

Research paper: Influence of color design on the functionality of new hospital buildings, in particular the well-being of patients, relatives and staff

Project partners Research cooperation:

Prof. Dr. Axel Buether
University of Wuppertal
 Institute for Color Psychology
 Faculty of Design and Art
 Fuhlrottstr. 10
 42119 Wuppertal
 Tel: +49 (0202) 439 5157 (tel. 9.00 - 13.00 Uhr)
 Email: buether@uni-wuppertal.de
 Web: www.axelbuether.de

Dr. Hans Thorsten Körner
 Senior physician
Central Hospital Bremen
 Parent-Child Center Prof. Hess
 Clinic for Pediatrics and Adolescent Medicine
 Dept. f. Neonatology
 St.-Jürgen-Str. 1
 28205 Bremen
 Tel.: +49 (0421) 497-76901
 Email: neonatologie@gesundheitsnord.de
 Web: <http://www.klinikum-bremen-mitte.de>

Collaboration on color design: Heike Krauss, Clara Götsch
 (intern), interviews and documentation: Fridhelm Büchele,
 Henning Wolters, evaluation Leonie Weddeling

Abstract

This study examines the influence of color design on the well-being and satisfaction of patients, relatives and staff using the practical example of the department of neonatology in the Clinic for Pediatrics and Adolescent Medicine in Central Hospital Bremen. In continuation of our previous studies, a new building was available for a study here for the first time.¹ The color redesign of the neonatology ward in the new clinic building became necessary because the largely monochrome color design of the ward (white walls and ceilings, yellow floors throughout) met with vehement rejection from the medical, therapeutic and nursing staff, which was expressed both verbally and in writing.² The color redesign was carried out in a participatory process according to an evidence-based methodology.

The results of the representative survey of medical, nursing and therapeutic staff before and after the color redesign, as well as the interviews and observations, show significant changes in the experience and behavior of the people concerned. The assessment of well-being, quality of stay, emotional mood, orientation and motivation improved on average by 207% from 4.3 (negative) and 2.1 (positive).

How would you rate the influence of the station's color scheme on:	Before	After	Steps	Change	Improvement
1. Their medical and nursing activity	3,8	2,3	1,5	1,65	165%
2. The well-being of the premature infants.	3,7	2	1,7	1,85	185%
3. The well-being, trust and confidence of the parents	4,4	1,5	2,9	2,93	293%
4. Their well-being and the quality of stay	4,4	2,1	2,3	2,1	210%
5. Their feeling that the employer values their activity	4,2	2,4	1,8	1,75	175%
6. Their identification with the place of work	4,2	2,3	1,9	1,83	183%
7. Their emotional mood and motivation	4,2	2,1	2,1	2	200%
8. Their orientation in the ward	4,6	2	2,6	2,3	230%
9. The effectiveness of regeneration during breaks	4,6	2,5	2,1	1,84	184%
10. The attractiveness of their workplace	4,5	1,8	2,7	2,5	250%
Gesamtauswertung Wohlbefinden	4,3	2,1	2,2	2,1	207%

*Assessment scale, whole marks were allowed: 1 very positive, 2 rather positive, 3 no influence, 4 rather negative, 5 very negative

Basic data:

Location: Klinikum Bremen Mitte, Eltern-Kind-Zentrum Prof- Hess. Clinic for Paediatrics and Adolescent Medicine, Department of Neonatology

Project period: Kick-off workshop on participatory procedure January 2021 - completion of evaluation August 2022, renovation phase spring 2022

Information on the department: As a special area of paediatric and adolescent medicine, neonatology deals with the typical illnesses of newborns and with the treatment of premature babies.

Size of the building: The new clinic building has side lengths of about 100m x 45m. The neonatology department is located on the upper floor and occupies about 3/4 of the floor, which results in a net area of approx. 2,600 sqm according to a rough estimate. The floor is accessed by long, windowless corridors, 3 of which run lengthwise and 5 crosswise.

Color scheme in the new building before the intervention: All walls and ceilings in the ward were painted white throughout and had a yellow floor covering. During the first inspection, the initial state was documented photographically (see appendix).

Lighting: The lighting was already installed at the time of the color design, so no changes to the luminaires and lamps were possible. There is considerable potential for improvement in adapting the lighting (color temperature, color rendering index, illuminance, arrangement, etc.) to the needs of the people concerned, and this should therefore be included in the design of the surface colors wherever possible.

Furnishings: The surface colors of the furnishings contribute significantly to the overall effect of the rooms. In this case, a large part of the furniture was already ordered in advance by the responsible departments of the operator. A problem arose in this project especially where furniture with black surfaces was to be used. In combination with the yellow flooring of the ward, black surfaces create a biologically determined warning color combination that produces harsh contrast effects and has an extremely disharmonious effect, which impairs the recreational effect in the break rooms and has a strong disturbing effect especially on the parents of the prematurely born children in intensive care. For these reasons, the black furniture was replaced where it was still possible.

Room program: Personal rooms, on-call rooms, preparation rooms, changing rooms, parents' association, parents' support rooms, parents' rooms, offices, ancillary rooms, corridors, ICU: support point, back office, 3 patient rooms 1- bed, 3 patient rooms 2- bed, 1 patient room 3- bed, IMC: support point, back office, 3 patient rooms 1- bed, 1 patient room 1-2 bed, 3 patient rooms 2-3 bed

Introduction:

Size as a problem factor: Many modern new hospital buildings are very large due to conditions and economic requirements. Due to the given room program, there are often rows of rooms of the same depth and height. Access is through long straight corridors, which are often windowless and uniform due to the economic framework conditions in health care construction.

In the long, narrow corridors, the doors are lined up to form a focal point. Doors that are identical in shape and décor are just as problematic for the orientation, scale and atmospheric effect of a ward as the undifferentiated design of the walls, ceilings and floors. An important goal, which was achieved by differentiating the colors of the different functional areas.

Problem factor development:

Access to the floors is usually from a central lift and staircase core, which often leads to several stations. In this case, assistance options are usually not available, as the support points are far away and can only be found after walking through a labyrinthine corridor system. Visitors and patients can

only determine the intended use of the rooms by looking at the signage, often focusing first on the multi-digit room code needed to supply and dispose of the rooms. If a differentiated color design is missing, patients and relatives perceive, by looking at the individual door signs, whether a storage room or a death room, a kitchenette or a patient room, a WC or a treatment room, is hidden behind them. After a certain time, which is influenced by the psychological and physical condition of the people, the feeling of disorientation and helplessness can arise in such an atmosphere; fears that can arise in patients as well as relatives are intensified by the social coldness, unkindness and anonymity of the atmosphere.³ Another important goal of the intervention was the hierarchical structuring of the entire access system, which was achieved on the one hand by camouflaging the functional areas that are reserved for staff only, and on the other hand by highlighting and differentiating in color the functional areas that are particularly significant for patients and relatives.

Problem factor of common rooms:

How are patients supposed to recover in a room whose sterile and impersonal atmosphere increases their fears and worries? How do relatives experience the last encounter with a loved one if it takes place in a room whose impersonal, cool, forbidding atmosphere robs the farewell and the deceased of their dignity. How are nurses supposed to relax after a long exhausting shift in a break room that has the same color, the same flooring, the same light as a patient's room in which they previously worked and experienced human suffering. By the time the inner images of the work are displaced and the recovery phase can begin, the break is often already over. These and similar observations can be made in all wards whose color design runs counter to the needs of patients, relatives and employees. Color design is not an end in itself; in the context of healthcare construction, it must be neither arbitrary nor intuitive, but like the design of form, it must follow the function in every spatial situation, which results from the needs of the users concerned. The most important goal of the intervention aimed at improving the quality of stay, which was achieved through a differentiated use of muted and light natural color tones in patients' rooms, parents' support rooms, parents' rooms and on-call rooms. One of the most important functions of color is the possibility to create changes of atmosphere, which was achieved through activating colors in the offices as well as restful colors in the break rooms.

Color design methodology:

With the method developed by Prof. Dr. Axel Buether, color can be used purposefully, effectively and evidence-based as a design tool in architecture, interior design and spatial design.⁴

Phase 1 Determination of basic principles - participation, criteria development

At the beginning of the project, the perception situation is analyzed. Personal impressions of the place, visits to facilities with comparable use, first conversations with the later users and the other project participants are brought up through descriptive texts, interviews, photos, sketches, drawings and collages. To ensure that the dialogic moment is not left to chance, a workshop will be held to focus on the needs of the users, as well as the desired characteristics and effects of the spaces. At the end of the first phase, content-related criteria are formulated and agreed upon, which are decisive for the decision-making process in the following design process.

Phase 2 Preliminary Design - Variant Formation and Selection

In the preliminary design, variants are developed on the basis of the previously determined criteria, which can be understood, reviewed and discussed by the project participants and representatives of the users. The preliminary design is concerned with the holistic nature of human perception, with the psychological dimension of architecture. It is clarified how the space might feel within the given boundaries, how it might be experienced and how it might influence user behavior. Expert-lay communication has a key function here. In the later users, who are mostly laymen, memories, emotional reactions and mental reflections are to be stimulated. They should recognize and express their needs in the respective room situation.

Phase 3 Design - composition of all light and surface colors

In the design phase, the planning of the light and surface colors is continued separately. The lighting design must take into account the design criteria as well as technical parameters, specifications and standards. The selection of materials, claddings and coatings is made depending on the lighting situation, taking into account the diurnal alternation of daylight and artificial light. Surface colors that are used rather or exclusively under artificial light conditions are to be judged fundamentally differently than uses that take place rather or exclusively in daylight. Differences in the effect of direct and indirect daylight must be taken into account. Important are the interactions between light and surface colors, as well as the contrast effects of all surface colors among each other and to the whole. The design presentation is based on views, floor plans and sections in which all color surfaces are designated and shown. For each color surface there are samples from the corresponding manufacturer or a DIN A 5 card from the selected color system.

Phase 4 Sampling - perception under conditions at the execution site

Colors change their effect with their extension, with the surface and light situation in the application situation. For an approximately realistic assessment of the complex interaction of all light and surface colors, on-site sampling is essential. For this purpose, a sampling plan is drawn up by the advertiser, which determines the selection and location of all color samples at the construction site. Where the intended effect is not achieved, changes must be made. A color system that allows fine gradations separated by shade, brightness and saturation is helpful here.

Study methodology:

In developing the accompanying scientific study, we relied on surveys, interviews, and questionnaires. We did not collect data on staff sick leave or medical data, such as medication consumption; for this, I refer you to the previous studies.

For the survey of the color concept, we chose the scientific method of Dialogic Introspection, which is mainly used in qualitative psychology and social research to make the potential of self-perception and environmental perception usable for science and practice.

With this method, the content-related criteria can be determined, in this case the unfulfilled needs of the relevant user groups, which form the concrete problem situation of the task. In our case, we held a half-day workshop with the interested employees, which met with great approval and enabled us to clarify the problem situation. With the subsequent preliminary design and draft of the color concept, an attempt is made, with the participation of the users, to find a design solution for each of the problems named, e.g. to improve the orientation of a concrete user group (parents) in a concrete area of the ward (parent-accessible area) for a concrete purpose (finding the children quickly without stress). If the needs are concretely named, a design solution can then be sought, which can be evaluated after implementation under trial and error in the concrete user situation. The requirements for the moderation of such workshops are very complex, since the valid clarification of the needs of individual user groups (in the sense of a general validity beyond the subjective perception of the person interviewed) can only be achieved through a method of thematizing, enquiring and evaluating in the group. It follows from our series of studies that when studying architecture, interior design and spatial design, knowledge from the field of psychology and interviewing should also be imparted, since a professionally qualified person cannot be consulted in every case.

Evaluation of the study:

The starting point for the project, including the accompanying scientific study, was the imminent move of the Department of Neonatology Clinic for Paediatrics and Adolescent Medicine from an existing building at Klinikum Links der Weser Bremen to a new building at Klinikum Bremen Mitte. A member of the staff contacted Prof. Dr. Axel Buether by e-mail, asking for help with the color design of the ward (see attachment, e-mail dated 19.11.2020).

In order to make the subjective description of the problem situation as objective as possible, Prof. Dr. Axel Buether, in cooperation with the head of the neonatology department, Dr. Hans Thorsten

Körner, and in agreement with the client's representative, Lars Nickel, and the staff council, conducted an anonymous survey. Before participating in the survey, the employees had the opportunity to walk through the new rooms. 26 people from the medical, therapeutic and nursing staff took part in the representative survey.

The evaluation of the answers (see comparison before/after) shows that the existing colour scheme of the ward works against the well-being of patients, relatives and staff and is therefore highly dysfunctional.

Results of the study:⁵

1. the color scheme is a significant factor for the well-being. (Overall result of the survey before the color change from 4.2 rather negative to 2.1 rather positive afterwards).
2. white walls do not have a neutral effect, but significantly counteract the well-being of patients, relatives and staff (overall result of the survey before the color change of 4.2 is significantly worse than the neutral result of 3).
3. The distribution of the answers proves that the effects of color and space can be objectively assessed, planned and used in the structural context of the utilization situation for the benefit of the user groups concerned. Deviations in the distribution of answers prove that the effects of color in space remain subjective within a range that is tolerable, as it does not significantly affect the success of the design (See chart).
4. the color design of the architecture has positive effects on the medical and nursing activities of the staff if it is needs-oriented and evidence-based. (From 3.8 rather negative to 2.3 rather positive)
5. the color design of the architecture promotes the well-being of patients if it is needs-oriented and evidence-based (from 3.8 rather negative to 2.3 rather positive)⁶
6. architectural color design promotes parent well-being, trust, and confidence when it is needs-based and evidence-based (from 4.4 tending to negative to 1.5 tending to positive)⁷
7. architectural color design promotes staff well-being and quality of stay when it is needs-based and evidence-based (from 4.4 tending to negative to 2.1 tending to positive)
8. the color design of the architecture promotes the staff's feeling that the employer values their activity, if it is needs-oriented and evidence-based (from 4.2 rather negative to 2.4 rather positive)
9. the color design of the architecture promotes the identification of the staff with the place of work, if it is needs-oriented and evidence-based (from 4.2 rather negative to 2.3 rather positive)
10. the color design of the architecture has a positive effect on the emotional mood and motivation of the staff if it is needs-oriented and evidence-based (from 4.2 rather negative to 2.1 rather positive)
11. the color design of the architecture has a positive effect on orientation in the ward if it is needs-oriented and evidence-based (from 4.6 negative and 2.0 rather positive)
12. the color design of the architecture has a positive effect on the effectiveness of regeneration during breaks, if it is needs-oriented and evidence-based (from 4.6 rather negative to 2.5 rather positive)
13. the color design of the architecture has a positive effect on the attractiveness of the workplace for staff if it is needs-oriented and evidence-based (from 4.5 rather negative to 1.8 rather positive)⁸

Response Distribution:

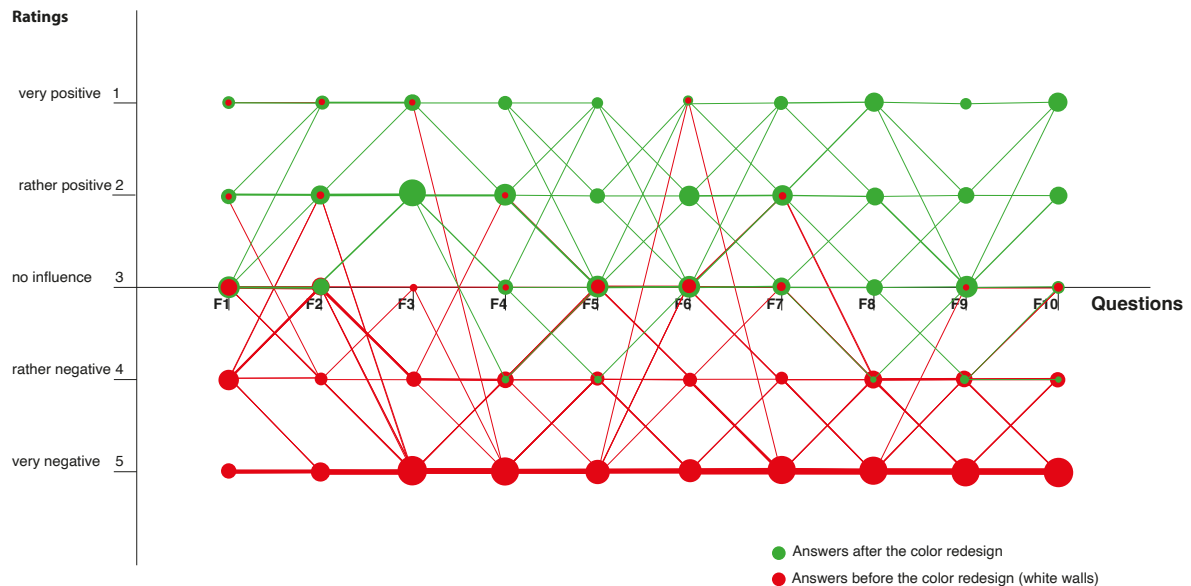
The distribution of responses allows 2 important conclusions to be drawn:

- 1) The effects of colors in space can never be completely objectified. Due to differences in genetics and personality development of individual people, color perception remains subjective to a significant degree.

2) However, the effects of colors in the room can be controlled with the help of the method used here, and all the objectives set at the beginning for the well-being and health of patients, relatives and staff could be achieved. The defense of the answers proves that all 10 examined effects of color and space shifted significantly from the negative to the positive range with all participants.

Evaluation of the questionnaires before and after the color redesign

The dot and line thickness is in relation to the response frequency



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Conclusion and Outlook:

On the relationship between well-being and health:

The WHO Constitution defines health as "...a state of complete physical, mental and social well-being and not merely freedom from disease or infirmity."⁹ Our study shows that the white wall design of the newly built ward counteracts the purpose of use, as it significantly impairs the well-being and, according to the WHO definition, the health of patients, relatives and staff at the same time.

A clinic whose atmosphere significantly impairs the well-being of the people in it is dysfunctional.¹⁰ The interplay of light and surface colors contributes significantly to the atmospheric effect of built spaces, taking into account the interactions of all environmental factors that can be perceived by the senses, such as the smell of cleaning agents and the exhalations of building materials, the acoustics of surfaces and the noise level of the premises, the quality of the food and, above all, the level of human attention and friendliness.

In summary, it can be stated that the abandonment of a needs-oriented and at the same time evidence-based color design causes a multitude of problems for the people concerned and for the entire hospital operation, which can be justified neither ethically nor economically. The costs for a needs-oriented and at the same time evidence-based color design are hardly representable in comparison to the construction costs, and vanishingly small in comparison to the total costs of planning. This project essentially consisted of 2 factors: a) the development of the color concept and

b) the repainting of the wall surfaces, which in this case only had to be done a second time because a needs-oriented and evidence-based color concept was dispensed with the first time.

In interviews and conversations, it was repeatedly mentioned that the built space itself had function as deficiencies, such as a lack of views of the surrounding greenery or sky from the interior hallways and the support points attached to them. Studies show that such views have positive effects on human health.¹¹ It follows from this that a needs-oriented and evidence-based color concept should, as far as possible, accompany the design, whereby important parameters must be worked out in advance, such as health-promoting views of the colorfulness of the surrounding nature, the sky, green space or water, or the creation of an outdoor space design that enables the planning of such views. Color is an essential ingredient for evidence-based health building, which also has many other important aspects, as evidenced by recent publications in the field of architectural psychology.¹²

Transcribed Interviews Staff:

(Note: The interviews are reproduced in excerpts, the authors from the staff team have been anonymized to protect their personal rights).

A) Effect of the atmosphere of the ward in the new building before the color redesign.

Quotation from the mail dated 19.11.2020 (A representative of the staff for the neonatology team from the Klinikum Links der Weser to Axel Buether:

"... I currently work in the neonatal intensive care unit at the Klinikum Links der Weser. Next summer we will move to a new building. The care of premature babies and their parents involves so much more than "just" intensive care. Unfortunately, we have no lobby whatsoever as far as the color scheme is concerned. White walls, LED spots, ... a dreary experience. In terms of equipment, everything will be there, but what makes up our special care is totally lost. Patients and their parents often stay on our ward for months. As nursing staff, our hair stands on end..... This is no way to create an atmosphere of well-being. Can you give us a hand? Can you help us to create a good working atmosphere and enable the fruits to arrive well in this world?..."

B) Effect of the atmosphere of the station in the new building before the color redesign.

Interview B1 station assistant, 19.08.2022

"I was there from the beginning and actually have no idea about color theory. I only know what I like, what looks good and what does not. I think the color design is wonderful and I think color is important here because it can have a calming effect. That the parents here have the feeling that they are well taken care of, they are in good hands, and I think that's the case here. I think the colors are wonderful. And because the feeding station is also on this floor, we have also provided orientation through color. You can see exactly where things start and end in the hallway. And I find that very, very nervous for parents who are anxious when they come up here, sometimes even distraught. So I think that was actually the most important thing for me, that the orientation is there."

Interview B2 Childcare worker, 19.08.2022

"Without color, very frightening, because that just had nothing at all to do with what, as we lovingly put it, had to do at home in the LdW (Klinikum Links der Weser). It was really just reduced to hospital, to white, to sterile. And that is in no way what we do with the children, for us many aspects are important between the care, and a room climate and a feel-good character are simply part of it".

Interview B3 nursery nurse, 19.08.2022

"I find the color tones incredibly beautiful. You enter the ward, it's warm, it's friendly, it's accommodating and you feel good".

Interview B4 paediatric nurse, 19.08.2022

"But I also have the feeling that the children are a bit better off under there. Of course, we can also do everything darkly, which premature babies need. And we no longer have this bright, glaring light. It feels very homely and warm. I have the feeling that it also helps the parents. First of all, our care base, where you can always find us. Routes out of the changing room, for example, to the right is the IMC (Intermediate Care Unit), straight ahead is the intensive care unit. That they don't have to make the paths, like for example I go around to the right and I can't find my way around here anymore. So it feels like no parent has ever asked how to get to their child. That was clear from the start, if I reflect it that way. I think our common room is quite nice, it's a darker color, it lets you come down a bit and switch off. And I find the color, for example in our work room, where we also draw up infusions and the like, very subtle, so that you don't concentrate on anything else, but that you are clear, can make yourself aware, I am now there to draw up an infusion and can simply do that precisely and not be distracted."

Interview B5; Dr. Hans Thorsten Körner, Head Physician, Department of Neonatology, 19.08.2022

"The initiative came about because we came to this new building for our first visit and were simply shocked at how white it was, how cold, how sober and we could not imagine working in such an environment with parents and small premature babies, neither that we would work there nor that these people would feel comfortable here. We had been in a completely different environment before, where we were provided with a completely different environment, so we thought about how we could create an environment in which we would feel comfortable and in which the patients would also feel comfortable. And that's how we came across Mr. Buether and his project, which he had already carried out elsewhere, and we found it very interesting, we made contact and we quickly came together.

I, as the director, of course rather moderated it, here from our side together with Mr. Buether. It was decided that all the employees were there and the interest of all the employees was great. They also actively participated and took part in the different workshops, the different stages where we met, from a conceptual preliminary planning, so to speak, where it was primarily a matter of saying what is actually important to us, what is important for us, what do we want to achieve?

and how can we use the color scheme as a means to an end there as well? Where we were limited was that the architecture was already predefined and in the end we couldn't change much about the rooms. We could really only work with the color scheme, and I think the result speaks for itself. So I think we made the best out of what we had here. I must say that because so many people were involved, many different professional groups, it was not only doctors and nurses, but also music therapists, art therapists, physiotherapists, so there were really many different professional groups involved. I think this gave it a relatively broad basis, and I think we all had the same feeling, even if we didn't always agree on individual points. We have a joint project and that was actually the most important thing. Ultimately, the process of getting to where we are now, so to speak, was almost as important as the result."

Pictures of the condition before - and after the color redesign:



Image 1: Care center before



Image 2: Care center after



Picture 3: Hallway before



Picture 4: Hallway after



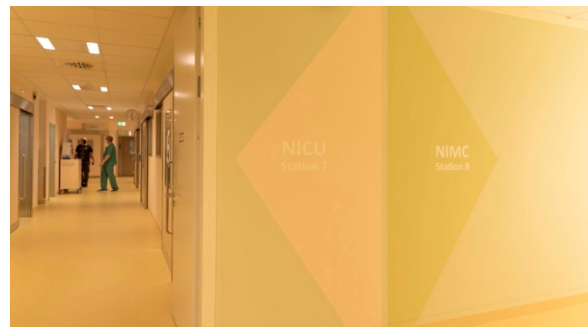
Picture 5: Patient room before



Picture 6: Patient room after



Picture 7: Entrance patient room after



Picture 7: Entrance patient room after

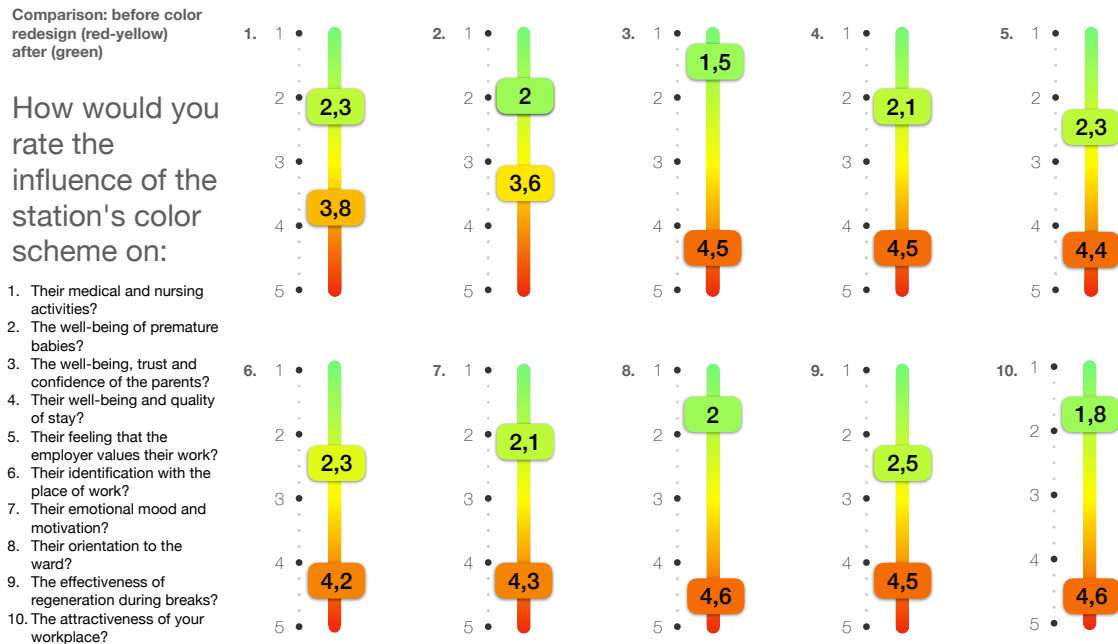


Image 9: Well-being parameters - survey result before (red) and after (green) color design

¹ Color design does not always have positive effects on users. It can have a counterproductive effect and be dysfunctional if it is not oriented to the needs of the users and is not executed in an evidence-based manner. A study on this issue is underway. Axel Buether was commissioned in 2021 to redesign the Interdisciplinary Pediatric Intensive Care Unit at Johannes Gutenberg University in Mainz, where the color concept had previously been conceived and implemented by an artist. A purely artistic color design can have positive effects for the user groups concerned, but at the same time it also carries the risk of failure, which is a legitimate outcome in art, but unacceptable in architecture, where the well-being of the users is of central importance in most cases.

² The rejection of the existing color design of the new clinic building was clearly expressed by the staff's cry for help (See Appendix), the interview with the medical director (See Appendix). The reasons for the rejection of the existing atmosphere were named in the questionnaire and validated by the result of the interview (See Table of Results).

³ These and other terms were repeatedly mentioned to us in discussions with patients, relatives and employees. Quote from the Helios study - Color in healthcare construction: "At the moment, it is so that there is no color here, it is actually very colorless and also very lovelessly designed." The documentation of the associated interview can be found on the non-profit educational platform <https://colour.education/> and the associated YouTube channel: <https://www.youtube.com/watch?v=43Dp9zB9o6M>

⁴ Buether, Axel. (08/2020) Die geheimnisvolle Macht der Farben. Wie sie unser Verhalten und Empfinden beeinflussen. Droemer München
 Buether, Axel. (2017, Neuauflage 2020) Die Sprache des Raums. Beitrag zur Publikation: Architektur Wahrnehmen. (A. Abel / B. Rudolf Hrsg.) transcript
 Buether, Axel. (2021) Taten des Lichts. Artikel Fachzeitschrift architekt 4/21 Effekt und Affekt. Bund Deutscher Architekten BDA

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concerned, but at the same time it also carries the risk of failure, which is a legitimate outcome in art, but unacceptable in architecture, where the well-being of the users is of central importance in most cases.

⁶ The reasoning behind how the nursing staff arrives at this assessment is clarified in transcribed interview A. In the interview, it is explicitly mentioned that premature infants react to a comfortable atmosphere, which is determined by the perceptual quality of light and surface colors. The observations documented by us show furthermore that colored cloths are used at incubators by the nursing staff to regulate the incidence of light and the color quality of the light in immediate proximity to the child even more finely. Our previous studies reported under 1 and 2 show that adult patients also benefit from color design if it is needs-oriented and evidence-based.

⁷ We saw the greatest improvement on this question, even though we did not ask the parents directly. The reasoning behind how the nursing staff arrived at this assessment is clarified in transcribed interview B. Here, it is stated that parents often stay in the ward with their prematurely born children for weeks to months and are under extreme tension. Here, the effect of a confidence-building feel-good atmosphere and the intuitive form of orientation on the color guidance system from any place in the ward to one's own child has a particularly clear effect.

⁸ Here we were able to achieve the second largest improvement, just behind the well-being of the parents. The evaluation in the questionnaire corresponds to statements made in the interviews with the staff.

⁹ Preamble of the WHO Constitution of 1948 (quoted from WHO 2020, p. 1).

¹⁰ Abel, A. (2020) Architecture and health. Needs-based architecture exemplified by a Maslow metamodel. Weimar, Germany: Faculty of Architecture and Urban Studies Bauhaus-Universität Weimar.

¹¹ Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. (1991) Stress Recovery During Exposure to Natural and Urban Environments. *J Environ Psychol* 1991; 11: 201 - 230

¹² G. Koppen und T.C. Vollmer (2022) Architektur als zweiter Körper, Gebr. Mann Verlag