are still in their rooms or come to the common area only relatively late due to nursing activities (Fig. 5-12.).

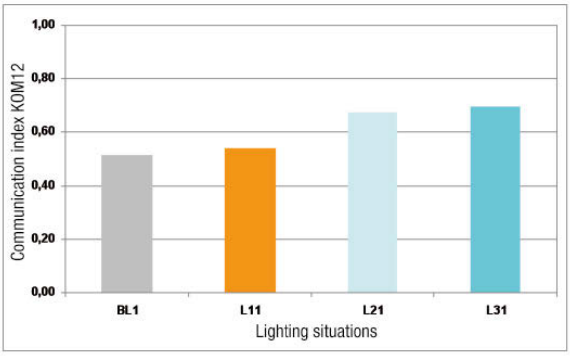

Fig. 5-13. Communication index for conversations of residents with nursing staff, average of all residents for the entire day

The influence of the lighting situation, however, is noticeable on a qualitative level when considering the distribution of conversations with different partners. A communication index was determined for this purpose, indicating the proportion of conversations with a group (co-residents, nursing staff, several persons) of all conversations. First of all, this clearly shows that the influence of the lighting situations on various groups of persons is different. In the case of conversations with co-residents - apart from a decrease from L21 to L31 in the afternoon -, no significant differences are observable. When considering the conversations with nursing staff (Fig. 5-13.) or in the situations with several conversation partners, we see a different picture.

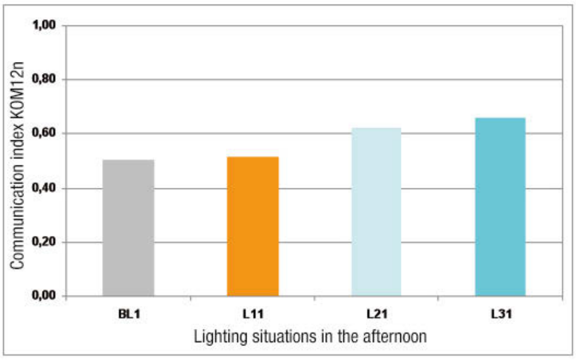

Fig. 5-14. Proportion of conversations of residents with nursing staff in different lighting situations

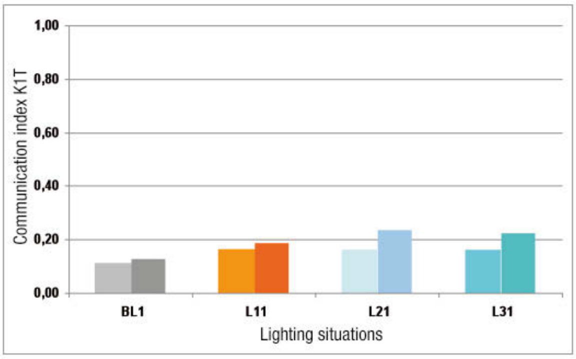

Fig. 5-15. Communication index for conversations with several persons, average of all residents, referring to the entire day (bright) and the afternoon (dark) in each case

Here, the proportion of conversations with nursing staff increases especially in lighting situations L21 and L31. If only the afternoon data are considered, this trend is particularly pronounced (Fig. 5-14.).

Overall, communication in the afternoon seems to be more intensive, as also the communication index for “communication with several persons” situations significantly increases in the afternoon (L21 and L31) (Fig. 5-15.).

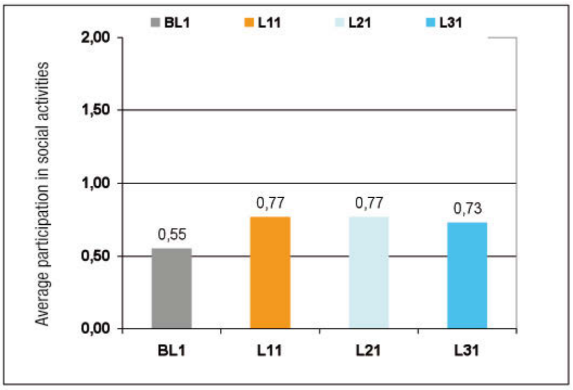

Fig. 5-16. Average participation in social activities during the lighting situations in the first run

Participation in social activities

The residents' participation in social activities which they are meant to be induced to share under the maieutic nursing concept is another communication criterion. This includes, for instance, joint activities like handicrafts, singing, games etc. Except for the so-called energy therapy taking place on one morning of the week - a sort of relaxation training outside the ward - there are no systematic offers, such as occupational therapy, for instance. It is up to the nursing staff or the "everyday life manager" to take the initiative in this respect. Accordingly, the frequency of such offers is more or less incidental and the amount of available data relatively low. Nevertheless it is obvious that overall the rate of participation is significantly higher in lighting situations L11 to L31 than in the baseline situation (Fig. 5-16.).

As becomes clear from the following illustration, participation in social activities varies. There are some "achievers" who let themselves be stirred into action, respectively are activated again and again. Generally, it must be said that - to the extent any data are available in this respect - participation is more frequent in lighting situations L11 to L31 than in the standard situation. For some residents an increase can be observed in lighting situation L11 rather than in the two other lighting situations (residents 1041b, 1050a, 1060a, 1070a).

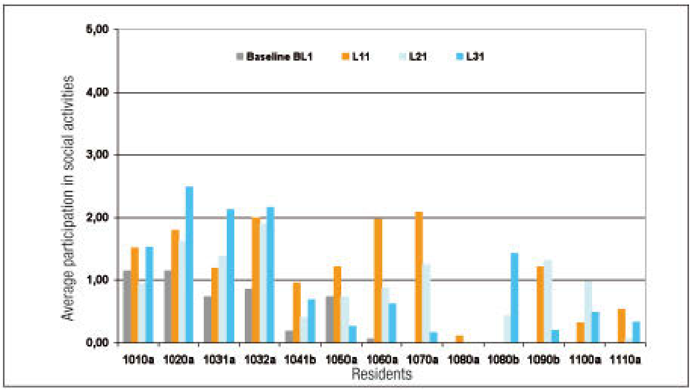

Fig. 5-17. Average participation in social activities in relation to individual residents

Here, too, the afternoon effect is evident; the rate of participation in social activities is significantly higher in the afternoon. But this effect cannot be assumed to be necessarily due to the lighting situation, as the morning is normally used for nursing care to a greater extent.
Moreover, the influence exerted by nursing staff is also noticeable in relation to conversations and the participation in social activities. In other words, some nurses attend more often to certain residents than to others, be it on the level of conversations or with a view to participation in social activities. That means, basically the effects of nursing and lighting situation overlap - with potentially quite positive consequences.

Helios Care Home Goldach | CH

Kittsee Care Home | AT

Gmunden Regional Hospital | AT

Elisabeth Residential Care Facility, Breda | NL

7 Discussion and outlook

Under the aspect that was to be clarified in the course of the project – efficacy of different lighting concepts with respect to dementia patients living in old-age homes – it may be noted that

- the residents communicate with significantly increased intensity with the nursing staff, especially in lighting situation 1 and in the afternoon,
- the residents communicate with several persons in all lighting situations significantly more frequently than in the standard situation – here, too, communication is more intensive in the afternoon than in the morning;
- the residents participate significantly more frequently in household activities such as folding the laundry, setting the table, preparing meals, baking cakes etc., in all lighting situations, but especially in the biologically effective situations (L2 and L3);
- the residents participate in social activities such as handicrafts, games, singing etc. significantly more often in all lighting situations, but especially in the high-illuminance lighting situation (L1);
- a light-dependent effect on the movement pattern and/or on the duration of staying in certain lighting zones can only be observed in individual cases.

These effects can be reinforced or attenuated by the nursing staff in case of individual residents to a certain extent. It was also shown, however, that individual residents respond to the lighting situations in different ways. This may be due to differential aspects - personality structure, chronotype, biographical circumstances, medical history; due to the small, non-representative sample and the incomplete information taken from the nursing files, however, this is only an assumption requiring further investigations.

Based on the results and/or the problems turning up in the course of the investigations, it may be noted that a clarification of the following aspects is desirable and necessary:

- Can light-induced effects be achieved already at lower durations of exposure?
- What is the effect of exposure to light on sleep, how can the circadian rhythm be supported in an optimal way? This also includes the question of how the lighting situation can be optimally integrated into the nursing situation, i.e.
  a) the integration of nursing staff should not only include systematic information about the effects of light, but also deepen their knowledge of using these effects in order to contribute to stabilising/reinforcing the benefits;
  b) this equally applies to the participation of physicians as regards any changes of medication;

With a view to bigger samples, it should be clarified which differential aspects moderate the effect of different lighting scenarios to obtain information as to which settings of light will be beneficial to what kind of activities and/or persons.

As opposed to standard lighting, the investment and energy required for the lighting will increase substantially. Calculations regarding amortisation can only be made if the increased quality of life of the residents through more satisfactory social behaviour, improved sleep and less medication, and the reduced strain on nursing staff are taken into account.

The extra investment for the lighting system may be estimated as follows: the installation costs were depreciated over ten years, and the operating costs assumed. On this basis, the cost per resident and day amounts to approx. €1.45.

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9 Brief portrait of the partners

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