Successive approximation in full scale rooms. Colour and light research starting from design experience

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Abstract

OPTIMA is a pilot study attempting to simultaneously involve all visual aspects of the room, with an analysis starting from the totality instead of dividing it into different parameters. Its primary aim is to develop and test methods for this, combining a scientific approach and experience based practices of art and design. In the long run we aim to improve the understanding of how artificial light, daylight and the shape and colours of the room interact in achieving different qualities, and the possible conflicts between these qualities. Tests have been made in full scale rooms, using a methodology of successive approximation. The method has shown to be fruitful, and the results include new hypotheses regarding the spatial interaction of colour and light, to be further tested.

1. Introduction

Most research on colour and light in rooms has concentrated on one or a few aspects, striving to keep other parameters constant. Research in otherwise unaltered full scale rooms has improved the understanding of how the character and perception of the room is affected by such as the placement of windows (Matusiak 2006), the colours of the walls (Vogels 2008), the type of artificial illuminant (Billger 1999) or the compass direction of windows (Hårleman 2007). A similar approach is also used in studies of physiological and psychological effects of different room colours or illuminants (Küller et al. 2006).

The spatial interaction of colour and light is, however, multidimensional and very difficult to capture in controlled experimental situations. Studies concentrating on specific aspects of an undividable and complex visual experience can point out important tendencies, but since all sense experience is relative their results cannot be seen as fully valid outside the specific circumstances defined in the study itself. Another approach to investigating visual reality starts from totality and strives to create a holistic understanding through artistic means. This may well capture and convey an emotional and sensory likeness to the multidimensional visual world, but neither the creative artistic process nor its result are meant to meet the standards of scientific scrutiny or a discussion about generalisation. A scientific holistic approach to colour and light starts from the understanding that the total visual experience is more than the sum of its identifiable parts. The challenge of the OPTIMA project has been to find methods for scientific exploration of the undividable totality.

2. Pilot studies aiming at methodological development

The OPTIMA project is funded by the Swedish Energy Agency and its full name is *Pilot studies regarding optimised energy saving, spatial experience and function in lighting planning.* It is carried out in close collaboration with the larger trans-disciplinary project SYN-TES, including

colour and light experts from six Nordic Universities and companies working with paint, illuminants and colour standards[1].

OPTIMA starts from the need for energy saving and the subsequent abandonment of traditional incandescent lamps. New light sources can deliver the same number of lumen using much less energy, but so far only little is understood about the quality of the light that they produce and their impact on the total spatial experience in a room. To obtain such understanding, there is a need for new research methods, which cannot rely on previous experience of traditional light sources and likewise have to go beyond measurements of technically quantifiable data. Thus, the main aim of OPTIMA is to develop a methodology for such investigations. This is made through full scale room studies where hypotheses and questions deal with the total spatial experience created by colour and light in interaction.

3. Theoretical and methodological starting points

The methodology tested in OPTIMA is built upon experience based practice as applied within art and design, in interaction with scientifically conducted tests. The method of *successive approximation* has been discussed by Piet Hein, the Danish mathematician, philosopher, designer, poet etc. (Hein 1985). In creative activities like art, problems cannot be clearly formulated until they are solved, and the process can be described as continuously approaching a good solution. Hein describes this knowledge process in a *grook*, his own characteristic form of expression (see box below).

THE ROAD TO WISDOM

The road to wisdom?
-- Well, it's plain
and simple to express:
Err
and err
and err again
but less
and less
and less.

Piet Hein 1905- 1996

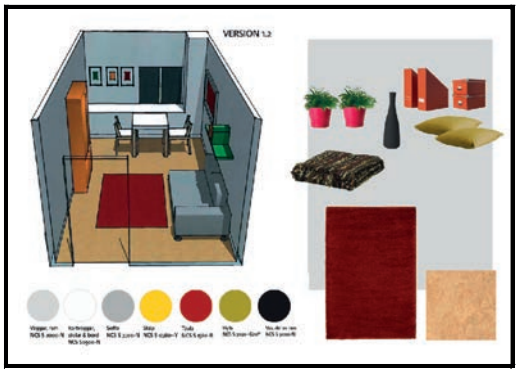

Figure 1 (right): Colour design of one of the tested room alternatives. Design Yvonne Karlsson

Working with the spatial experience of full scale rooms, OPTIMA has used the method of *successive approximation* in a version that has been tested and developed as part of the project. The research team has formulated goals for energy consumption and spatial qualities after preparatory discussions with expertise from colour and light industry. Professional colour and light designers have designed colour and light in the room in order to fulfil these goals. In this, they have based themselves on their own professional experience and not on any given norms or recommendations.

The colour and light design of the room has constituted a concrete, experience based ”hypothesis” which has been scientifically tested and analysed by the research team. The results of this analysis have been discussed jointly by researchers and designers, a process that has lead to new understanding and an improved ”hypothesis” in the form of a revised colour and light

1 Alcro-Beckers, Philips and NCS Colour.

design. After that the new ”hypothesis” has been tested. A continuous repetition of this process has lead to an accumulation of knowledge and to development of new knowledge. Thus, the important result is what has been detected during the process, not the evaluation of the single design alternatives.

4. Studies in full scale rooms

The following quality criteria and functional demands were used within OPTIMA:

- The energy consumption should be minimized
- The room should have a positive atmosphere. Two different specifications were given: In the first design alteranative the room was to be experienced as dynamic and stimulating, in the second as calm and harmonic.
- Reading: Reading of a pocket book should be as easy at the table in the test room as in a reference situation with daylight.
- It should be possible to discriminate between very similar colours: The result of a simplified Farnsworth-Munsell colour discrimination test, carried out at the table, should be as good as in a reference situation in a light box with good daylight simulation.
- Colour rendering: Categorisation of colour samples regarding hue and chromaticness should give the same result as in a light box with good daylight simulation.
- The lighting solution should utilize products and knowhow in the forefront of today´s possibilities and be technically and economically applicable also in larger scale.

The test room (Figure 1) was approximately 18 square meters. It was designed and furnished with the aim of not giving direct associations to any particular room function or style. It had no daylight but a window facing darkness imitating night. Four different design alternatives were tested, each one by 12-15 persons of different age, gender and professional relationship to colour and light. The room was observed by one person at a time, according to a preset procedure with observation protocol and manual for the observation leader. The test persons were asked questions regarding the appearance and experienced atmosphere in the room. There questions were of different types, both open ended and with pre-set alternatives. Test persons were also given tasks regarding reading, colour discrimination and colour categorization. In the analysis of these tests each person’s results were compared to his/her own results in the reference situation. Technical specifications were made through measured illuminance and luminance at several places in the room, the correlated colour temperature, spectral distribution and colour rendering index of luminaries, and the total effect of the lighting expressed in W.

5. Building knowledge through interdisciplinary and interprofessional discussions

The answers and performances of the test persons gave a rough understanding of how the designed rooms managed to meet the design goals. In this, the most interesting results were those that showed that goals had not been fulfilled. For example, test persons pointed out that they experienced a lack of harmony in the room or that they found it difficult to focus when reading. Also, the colour discrimination and colour categorisation tests showed systematic colour shifts that could not easily be explained.

These failures in achieving the design goals gave the start for discussions between

researchers, designers and industrial practitioners. This created an interchange of knowledge that could hardly have been achieved without these concrete problems to discuss. It also gave rise to new ideas about possible interaction between colour and light and to new hypotheses to be further tested. In the next step of the process the room was altered according to these hypotheses, tested with new subjects, analysed by the researchers and once more discussed by the whole team.

6. Results and conclusions

The process resulted in well formulated new hypotheses that are to be tested in subsequent, more specified research projects. One of these hypotheses deals with the possibility to enhance subjectively experienced lightness in a room through the systematic placement of surfaces with different colours (co-shading and counter-shading). Another hypothesis formulates how experienced lightness is supported by large contrast distribution between light and dark colours and between chromatic colours of different hue. The discussions also resulted in suggestions regarding the design of LED fittings, in order to achieve a more even spatial distribution of light.

OPTIMA was, however, a pilot study with a mainly methodological aim, and its main result was the evaluation of the successive approximation methodology. We found that the method is very appropriate for investigations of the interaction between light quality, light distribution, chosen surface colours and their placement in complex spatial situations. Through the successive approximation it has been possible to gradually define which aspects of the spatial totality that were important for the test results and the test persons' evaluations of the room. In a longer test series, with time allowing more rounds of evaluation and modification starting from an unaltered demand specification, this method can most likely lead to more specific conclusions than what was possible in this pilot study. A promising, slight, modification of the method would be to start with variations of only a few factors and make developed expert evaluations of the totality in each case. As a second step the qualities of the thus optimised room can be tested in a more traditional way, with a larger group of subjects.

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