FULL-SCALE MODELING AND THE SIMULATION OF LIGHT

Proceedings of the 7th
European Full-scale Modeling Association
Conference in Florence, Italy,
February 18-20th 1999

FULL-SCALE MODELING AND THE SIMULATION OF LIGHT

Proceedings of the 7th
European Full-scale Modeling Association
Conference in Florence, Italy,
February 18-20th 1999

EDITED BY BOB MARTENS

INSTITUTE FOR SPATIAL INTERACTION
AND SIMULATION (ISIS)

CIP-Kurztitelaufnahme der Deutschen Bibliothek:

Martens, Bob (ed.)

Full-scale Modeling and the Simulation of Light. Proceedings of the 7th European Full-scale Modeling Association Conference in Vienna, 1999 -
IRIS-ISIS-Publications at ÖKK-Editions - vol. 5 - Österreichischer Kunst- und Kulturverlag, Wien 1999.

ISBN- 3-85437-167-5

NE: Martens, Bob (Hrsg.)

Cover (image processing): Oliver Pestal

A-1040 Wien, Freundgasse 11
Tel.: (+43-1-) 587 85 51; Fax: (+43-1-) 587 85 52

Preface

The main objective behind the biannual EFA-Conference is to create a platform for an exchange of ideas and for further cooperation on the field of full-scale modeling. As agreed at the 6th EFA-Conference (Vienna 1996) the next event in 98 was to take place in Bologna. Unfortunately, both time and place had to be changed, what, on the whole, did not make much difference as Florence and Bologna are only a 1-hour`s car-drive apart. Compared with the 6th EFA-Conference at the Vienna University of Technology the follow-up conference seemed to run the risk of turning out to be more or less “unassuming” due to the very short preparatory period. The unique ambience of the Florence conference site and the supporting acts, however, worked out to everyone`s greatest satisfaction.

Scheduling the conference biannually predominantly results from the fact that noteworthy findings can be collected within a two-year period. As such conferences act as the main trading place for specific exchange of experience, longer breaks in between also expose the participants to the risk to loose out on their “connections”. A dilemma which can only be insufficiently made up for despite all the (functioning) Internet contacts.

Though a successful conference event is to be compared to a fair of surprises and spontaneous encounters, the collection of the published Proceedings is to be regarded the “collective memory” of the specialized field of 1:1 simulation in the broader sense of its meaning. Due to the vivid exchange of publications between the university libraries a meaningful expansion has been accomplished, approx. 70 copies of the Proceedings having been distributed to the various library locations. Furthermore, an adequate increase of accompanying and advancing scientific activity, e.g. by means of diploma dissertations and theses, are systematically encouraged by this journalistic activity. But now and again “unwritten rules” concerning the attitude to “research work” at some faculties of architecture thwart these plans. Anyhow, it seems to work out very successfully every now and then to treat “building” as equivalent to “research” and to furnish logical explanations therefore, certainly a circumstance to be considered under polemical aspects sooner or later.

This year´s topic, however, covered the use of light throughout 1:1 simulation. As a rule the field of light design has a closer relation with simulation in true scale. Therefore, it is surprising that a conference dealing with this field did not take place at an earlier stage which might be due to the differing approaches concerning implementation and working focus at the various laboratories. The remarkable achievements of the individual lighting companies on the market regarding research work seem very promising and necessarily are to be duly acknowledged also on the part of academic circles. Furthermore, a productive exchange of information might develop between the, somewhat incompatibly seeming, interest groups. More interaction would surely prove wise, as the stage for successful research work in the field of light design and light impact is only to be set by combining all strengths.

EFA '99 was hosted by the University of Firenze (http://www.dpmpe.unifi.it/) in collaboration with Targetti Sankey S.p.A. (http://www.targetti.it/), which we render our sincere thanks.

Bob Martens
December 1999

C O N T E N T S

Making Light Tangible: Simulation of Light Design within Architectural Education

Bob Martens (bmartens@email.tuwien.ac.at)

Vienna University of Technology, Austria

Keywords: Lighting Design, Full-scale Modeling, Architectural Education, Simulation Dome, Visual Simulation

Abstract

In times where computer-assisted representations dominate the “market” of visual simulation, the major strongholds of simulation in true size in conveying (artificial) light configurations have been observed. Though light cannot be “touched” due to its material absence the human eye reacts extremely sensitively to differing constellations. In matters of seconds differences are perceived and classified. Opening up a rift between the various simulation techniques, however, would not prove wise. The normal procedure still consists of trial positioning of lighting objects on site (i.e.: 1:1 simulation at building site). Regarding the effort this causes attempts as to gaining similar results by means of (partial) computer representations are worth considering. The degree of abstraction, however, might be too significant to make for conclusive decisions. In other words: Can the gap between imagination and translation thereof into reality be bridged? This contribution deals with the experimental implementation of artificial light in the full-scale lab and its possibilities regarding the 1:1 simulation at the Vienna University of Technology, with special attention to the didactic aspects related thereto.

Considerations: virtual-digital and/or physical-analogue?

First a brief glance is dedicated to the work of *James Turrell* issuing remarkable specimens of “handling of light” [1]. Could the experience of viewing his work - and particularly the adaption processes of the human eye - be simulated by means of computer assistance, at all? The answer surely is no. On no account are Turrell`s spatial installations, however, to be deemed “optical illusions”. Their impact matches a time-based ascertainable event, thus curiosity dominates upon entry, while the eye adjusts to the situation. The Installation wants to be “discovered”. An obviously two-dimensional surface “surprisingly” turns into a somewhat graspable color volume on continuous viewing. The viewer reaches out for the light. A photograph of such a scenario can only act somewhat like a visual memento or an appetizer, also due to the restrictions of photographic material.

What is getting increasingly more difficult is to determine whether an image is “genuine” or has been subjected to composition or manipulation by means of editing procedures. This takes us to a project of the architect Richard Meier for the church “Chiesa dell’Anno 2000” [2]. As a rule comparable projects will not get by without 1:1 model simulations as far as planning of lighting is concerned. Reliable specifications were issued, however, by means of CAD-simulation and according to the project team mock-ups were not necessary. Working in teams doubtlessly benefits from the implementation of computer-assisted (network-) methods - also over major distances (independent of site!). As the project still is in the planning stage the degree of accuracy should be conclusively checked upon constructional realization.

Developments at the Universities of Technology suggest a new orientation. A simulation dome is being developed at the ETH Zürich [3] to be utilized for interdisciplinary visualizing purposes - beyond the narrow limits of specialized branches of studies. Similar approaches are being envisaged presently at the Vienna University of Technology [4] where synergy-effects between the so-called RISG-lab (computer-assisted high-performance visualizing with a SGI Onyx RE2 as main device) and the full-scale lab [5] are being studied at a Research Institute of Space-related Information, Simulation and Design, thus making for focussing particularly at virtual-digital and physical-analogue fields of simulation:

- research in the fields of visual simulation, 1:1 models and rapid prototyping, stereo- and endoscopy, planning databases, simulation supported collaborative work (SSCW); furthermore, main emphasis is put on the interrelations of simulation 1:1 (n) and virtual reality (VR) and the particular consideration of assistance regarding obtaining decisions in space-related matters (generation, moderation and assessment of solution variants and scenarios).

Lighting Equipment and Related Experiments at the TU Vienna

Daylight experiments are practically impossible at the Full-scale Lab of Vienna University of Technology due to the structure of the Main Building. Regarding implementation of artificial light a basic outfit is available. The centerpiece of this equipment is a professional dimmer-box controlling 24 circuits via DMX-signals, thus, if necessary, manual or programmed control of lighting is possible. Power supply thus is to be regarded as substantial and can be provided either via outlets or three-phase busbars. Two high-voltage terminals (380 V/16A or 32A) also exist. Donations from light manufacturers e.g. lamps and lighting devices (spots, fluorescent tubes, incandescent lamp fittings, etc.) complete this “hardware”. Regarding contacts to firms, however, an independent position is being maintained.

What role did the subject lighting design play at the Full-scale Lab of the Vienna University of Technology up to now? The first attempts were like feeling one's way with the lighting devices and means. The first experience was of great significance particularly for students of the lower terms being enabled to test, what can be "produced". For obvious reasons the motto learning by doing was applied for the light experiments performed throughout the lab workshop. Light planning, however, cannot be achieved without a spatial concept, as light merely makes the space visible, the material boundaries naturally result from the structural entity. Furthermore, the experiments have concentrated on the adaptability of architectural structures due to light design. There is a certain danger of creating stopgaps based on the attitude: If you do not know how to continue, then a full array of slide projectors and video-monitors might come in handy. Actionism combined with cheap showmanship might become too dominant in that respect. These outlined didactic ideas are to be considered in connection with three lab exercises performed.

- Example I: Experimental Color Design [6]

As integral component of everyday perception color in architecture is not a mere minor visual addition but an effective means for shaping structure and significance. Impact and meaning off architectural design are substantially determined by the color of appearance. Therefore space-related color is not a simple perceptive unit, but the outcome of complex (inter-) actions of material and surface properties like light and lighting (spectral properties, intensity, distribution, etc.).

Fig. 1 Course Work: Experimental Color Structures.

• Example II: Simulation of Space [7]

Space can appear either vertical or horizontal, single elements suggest one or the other component, a phenomenon already very popular throughout the Renaissance. Neon-lisenes were the structural elements put to use under the project title “horizontal-vertical”. The possibility of a rapid change of vertical and horizontal space, its sequence and its management was the final intention. By turning the light switch the space obtained one or the other design configuration.

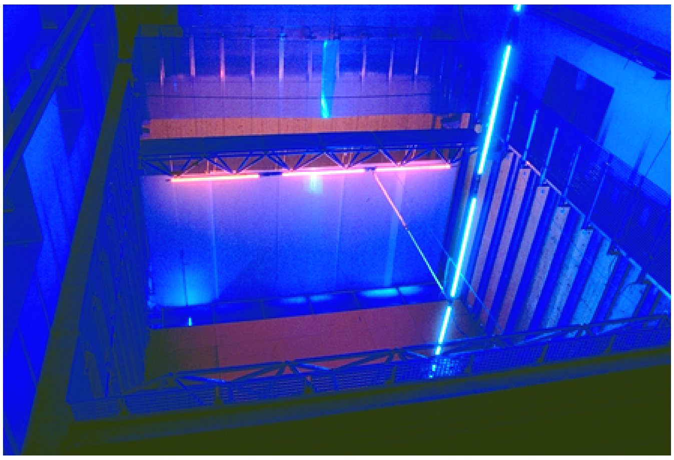


Fig. 2 Course Work: Horizontal - Vertical.

• Example III: Experimental Spatial Structures [8]

The theoretical background of this lab exercise is characterized by the analytic distinction of various kinds of spatial structure not only determining architecture but all expressive human statements within their environment: geometrical-stereometric structures, physical structures: gravity space, experience space: perception and space illusionizing. The main phenomena are elaborated from direct viewing. The space issue is regarded and represented in connection with the human being (his thinking, his body and his activities).

Fig. 3 Course Work: Spatial Structures.

Light Design as a (Postgraduate) Study at the TU-Vienna

Three of a total of five exercises taking place at the Full-scale Lab of Vienna University of Technology have been outlined above. These are incorporated as elective courses in the present curriculum for the study of architecture and offered in parallel due to great demand. The focal subject "Architectural Design" is represents a required course.

Principle considerations as to light and color design are furnished within the obligatory lecture "Spatial Design" (2nd stage of study). As a further area of concentration an elective course on "Planning of Daylight and Artificial Light Plants" is offered. Considerations concerning light naturally have to be made in quantitative and qualitative terms. A profound knowledge of light-technical values will prove wise but surely will not be sufficient in this respect. A difficult question is whether theoretical basics are to be issued prior to practical work or not. Due to the fact that the curriculum for the study arrangement of architecture is to be reformulated ideas as to further development of this subject could be included, such as a lab exercise concerning "Applied Light Design", the contents and training target of which would have to be defined.

Due to the fact that the average duration of study at the Vienna University of Technology amounts to approx. 19 semesters (nominally 10 semester for the study of architecture) *postgraduate education* hardly fits into the whole regime. Provided the attempts as to tightening up the curricula with the resulting reduction of duration of studies work out postgraduate university courses and -programs might become easier to handle, e.g. by establishing cooperations with some light-companies or extra-university institutions, granting an independent position, however. The Full-scale Lab would lend itself well to the end of continuing education in the field of color and light design, also due to the possibility of providing the required appropriate- and visually demanding instruction.

Conclusions and Outlook

So far the Full-scale Lab at the Vienna University of Technology has aimed at integrating as great as possible a variety of individual schools of thought. Thus a team of national and international adjunct faculties was set up consisting of highly qualified persons particularly dedicated to the field of spatial experiments. Light-design matters have been covered by various courses to a certain extent, following the working experience gained a practical lab course surely would be meaningful to be expertly performed by a specialist in this area.

By the way: the theater stage acting as a source of inspiration. Full-scale labs could also be utilized for such purposes as links between stage set and architectural simulation evidently exist, such as when working with (fragmented) stage decorations on stage creating space to be interpreted accordingly. Light design is of great significance in this respect. Attending a live-theater performance can hardly be matched by an (audio-visual) recording thereof. The “actual information input” does not vary too much, but the phenomenon of shrinking away is experienced, i.e. the individual viewer is exposed to the considerably larger stage area in reality. This sensation is ruined e.g. when viewed on TV. Presettings (framing) are used, close-ups (compare opera glasses), however, are possible.

All in all light is linked to the physical presence of built or structural objects. Light can undo single aspects of this structure. In order to gain control over light we avail ourselves of artificial light. Dealing with artificial light has a lot in common with a simulation process, where single aspects to be showed to the viewer are selected. Light in 1:1 simulations is equivalent to a simulation within a simulation. Thus the potential provided by simulation is significantly increased by using artificial light.

References

[1] Exhibition “The Other Horizon” [Museum für Angewandte Kunst in Vienna, 1998].

[2] *ERCO Lichtbericht* No. 59 (1998)12, S. 20-21 (http://www.erco.com).

[3] “VIS DOME”, a Visualisation Cave for the ETH Zürich (http://caad.arch.ethz.ch/~patrick/LOCAL/research/visdome)

[4] URL of the RISG-Laboratory: http://risg.tuwien.ac.at/risg/

[5] URL des Full-scale Laboratory: http://info.tuwien.ac.at/raumsim/ Information furnished on the teaching and research scope. A summary of development approached in the 90ies has been published in the “Bauforum” Magazine (no. 2 and 3 of 1998) issued as offprint thereafter.

[6] Study Course 256.018 UE / Lecturer: Leonhard Oberacher (http://info.tuwien.ac.at/raumsim/LVA-Katalog.html#efg)

[7] Study Course 256.014 UE / Lecturers: Bob Martens and Wolf-Michael Tschuppik (http://info.tuwien.ac.at/raumsim/LVA-Katalog.html)

[8] Study Course 256.017 UE / Lecturers: Wolfgang Meisenheimer and Benedikt Stahl (http://info.tuwien.ac.at/raumsim/LVA-Katalog.html#ers)

[9] Lecture Course 262.713 VO / Lecturer: Christian Bartenbach (http://www.lzk.ac.at/lva/tuwien/262.713)

VDU Work in Different Lighting Conditions

Christian Bartenbach and Walter Witting

Bartenbach LichtLabor (Aldrans), Austria

Keywords: VDU, Optimized Lighting, Performance Test, Lighting System

Abstract

In order to avoid the disadvantages of purely subjective methods in a technical evaluation of daylight and artificial light systems, the *Bartenbach LichtLabor* developed new test methods which can determine objectively and quantitatively the visual or psycho-physiological stress connected with VDU work [1], depending on different lighting conditions. Daylight and artificial lighting systems were tested with these methods and compared by using the performances achieved by the test subjects. Some highly significant differences in performance done under the individual lighting systems became apparent and demonstrated that the visual stress or the physical or physiological fatigue from an ergonomic viewpoint depends largely on the lighting conditions at the workplace. This holds true for daylight systems (glare protection, re-directing lamellae, clear window as a control condition) as well as for purely artificial lighting systems where especially the choice of color temperature of the light and the used control gear (conventional or electronic) determine the resulting performance. Optimized lighting also positively affects the productivity and economy for the design of workplaces that take the human factor into account.

Fig. 1 Ground-floor Plan of the testing facility.

1. Introduction

For about two years now the perception-psychology department of the *Bartenbach LichtLabor* in Aldrans near Innsbruck has done systematic research on the influence of different lighting variations in offices on the psychophysical or mental stress of people who work at VDUs. Great emphasis is placed on the objective and quantitative measurement of visual stress versus relief in an actual performance situation. The test methods which were developed measure each time one specific partial performance from the wide range of visual tasks that are connected to VDU work. Under the conditions of installed daylight and artificial light system, these test methods measure, among others, the following performance variables:

- certainty of perception and speed of perception for VDU work;
- degree of attentiveness;
- stress capacity of attentiveness;
- attainment of an overall perspective of the VDU;
- detailed stimulus differentiation;
- concentration capacity;
- carefulness in looking back and forth between screen and manuscript;
- certain factors of short-term memory.

Based on the data of these variables, lighting systems are compared with each other in order to analyze the stress factors and to determine which lighting conditions are the most favorable for minimizing visual stress. The tests were done under virtual field conditions in order to eliminate the disadvantages of a classical field study and to benefit from the advantages of a lab study. For this purpose, actual office spaces were constructed as test spaces in which the lighting systems could be changed and where desired and undesired influence factors could be systematically controlled and altered: for example, the position of a seat within a space (facing the window or turned sideways), the reading conditions of VDUs (color or monochromatic, positive or negative representation, tests with or without manuscripts, manuscripts on a stand or on a desk, glossy or matte manuscripts). In connection with lighting systems, the influence of these variables on the performance or the development of performance (duration of test: 4-5 hours) was measured using the methods described below.

2. Description of Tests and Measured Variables

Because a true measurement of performance gives performance comparisons between the selected lighting systems, a higher degree of quantitative precision, a decision in favour of quantitative methods of measurement rather than totally subjective surveys (such as evaluation scales based on self-observation) was made. However, a subjective evaluation of the test spaces by the test subjects was not omitted since the qualitative light environment and the individual overall impression of a space cannot be fathomed by performance values alone.

2.1. Survey of Subjective Impressions of Lighting Systems

The evaluation was done with a semantic differential of 28 pairs of bipolar attributes which, for the purpose of factor analysis, were used for the survey of 40 test subjects. The research tool of a semantic differential makes it possible to determine the general "human" character of a space as it is experienced by its users. The individual evaluation dimensions were formulated in such a way that they would necessitate a view of the space as a living whole. This measured the emotional willingness to accept the space, with the advantage of finding an unconscious psychological rapport to the space.

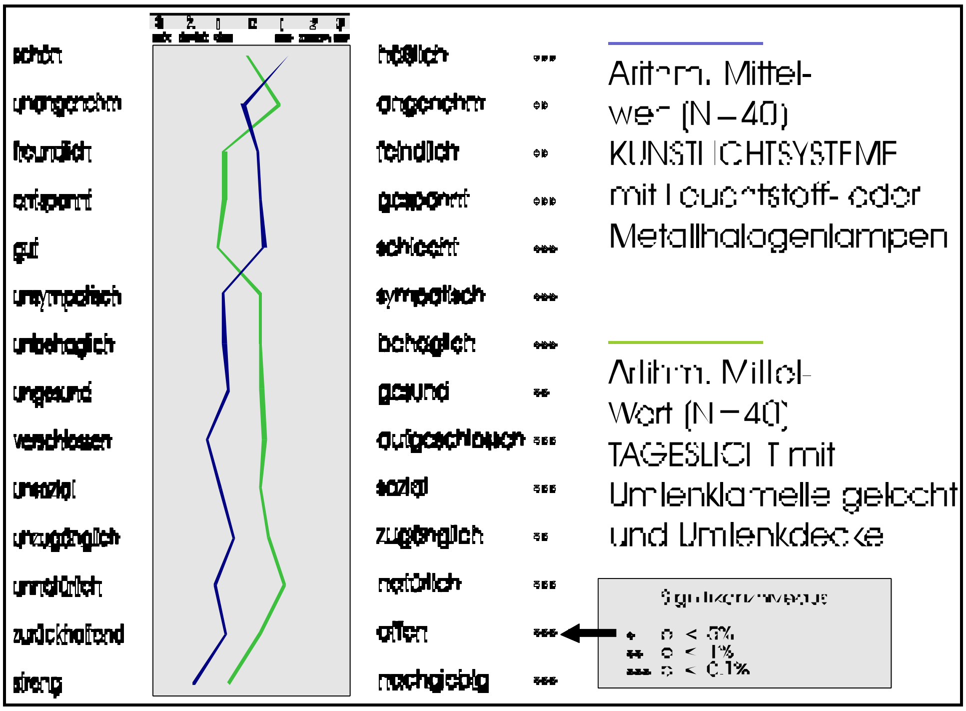


Fig. 2 Comparison of the evaluation profiles of two different lighting systems produced by the semantic differential.

Figure 2 shows the evaluation profile of a space with artificial light (HQI/TS [high-pressure metal vapor lamps], 70 Watt, warm white light color, conventional control gear) in comparison with the profile of a space with daylight, reduced window luminance and even light distribution (perforated re-directing lamellae with re-directing ceiling). One can see that the daylight space is described throughout as having a significantly livelier character than the enclosed space with artificial light.

2.2 Objective Measurements of Performance

Although it might be meaningful to establish to what degree differences in evaluation and acceptance can be verified by quantitative data for performance, and although subjective evaluation might serve as a secondary control tool, priority must be given to quantitative measurement of performance levels and their comparison. It was for this purpose that the test methods listed below were developed by the Bartenbach company. This required a development stage that lasted a year because the theoretical criteria for quality (reliability, validity, objectivity) had to be optimized through calibration, and because we also had to establish an appropriate degree of difficulty.

The close relation of the visual test demands to actual VDU work ensures that the results can be generalized vis-à-vis the actual demands of real work (external validity). The test subjects were compensated for their participation; a factor which led to a corresponding motivation and a willingness to make an effort. The analysis included six test methods whose individual variables each measure a significant essential component of mental or visual stress (or relief) in connection with the lighting of workplaces (here mostly VDU stations):

PRT: Primary test

- Precision and speed of word recognition on a screen as performance of figure-background-vision;
- Example: proof-reading of text;
- Dominance of the primary infield; secondary infield as context;
- The test field on the screen is divided into four individual fields each possessing a different contrast of representation. The positive (i.e., the correct reactions) are evaluated separately for each field (upper left, upper right, lower left, lower right).

LVT: Line tracking test

- Global vision. Global-figurative perception of “gestalt” related to purely graphic pictures without cognitive content. Highest demands made on overviewing;
- Example: CAD stations;
- Dominance of secondary infield.

BRV: Comparison test dealing with string of letters

- Developed on the basis of the QDO-Test;
- Detailed stimulus discrimination; foveal difference vision, perception speed of fixed stimuli on the screen and on the manuscript. Precision of the time/space behaviour of a fixed and a changing view in a mostly horizontal direction;

- Example: Comparison of VDU contents with data on manuscripts;
- Dominance of the primary infield;
- Since the BRV is evaluated separately for each quarter of the test, it is possible to detect performance fluctuations during the duration of the test (increase, decrease).

AT: Transcription test

- Controlled change of view between given stimulus and reaction result;
- Care in changing view; economy in changing view. Exact perception of word and sentence image in the manuscript and on the screen;
- Example: Transferring texts (manuscripts) onto the screen (word-processing);
- Dominance of the primary infield;
- The AT mostly counts the number of typing errors which can be attributed to fast and to uncertain visual registration of the visual content (=> fatigue). The test is administered in two (or four) blocks of 80 one-syllable German nouns each of which also contains capital letters.

PT: Screen Position test

- To assess and establish the relative stimulus-position in comparison between manuscript and screen;
- Topological transference of structure;
- Horizontal and mostly vertical gliding of view;
- Example: Creation and structuring of tables:
- Dominance of the primary and secondary infield.

TUT: Test involving overviewing of tables

- Rapid registration and comparison (manuscript - screen) of highly complex stimuli in a preset structure of order. Achieved overview and visual resolution of existing orders;
- Example: Calculation of tables;
- Dominance of the secondary infield;
- Because the speed of registration and perception is of central importance here, mostly time variables are measured (reaction time, processing time).

3. Fatigue Measurements

Inadequate lighting represents a physiological and psychological interference factor whose effect of stress begins relatively early in the unconscious, but is experienced consciously only as it increases. With the choice of the cybernetic flicker blending frequency analysis, a method was chosen which could measure quantitatively and objectively the vegetative-cerebral degree of fatigue of test subjects in connection with VDU work and with dependence on installed luminaries.

The controversy surrounding this method might be due to the fact that the current adaptation condition of the eye is given too much weight with individual or single measurements. This influence was reduced to a statistic inconspicuousness by taking pre-test measurements after a phase of adaptation to the space that lasted 5-10 minutes during which the test subjects were informed about the course and the goal of the tests. In addition, only arithmetic averages from measurements of 30 people were compared and used in further calculations; in this way a so-called “runaway” could not noticeably influence the average. In order to analyze the fatigue gradients over time, the vigilance measurements were carried out before and after the tests. The time span of 4-5 hours in between was necessary to complete the entire battery of tests. Because the flicker blending frequency depends on the size of the stimulated area in the retina, the blending frequency was measured throughout for three flicker point sizes. Furthermore, the measurement is done cybernetically, meaning that the blending frequency is approached both from increasing and decreasing directions.

For each test subject, six individual fatigue values were measured on the basis of the flicker blending frequency analysis. The differences (i.e. gradients) between the measurements before and after were then used for the statistical data analysis. Positive as well as negative values (differences) are possible because, with a high blending frequency, a low degree of fatigue can be recorded and on the other hand a decreasing blending frequency goes hand in hand with increasing, mostly still unconscious fatigue. If a negative fatigue gradient is designated here as “recovery”, e.g. with eVG [electronic control gear], is does not signify a steady decrease of visual fatigue but rather a statistic average which indicates an evenly high and constant cerebral level of activity (vigilance).

4. Comparison of Daylight Systems: Partial Results

With the help of the test series TL8-TL12 (fig. 3-7) done on 30-40 test subjects, the following daylight systems were studied with regard to their effect on the performance capacity and fatigue of the test subjects who were doing VDU work:

a) glare protection in the form of a relatively closely-woven cloth blind;
b) clear window with no sun-protection system;
c) unperforated re-directing lamellae (bright on the inner side) with re-directing ceiling;

d) perforated re-directing lamellae (grey on the inner side) with re-directing ceiling;
e) like d) but only on the upper half of the window.

The distribution of the daylight factor (TQ) for the individual systems is shown in fig. 3.

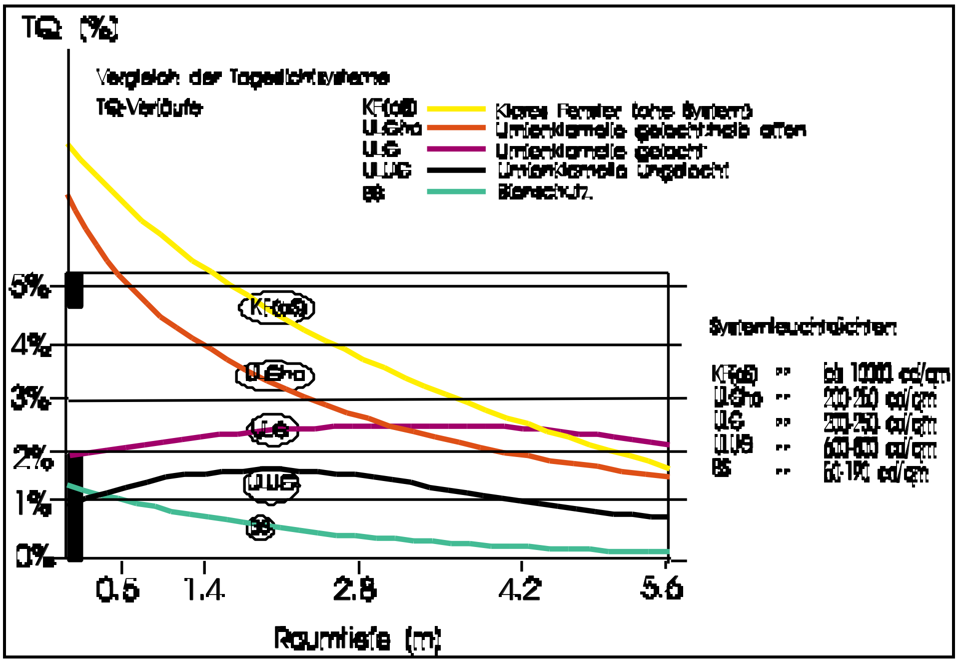


Fig. 3 Daylight distribution for all tested daylight systems (clear window, perforated lamellae, etc.).

It shows very different, i.e. partially very uneven, distributions of daylight factors for the aforementioned systems. In particular, the clear window (with no shading system) gives too much light in its vicinity and too little light in the depths of the space. To reduce the window's luminance to 50-200 cd/m2, a textile, partially transparent, glare-protection device was chosen which on the whole was too dark (i.e., creating an overly low level of illumination in the space). The best system in relation to the level and evenness of the daylight factor is the ULG system [perforated re-directing lamellae], provided it is installed over the entire window front. If it is only mounted on the upper half of the window (ULGho [perforated redirecting lamellae, high]), it practically loses its effect and exhibits a disadvantageous distribution of daylight factors similar to that of the clear open window. The general level of lighting and the type and degree of balanced distribution of luminance have a decisive influence on the quantity and quality of performance, especially with regard to the visual environment of VDU work stations. Figure 4 shows these differences in relation to the horizontal illuminance of the desk surface.

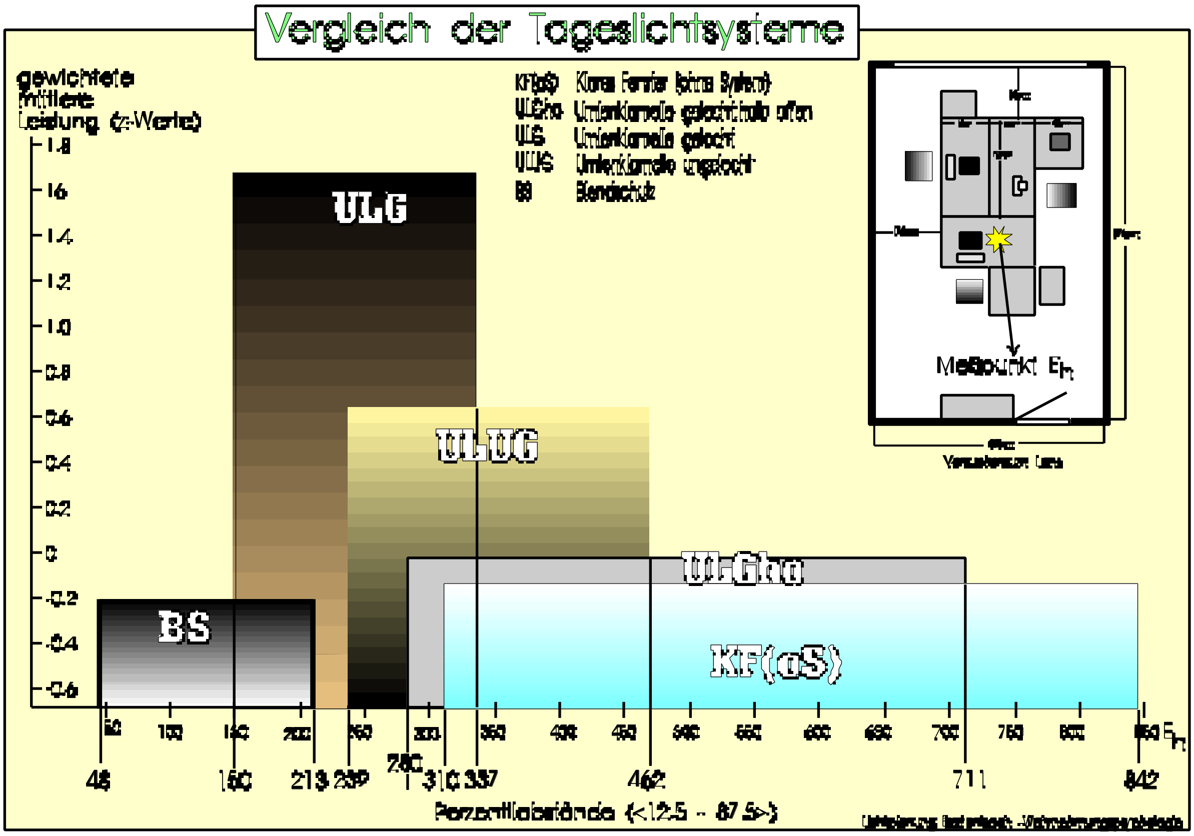


Fig. 4 Fluctuation ranges of horizontal illuminance (x-axis) and evaluated quantity of performance (y-axis); comparison of daylight systems.

Although the “bright variations” (KF-oS [clear window without a system], ULGho) produce illuminance levels of 300-800 lux, the recorded performance levels are as bad as with the dark glare protection device which only permits an illuminance of 50-200 lux at the desk. However, it is not the luminance itself that seems to form the parameter for the performance but the interaction of the system's luminance with the distribution of the light inside the space. The perforated re-directing lamellae are able to combine these parameters best, resulting in significantly higher mid-level performances than those of other tested systems. That the horizontal illuminance alone does not determine performance becomes apparent when the system is kept relatively constant (200-300 lux). Even then the ULG re-directing system comes out ahead because the system's luminance and the evenness of distribution apparently interact in a most advantageous manner (fig. 5). The fatigue gradients also indicate clear results which favour the re-directing systems (lamellae, louvers). Whereas the clear window and the glare protection device produce excessive stress on the eye (fatigue positive), due to their overly high or overly low luminance (adaptation glare), the re-directing systems (with or without perforation) cause fatigue values that are consistent with a constant and relaxed level of activity (fig. 6).

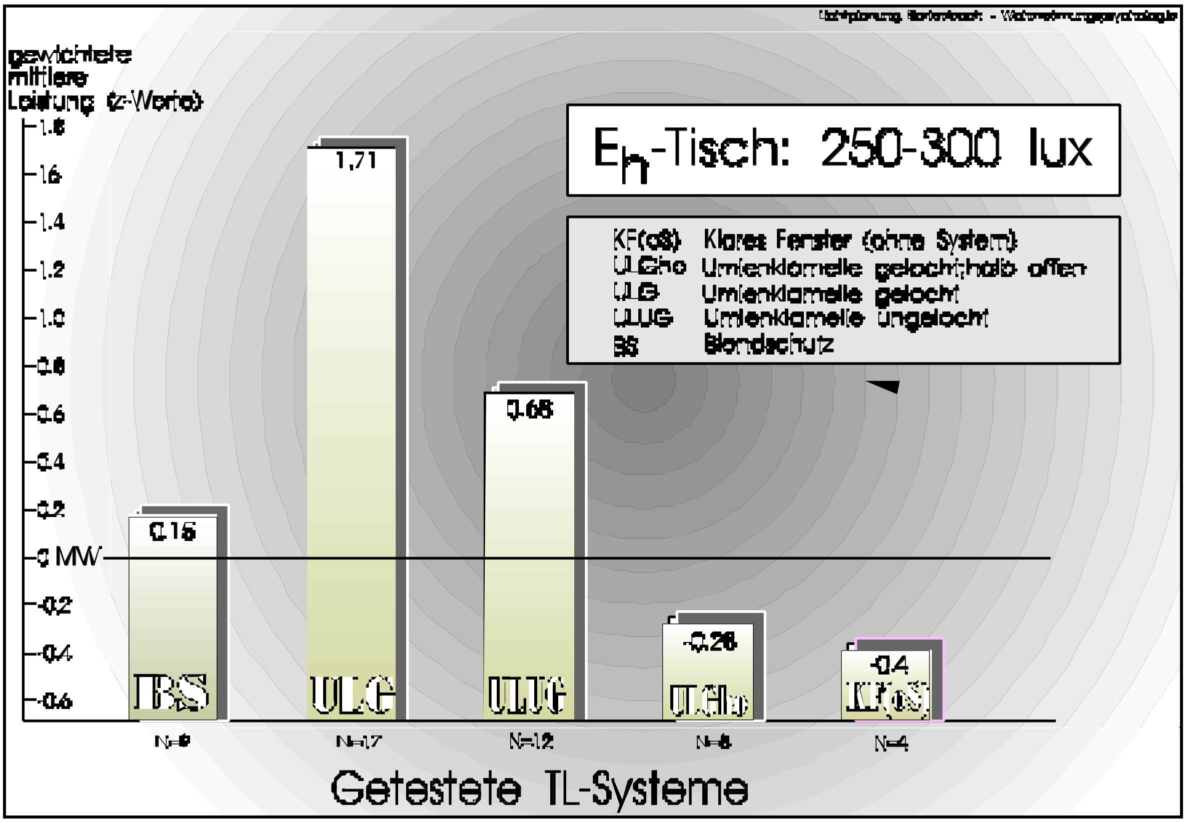


Fig. 5 Evaluated performance (y-axis) in the tested daylight systems for equally high illuminance (200 to 300 lux) of the same workplace.

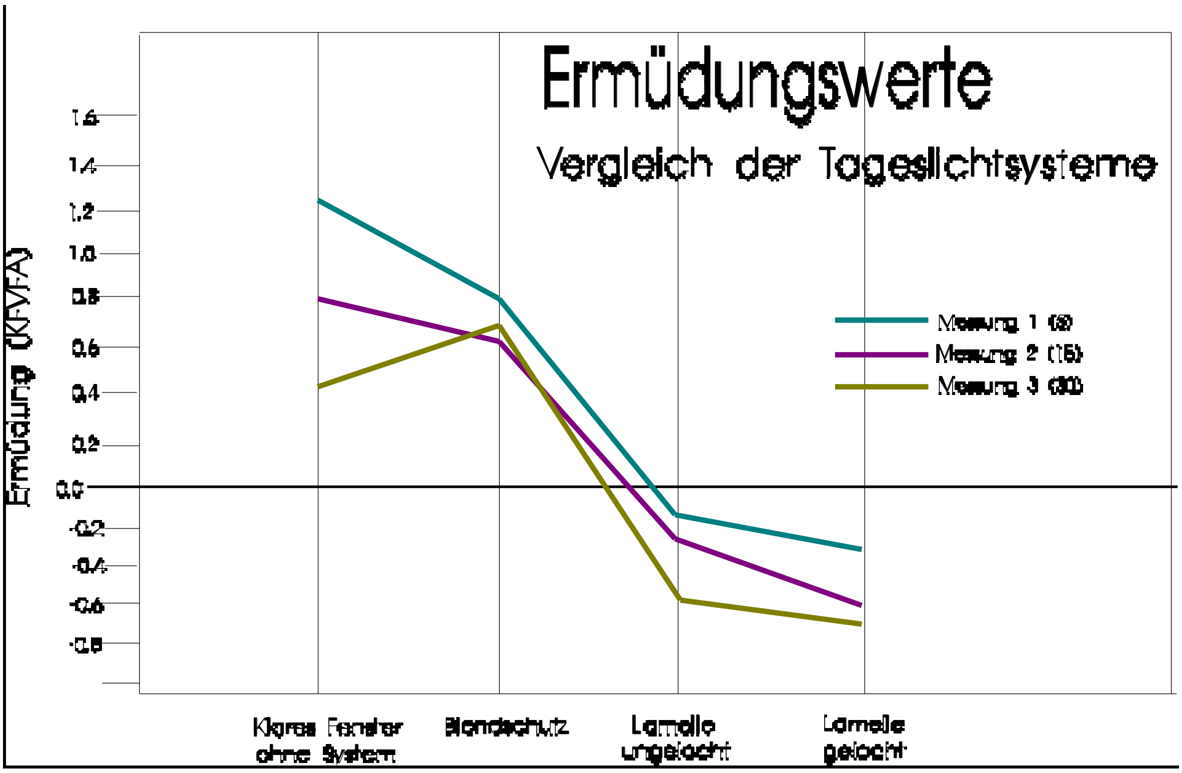


Fig. 6 Fatigue gradients for four tested daylight systems.

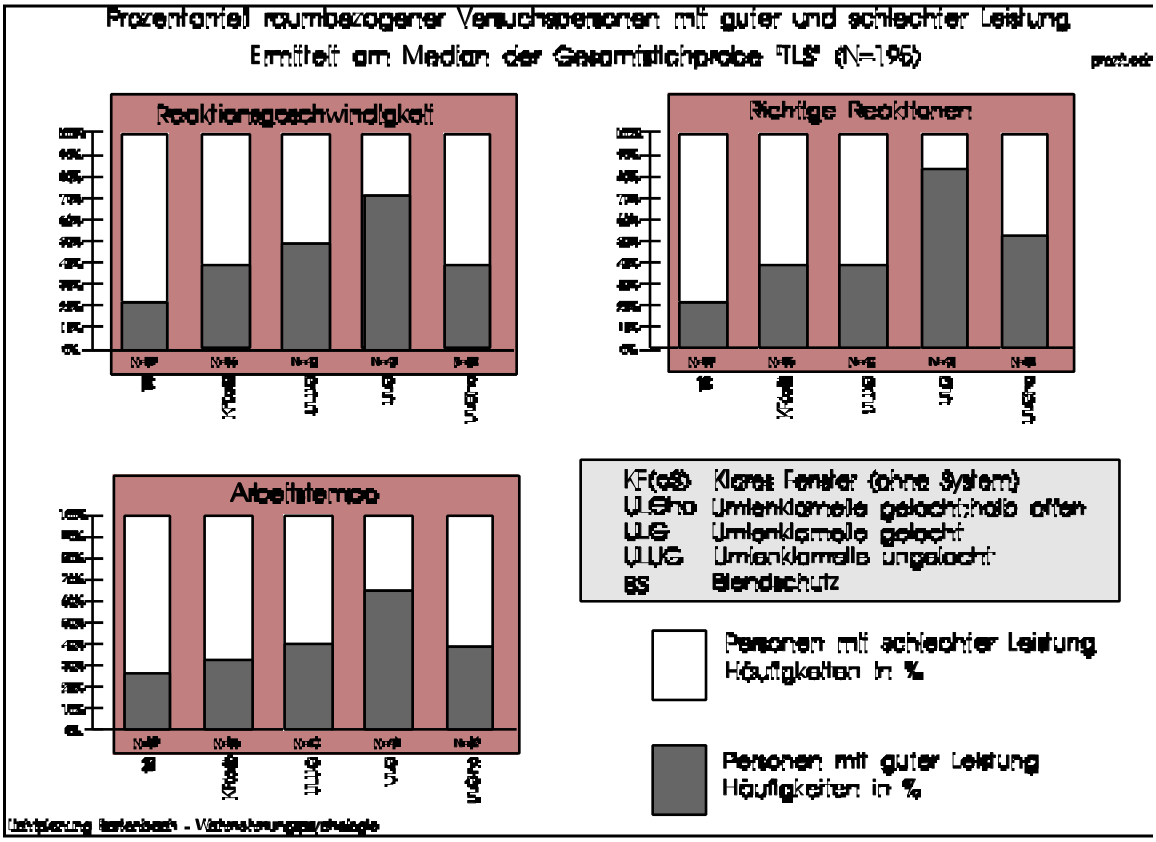


Fig. 7 Allocation of test subjects with good and bad performances to the tested daylight systems.

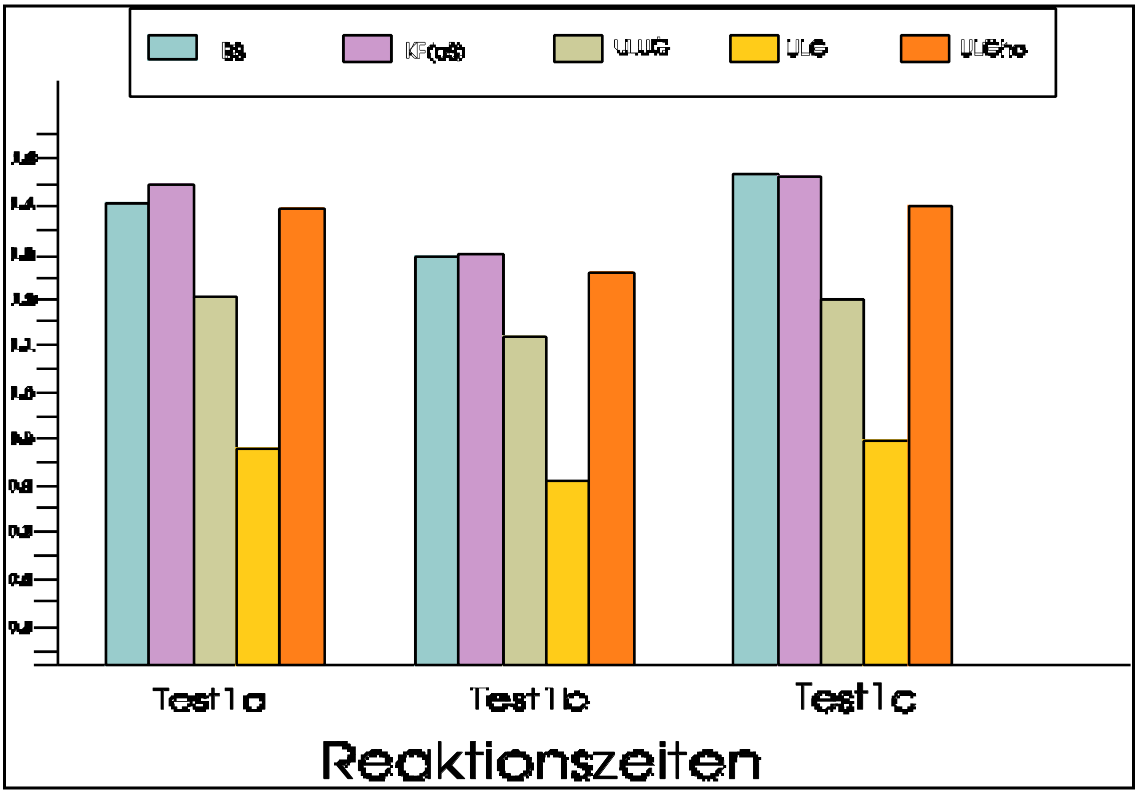


Fig. 8 Test-specific reaction times in the tested daylit spaces.

If one ranks the performance categories of all test subjects from all tested spaces and divides them at the median, one can establish the percentage correlation of people with bad performances and those with good performances to specific spaces (i.e. daylight systems). This relates the distribution of people with bad and good performances to the individual spaces (fig. 7). We can clearly see that the test subjects with good performance results (i.e., with high reaction speed, high work speed and few mistakes (many correct reactions) were working for the most part in the space with the perforated re-directing system. If we just examine the reaction time, we notice the same trend in favour of the perforated re-directing system in combination with a re-directing ceiling because the reaction times are significantly shorter than in the listed comparison spaces (fig. 8).

The productivity of a work task that is represented here by the test performance reaches its optimum if few mistakes are made at a relatively high speed of work. If every test subject from all types of spaces is represented by a point which equals the median work speed on the x-axis and the median number of mistakes (in all tests) on the y-axis, for every system we obtain a locally concentrated cluster which expresses the quality of the daylight system with regard to the combination of work speed and errors (fig. 9).

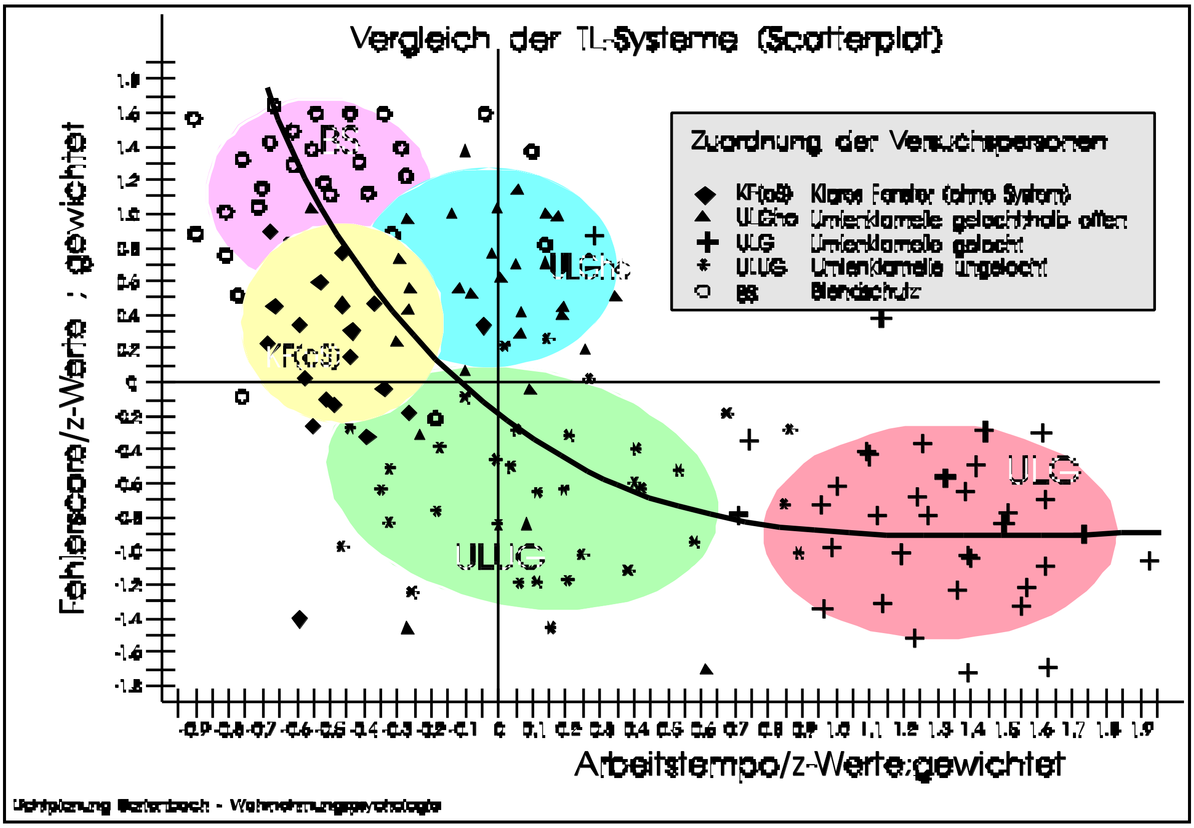


Fig. 9 Cluster pattern of test subjects from the tested daylight systems according to work speed and number of errors made.

Here we can once again observe that the ULG system is in first place with a relatively high speed of work and the lowest scores of mistakes, whereas the glare protection device is characterized by the slow work speed of the test subjects who nevertheless made the highest number of mistakes during the test. Often the question is posed whether daylight can be substituted by artificial light in all contexts or whether daylight is principally better than artificial light. This can only be answered in the affirmative if daylight is controlled in the same way as artificial light. With regard to their suitability for reduction of visual stress, the different daylight systems vary as do the different artificial light systems, mostly in their dependence on the color temperature of light. The performance differences (correct reactions) in different versions of artificial light were clearly manifested in the case of mirror-grid lamps (with conventional control gear) suitable to VDUs for common light colors (color temperatures / fig. 10). The best color of artificial light is still significantly inferior to daylight if window glare is avoided and the distribution of light in the space is evened out. Compared to rather bad daylight environments (clear window, open; glare protection: too dark), good artificial light conditions are quite able to produce higher performance levels and less fatigue.

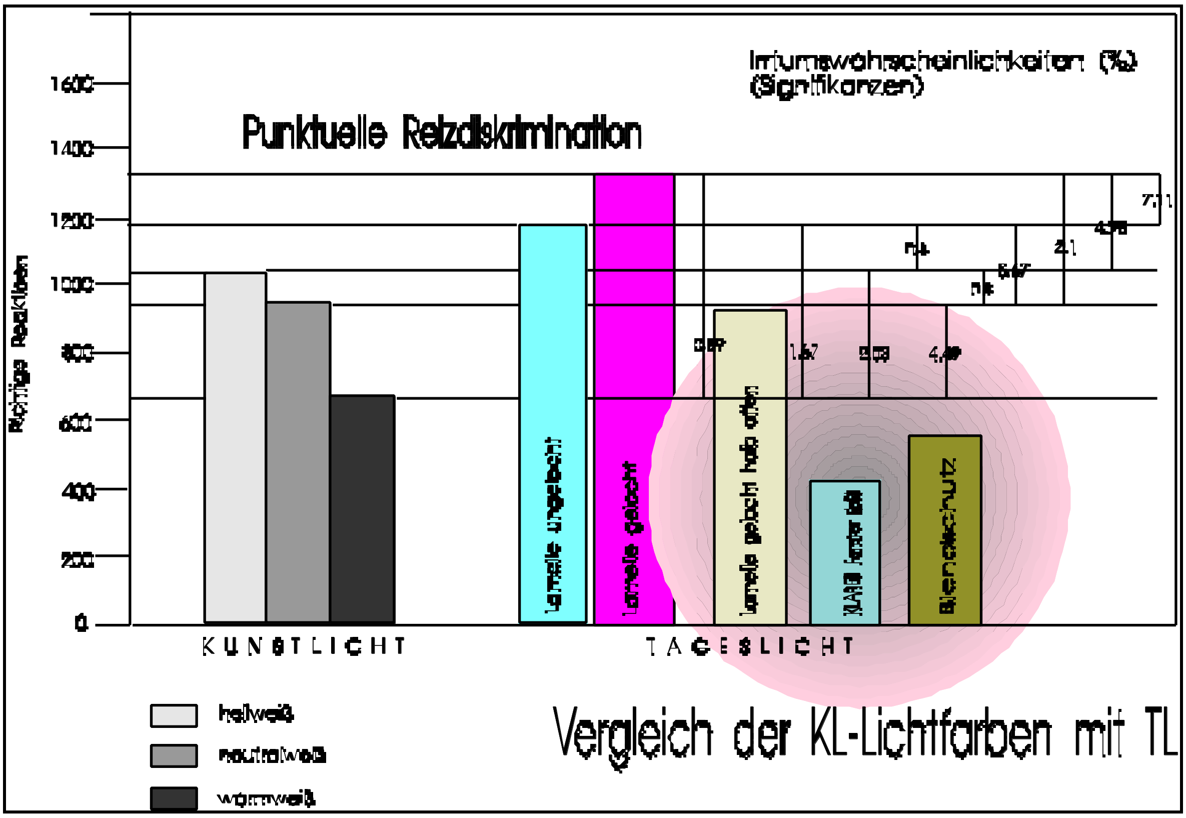


Fig. 10 Specific comparison of test performance (differentiating detail vision) between daylight systems and three types of artificial light (fluorescent lamps with the light colors bright white, neutral white and warm white; electronic control gear).

5. Studies of Artificial Light: Partial Results

The present study deals with the question of whether the effects of artificial light from gas discharge lamps (fluorescent tubes) on the visual and psycho-physical stress or relief of people differs between fluorescent tubes with conventional standard control gear (50 Hz flicker frequency) and tubes with electronic control gear (high frequency; 20.000 Hz).

5.1 The Influence of Control Gear for Linear Fluorescent Lamps on Visual Work Performance

Since all tests were performed at VDU stations with monochromatic screens having positive contrasts (white background; black letters) as well as with negative contrasts (black background; bright letters), and also with a common color display, the results are significantly representative of all such screen conditions. In this context, it should be mentioned that the performance differences of the control gear were, in the case of color monitors, even significantly more favorable in the electronic version.

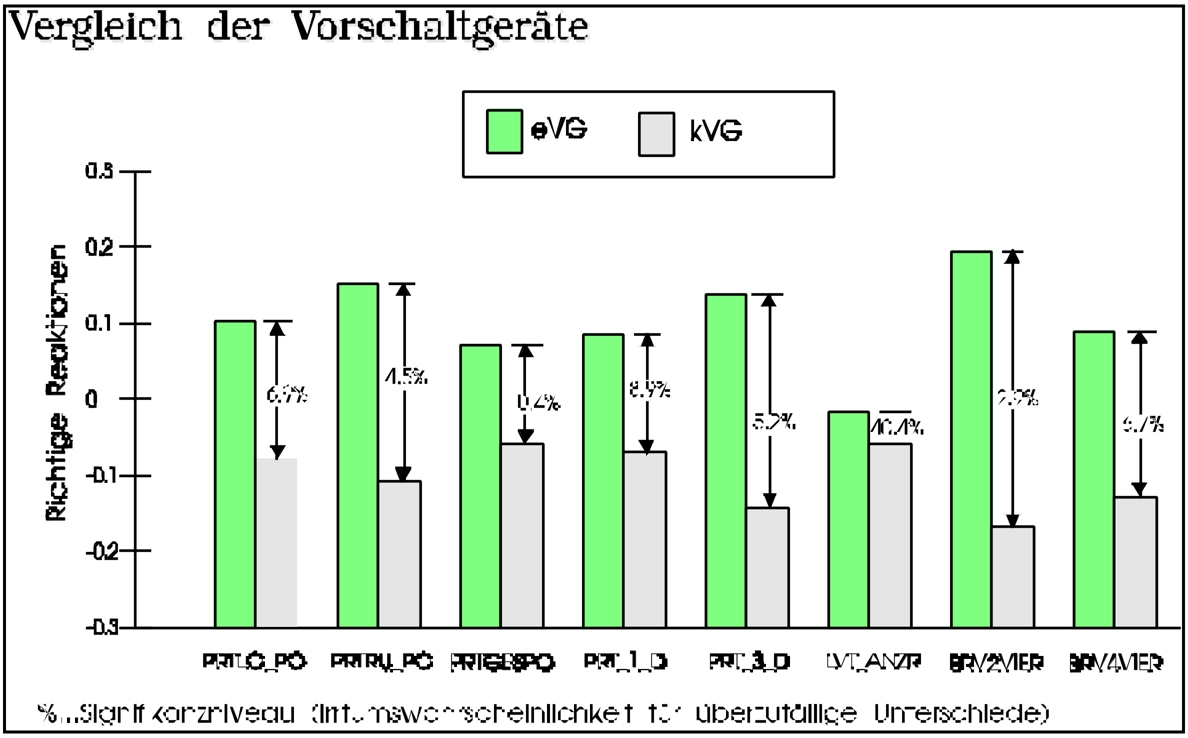


Fig. 11 Performance differences related to variables which can only be attributed to the difference in control gear (conventional vs. electronic) because lamps and fluorescent agent remained the same (comparison of correct test reactions).

For visual tasks which require holistic structural overview (fig. 11: LVT; fig. 13: PT), differences in performance could not in general be detected between eVG [electronic control gear] and kVG [conventional control gear]. However, if one specifies the results solely for color displays, highly significant performance improvements are evident even for global gestalt-perception. In the case of true monochromatic displays, we can see that the electronic control gear improves the performance levels of speed and certainty of word recognition, particularly in the case of negative displays. This might be due to the fact that a dark screen background is substantially more susceptible to distracting reflection glare which causes the flicker of fluorescent tubes with kVG to be reflected much more strongly on the screen and thereby be “transmitted” to the eye. Because a significant overall test result (e.g. PRTGESPO [total of positive responses in the primary test]) does not convey anything about the course of the performance, it was very informative to look at the primary test (PRT) in three segments. In comparison with the kVG, the eVG proved to have much higher start values (PRT_1_D: first test segment) as well as significantly better performances at the end of the test related to endurance (PRT_3_D: third test segment).

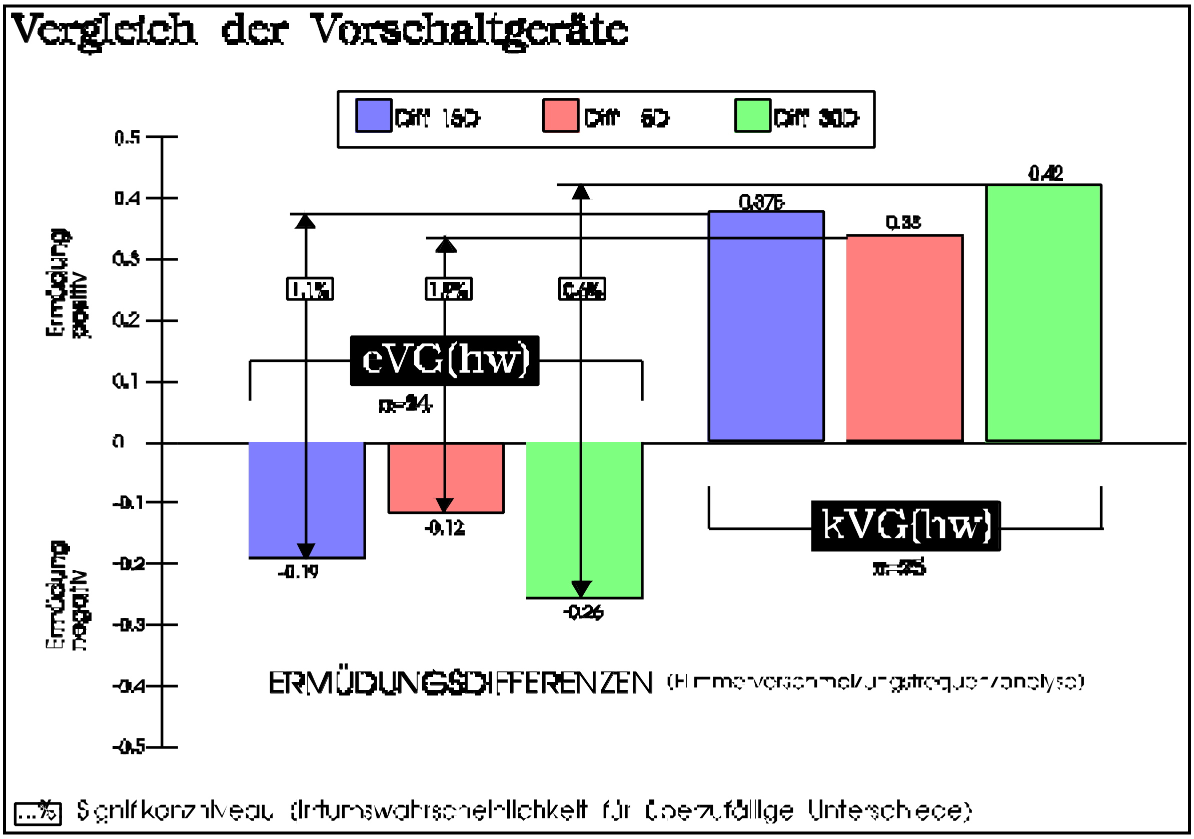


Fig. 12 Comparison of fatigue parameters for electronic and conventional control gear systems: negative fatigue differences in the case of electronic gear indicates a lower vegetative fatigue and a more even level of activity.

This result is consistent with the fatigue measurements which showed for eVG a continuous, even cerebral alertness in the sense of “relief” so that an unconscious activation could not cause a downward trend of performance, as in the case of kVG. This is clearly shown by the negative differences of flicker blending frequencies (measured values after the test minus the measured values before the test) for eVG (fig. 13). This superiority of the electronic control gear in particular has an effect on those visual tasks which are characterized by a dominance of the primary infield, i.e., those tasks which require a (foveal) vision differentiating details even if the visual target field alternates continuously between screen and manuscript. The significance of the BRV results [string of letters comparisons] allows us to conclude that the electronic control gear, after the start of visual "work" (BRV2VIER [results of the second test quarter]), causes a significantly higher quantity of performance which is practically maintained until the end of the test (BRV4VIER [results of the fourth test quarter]). In the case of conventional control gear, on the other hand, the median productivity lies substantially lower in absolute terms.

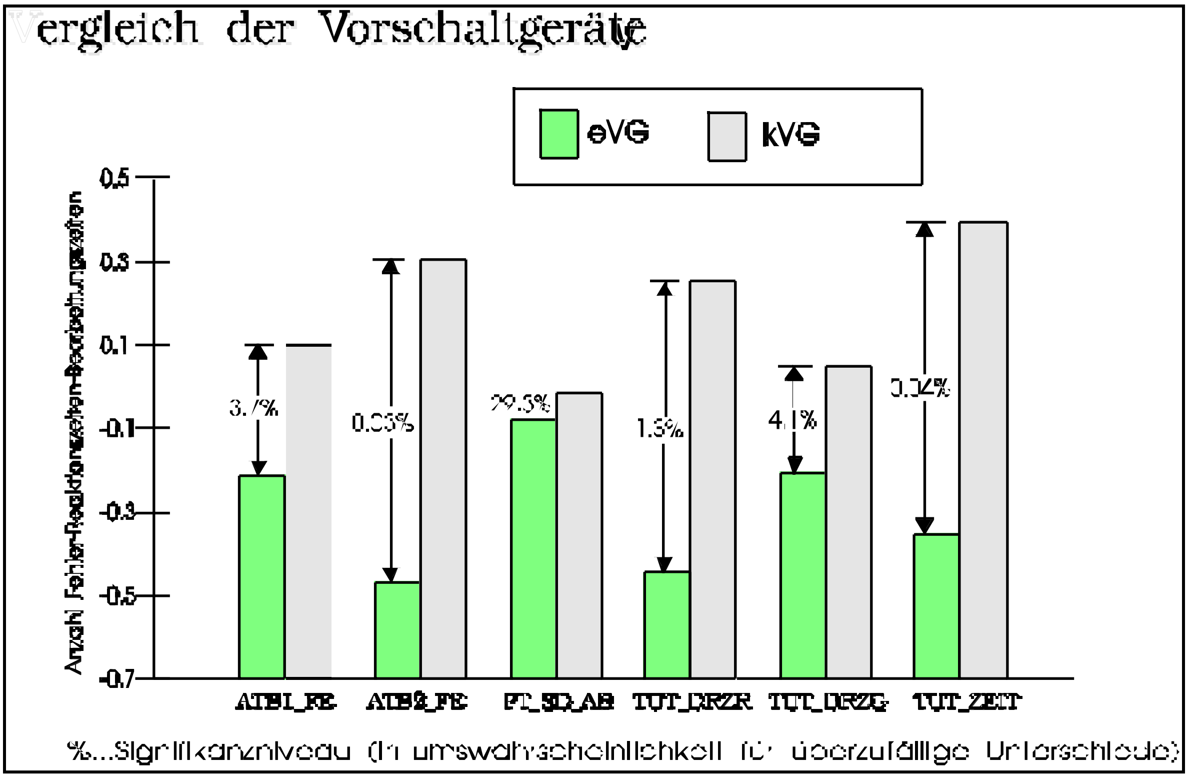


Fig. 13 Differences in performance related to variables which can only be attributed to different control gear (conventional vs. electronic) since lamps and fluorescent agent remain the same (comparison of the number of errors made, of reaction speed and time needed for job completion).

The design of a so-called transcription test (AT) must ensure that the linguistic cognitive text components, particularly the syntactic ones, are diminished in relevance so that the elementary perception process can "respond" by itself to the independent variable (eVG/kVG), thus better the highlighting the differences. Recurring mistakes can thus be attributed unambiguously to the visual conditions (here: lighting). Transcription further entails a successi-

ve reproduction of an original which necessitates constant change of viewpoint for comparison between the given stimulus (original manuscript) and the result of the work (screen). Under these conditions, typing errors can no longer be exclusively attributed to an insufficient or wrong motoric process; rather they are the consequence of reading mistakes (i.e., perception mistakes) related to the original manuscript which are then only put into effect when typing. Figure 18 impressively indicates that with eVG the number of mistakes even decreases over time (ATB2_FE [mistake score in second block of copying test]), whereas the opposite trend is evident with kVG (ATB1_FE, ATB_2FE) resulting in a highly significant difference in mistake scores at the end of the test, the result favouring eVG (no fatigue).
When reaction times for the recognition of minute differences between complex stimuli pattern on the screen and the manuscript are measured, the electronic control gear is far better than the conventional one (TUT_DRZR [average time for correct reactions in test involving overview of tables]; TUT DRZG [average time for all reactions in the same test]). This is equally valid for the total processing time (TUT_ZEIT), i.e. the work speed, which in turn indicated more stamina of perception and a higher certainty of perception under “eVG”.

The performance differences between eVG and kVG that were proven with this study could also be explained by the latent flickering of low frequency tubes which signals, a kind of danger which the organism tries unconsciously to escape by excessive physiological tension (stress; stimulation of the sympathetic nervous system) which, under “kVG”, causes an uneconomical development of performance reserves. A high-frequency light source, approximating daylight in this regard, does not get the human organism ready to turn (something which requires maximum performance only for a brief time), but “switches” the vegetative system to endurance (parasympathetic stimulation) and conserves high capacities of concentration and attentiveness over long periods of time. Some light therapies exploit this fact. One can expect less psycho-physical stress on working people under artificial light with electronic control gear; this guarantees more work satisfaction, fewer mistakes and a higher productivity.

5.2 The Influence on Visual Work Performance of the Color Temperature of Light from Linear Fluorescent Lamps

The color temperature of a radiation which is perceived by human beings as light or illumination means, in its physical definition, simply the color of light radiating from a light source. It is expressed in Kelvin degrees and refers roughly to that light color which a heated body (Planck's Radiator) has at a certain temperature. In this sense, warm red light has a low color temperature and cold blue light a high color temperature. The light environment at a workplace is therefore decisively determined by the warm or cold color of light, particularly from artificial light sources, and has (according to the tests that were done) influence on the resulting performance of visual tasks which must be accomplished fast and without mistakes on VDUs. For this purpose, visual performance was statistically compared for three common light colors (color temperature) of linear fluorescent lamps with electronic control gear. The light temperature with warm white (Philips 83/36 W), bright white (Osram 21/36 W) and daylight white (Osram 11/36 W) was chosen as an independent variable. The dependent performance values are the test results (T1, T6, T7, T8) which were standardized on a standardization scale.

Figures 14 through 19 show that the work performance for mostly visual tasks indicates significant differences depending on the color of the work light that is used. In general, the results demonstrate that bright white light color, especially when compared to warm white light color, causes significantly higher levels of performance. But even daylight white color is inferior to the bright white version, although the daylight-white fluorescent lamp has a better effect on performance than the warm white light. These differences are most pronounced when color display is tested. The color temperature of the light seems to have less influence if the tests are carried out with monochromatic monitors. This is especially apparent with the warm white light color because, in comparison with the bright white and daylight white, one can hardly detect a diminishing effect on the performance. This leads to the conclusion that color displays on monitors (which are quite common today) are more sensitive than black and white displays to light color as it relates to visual stress. This might be due to the fact that the color reproduction characteristics which are connected to the spectral composition change with the color temperature of light. By virtue of their technology, monitors themselves are light sources, according to the displayed image, different wavelengths for certain times and places. Due to the variety and changes of the displayed colors, the light which radiates from the screen interacts with the light of the space's lighting system which then causes a much broader steady modulation of the “information light” transmitted from the screen to the eye than is the case with monochromatic monitors. If the color structure of the space light, due to overly low or overly high color temperatures (red or blue), is too unbalanced or one-sided it will produce more stress and exertion on the eye, increase fatigue to an excessive degree, and consequently diminish the capacity for a constant performance over a longer period of time. In order to optimize visual performance related to color displays, the color temperature of artificial light should therefore be no less than 3.500° Kelvin and no more than 4.500° Kelvin.

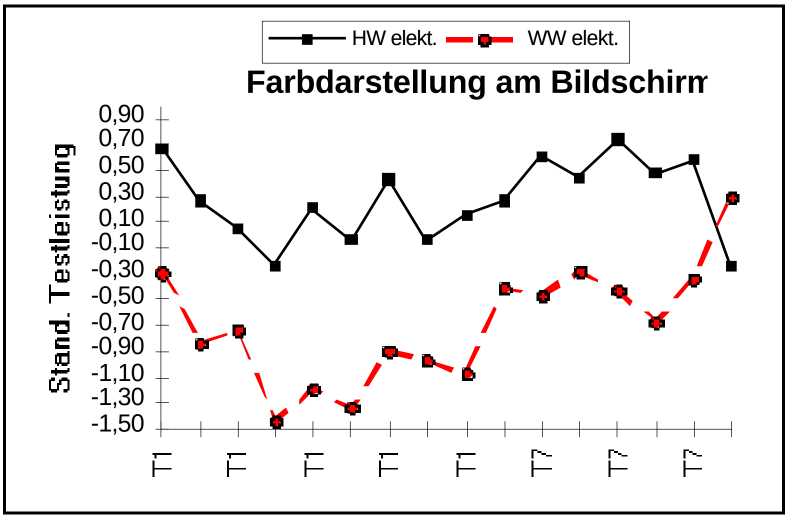


Fig. 14 Comparisons of test performance under bright light warmtone white and daylight-white light color on color displays.

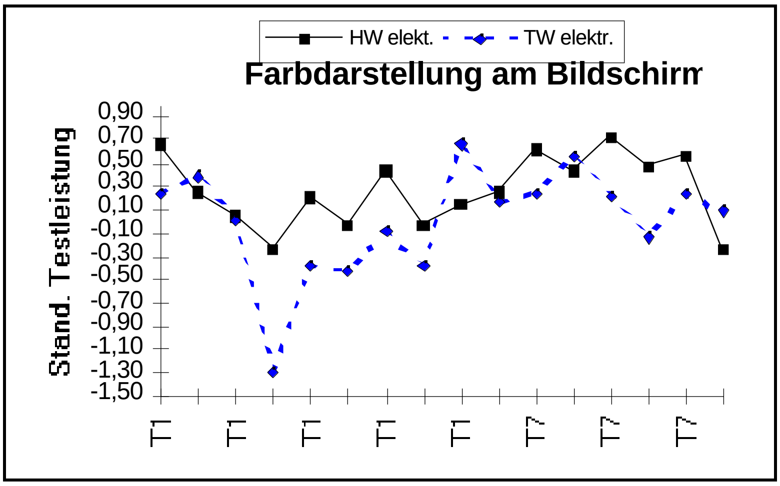


Fig. 15 Comparison between test performances under bright white and daylight-white light color on color displays.

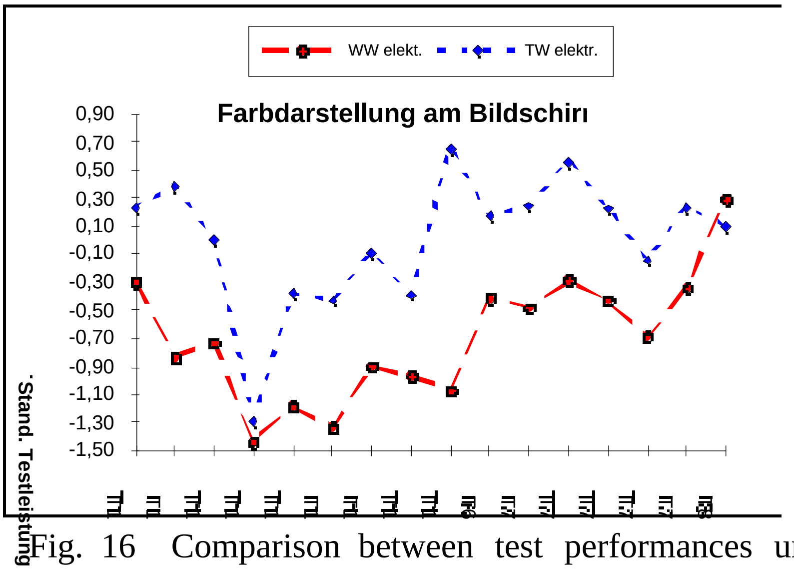


Fig. 16 Comparison between test performances under warm-tone white and daylight-white light color on color displays.

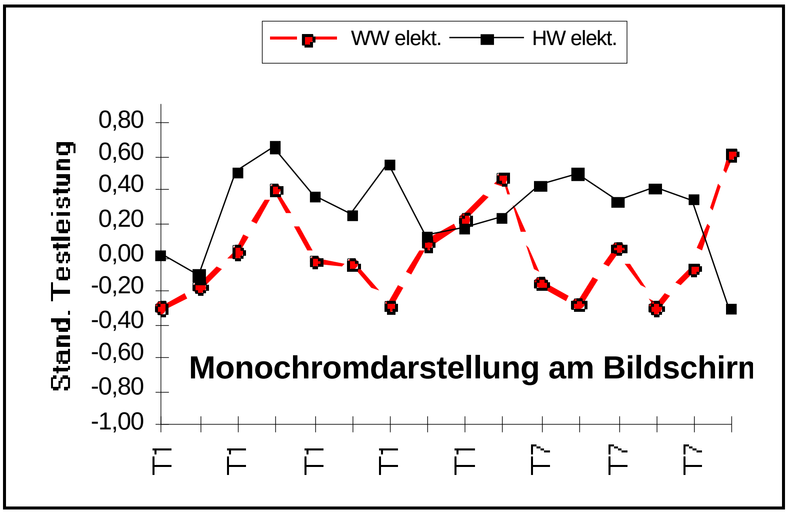


Fig. 17 Comparison between test performances under warm-tone white and bright light color on monochromatic displays.

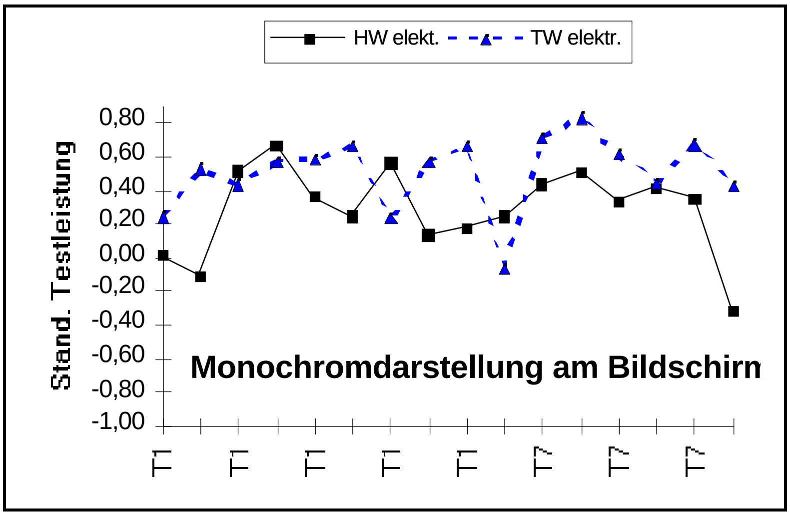


Fig. 18 Comparison between test performances between bright white and daylight-white light color on monochromatic displays.

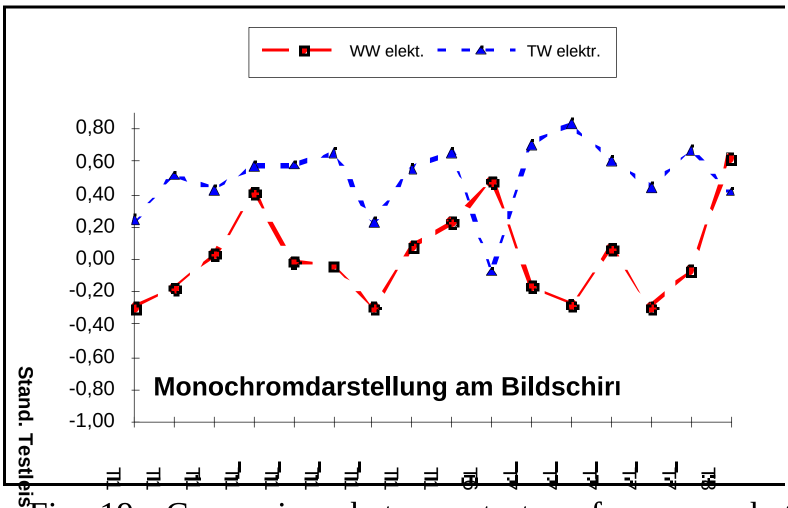


Fig. 19 Comparison between test performances between warm-tone white and daylight-white light color on monochromatic displays.

6. Further Procedure

The practical value of scientific study must be measured by its external validity. In other words, one must examine to what degree the results and findings can be transferred to realistic everyday situations. In this regard, the method of a virtually experimental field study, employed for the tests described herein, is probably the most suitable because it requires real test conditions (here: actual offices) already at the planning stage of the experiment and especially during the test runs. But not only were the necessary spaces and lighting systems constructed true to real conditions, but it was also ensured that the developed test methods provided a true representation of actual occurring visual tasks related to the visual stress of VDU work.

The main purpose of the employed test methods was to compare lighting systems on the basis of fatigue gradients and visual performance variables which cover eight different functions of the visual organ that are important to VDU work. This can also be achieved by comparing actual values with required values within the frame of workplace analysis or improvements in lighting conditions. The mentioned test methods are then used at the actual workplace in order to study and evaluate on site the lighting conditions as they relate to visual stress. On this basis, statements can be made on how to optimize ergonomically all criteria which relate to lighting technology and perception physiology. Such evaluation criteria and areas for improvement encompass:

- type of lighting
  luminaries and luminaire systems for the general illumination of the secondary surrounding area; for the zoned illumination of the task-related infield;
- type of light (fluorescent light, metal vapor lamps, halogen lamp, etc.);
- light color or color temperature of the artificial light (warm, bright white, neutral white, daylight white);
- radiation characteristics
  direct radiation, indirect radiation, secondary radiation, direct-indirect radiation;
- flicker characteristics
  electronic control gear, conventional control gear;
- supplementary artificial light
  necessity, amount, avoidability through better use of daylight;
- daylight use
  expansion of areas that receive daylight through re-directing systems;
- glare protection measures
  in order to keep the adaptation level constant over time and space;
- sun protection devices

in order to prevent excessive heat in work areas through the direct parallel radiation of sunlight;

- illuminance conditions and illuminance distribution
  adjusted for the components for infield and surrounding area in order to achieve stable perception conditions;
- seat position and direction of view
  parallel to the window, facing the window, mixed;
- selection of furniture
  especially with regard to their surfaces in order to achieve balanced illuminance levels for the infield and surrounding area as well as to achieve a harmonious luminance structure for the entire appearance of the space;
- arrangement of work tools (e.g. monitors) and desks
  in single offices, in open-plan offices, in multi-functional spaces;
- design and adjustment of the secondary surrounding area
  selection of materials, degrees of reflection, surface structure, color design of the ceiling, floor and walls;
- design and adjustment of the primary and secondary infield
  tasks-related infield illuminance as a condition for reading the screen, manuscripts, keyboard. Evaluation of color or monochromatic display in relation to lighting. Elimination of gloss on vertically tilted or horizontal manuscripts;
- elimination of direct glare
  for artificial light sources or from daylight openings in order to prevent massive fluctuations of adaptation due to alternating and roving eye movements;
- elimination of reflection glare on screens
  independent of their placement and degree of reflection control;
- intensification of contrasts
  in the area of specific visual tasks;
- reduction of shadow formation
  to a level where the perception of form and “gestalt” is not impaired but rather supported;
- differentiation of visual tasks

in accordance with perception-physiological performance criteria in order to adjust the lighting more efficiently for visual tasks having priority. The necessary time for this type of evaluation is 3-4 days and the costs amount to about 8,000 to 10,000 DM; several workplaces can be tested at the same time if the employees are available as test subjects. Subjective evaluations can be used as supplementary methods in order to establish the coincidence of performance values and mental state. After analyzing actual on-site conditions, the results can be compared with the performance values from already tested lighting systems or from suggested lighting systems in model spaces of the *Bartenbach LichtLabor* in order to find (for the client) optimized lighting solutions and appropriate materials specifically selected for actual workplaces and for specific visual tasks. Performance improvements obviously imply a gain in working hours, promising thereby economical advantages resulting from the full utilization of employees. To achieve the goals of better performance and improved mental state at the workplace through better light, the *Bartenbach LichtLabor* is prepared to do its share with scientific competence - also in consideration of the new EC requirements (e.g., the obligation of every employer to provide an ergonomic analysis of the work environment).

References

[1] Abbreviation for *Video Display Unit*.

[2] Flagge, I. (Ed.). *Annual of Light and Architecture*. Ernst&Sohn, 1992, 1994 and 1998.

A Didactic Concept for Training Architects and Interior Decorators

Volkher Schultz

Fachhochschule Lippe (Abteilung Detmold), Germany

Keywords: Lighting Laboratory, Interior Design, Didactic Concept, Visual Comfort, Architectural Space

Abstract

The 20th year anniversary of the *Lichtlabor* is used as an opportunity to look back. Two decades in a period of rapid technological development is a long time, during which furnishings pass or fail their trial period. The organizational structure of the *Lichtlabor* which includes lay-out and appliances has continually expanded since 1977 although the theoretical approach has not changed. Even the ideational structure of the *Lichtlabor*, without which an organizational structure would be worthless, has proved to be workable and effective as a didactic concept. This concept is based on the interdisciplinary midpoint between a technically (basic) understanding of light – a combination of abstract knowledge and experience gained – and its design-related application.

Introduction

Design-related application inevitably assumes an analysis of the subject. Interior design today can no longer be confined to the principles of the historical influences of stylistic models, but has to look for elements which appeal to the senses, namely the criteria of lay-out and perception. Spatial lay-out and spatial perception are corresponding terms which are mutually dependent. Spatial lay-out means that a volume must be metrically defined and enclosed. The enclosure or shell is usually substantial and contained. But even open confinements, such as alleys and glades are perceived as spaces, at least from an appropriate line of vision. Activated by experience, the inborn ability of dimensional imagery which flows to the three information levels enables us to complete missing ideation. Thus, contour antecedents, light and color contrasts which are linked in a real spatial situation, also rouse dimensional associations in their own right. Line systems, light-dark patterns and color sequences are unconsciously understood in dimensions as soon as they are visible. A volume filled with light does not require a rigid shell to be recognized as a space of light. A sufficient number of the finest particles or dust particles are adequate if they are only illuminated. Therefore, light is a necessary medium for perception, starting with a metrically defined volume, continuing through to the texture of the shell and ending up as an architectural space which can be enjoyed.

The didactic concept of the *Lichtlabor* blends with a dualistic method of procedure. On the one hand, a receptive antecedent should reveal an insight and convey methods. On the other hand, a constructive conclusion must arouse that slumbers and cultivate beginnings which have been found. The moment when dealing with light begins to fascinate lies between the antecedent and the conclusion. A report on the dualistic method of procedure can be found in this contribution.

Spatial Organization

During my study period as assistant professor at Professor Johannes Ludwig's Chair for Architectural Drawing and Interior Design at Munich University of Technology, I had the opportunity to analyze the design and illumination of large interior spaces, mostly churches. The topic of my doctoral thesis *Light Direction in the Architectural Area* [1], derived from this experience, caused me to carry out experimental lighting engineering investigations which I first carried out on abstract space models and then on concrete space models. In a black box, which I was able to convert to a white box of the same volume, and using the artificial calotte sky room of the Keller company in Wallisellen near Zurich, I studied the light incidence through a window opening which I orientated towards significant points of the hemisphere. I fitted this quadratic window opening with attributes like, window sill, window reveal and deflectors also encouraged by measures I had seen in Alvar Aalto's buildings. In this way, I discovered typically formed light distribution bodies and investigated their effect in the white box. Here, I let the light distribution body collide with a fixed space shell and imagined that the shell could, like a living cell, envelop through contraction or make way through expansion and so give the light volume less or more space.

In 1976, when the opportunity arose to realize a *light laboratory* in approx. 160 m^2 of space in a new building of the Fachhochschule Lippe (Abteilung Detmold) situated in the Bielefelder street, I was immediately in a position to specify the spatial divisions and functions. Specifications which I have not changed since: a multi-use *daylight room* of approx. 50 m^2 with a through-going fenestration on one side, a *white room* of approx. 25 m^2 and an adjacent *black room* of identical size, a *light measuring track* approx. 16 m^2 long, an *artificial mirror sky* of approx. 12 m^2 and a room for equipment and own working space are the significant rooms which were able to be expanded with a *fore-zone* with exhibition possibilities (see figure 1).

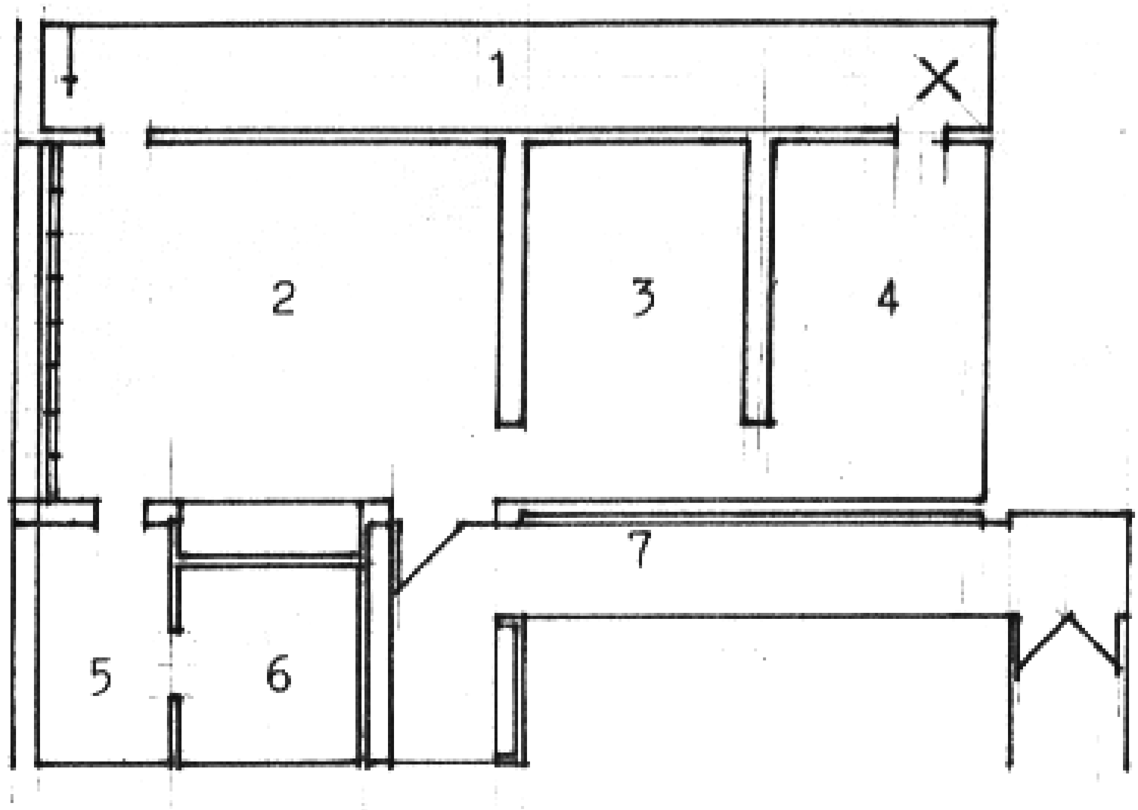


Fig. 1 Ground-floor Plan (#1 Light Measuring Track / #2 Daylight Room / #3 White Room / #4 Black Room / #5 Working Room / #6 Artificial Sky / #7 Fore-zone).

The window in the *daylight room* is fitted with a grille having quadratic fields which can be partially closed by flaps until the room is completely darkened. The boxes integrated in the grille permit the demonstration of the illuminant chromaticity of artificial illuminants which can be compared with the daylight. A built-in display window situation which can be used in isolation or in competition with the daylight is located at a side wall of the daylight room. Further built-in demonstration facilities demonstrate the influence illumination intensity has on a body color, the change in object effect through the surroundings and the modeling of a surface which shows differently formed stereometric projections and hollows by diffused and directed illumination. The *white room* and the *black room* have the same metric dimensioning. The ceilings of both rooms are fitted with similar spot, line and area-shaped ceiling lights.The *measuring track* which originally had a manually-moved pivot carriage now has an automated version so that the measurement data can be stored and evaluated with software programs. In the *artificial mirror sky* which has an effective useful area of approx. 9 m^2 at a height of 2.75 m there is a centrally located lifting table for the positioning of space models. An artificial sun which, in line with the third generation of my designs is a parabolic reflector guided along a fixed arc to automatically travel all possible sun paths, provides parallel directed light.

Receptive Phase of the Study Period

Although every study-starter reflects on a life period in which he has grown up with the nature of light and has had time to consciously question his impressions, he has usually not done so. When you ask him to sketch an illumination situation, this will usually show a window through which the sun projects a memorable pattern and not the image of a space modeled by light. It is first necessary to open the eyes to all the phenomena important for dealing with light: generation, characteristics, spreading, reflection, transmission, all type of effects and finally also the photometric detectibility. Light is a medium which transports information but, as an energy form, is just not visible.

Working in Natural Scales

The *daylight room* is suitable for studying the effects of window sizes, window shapes and window arrangements. For the latter, the position can be high, at eye level or low as well as vertical or horizontal bands. For each fenestration situation, the associated horizontal illuminance values can be demonstrated for each measuring grid and for each measuring time point - and also compared with calculated values. The visibility requirements and sensitivity can be assessed for each fenestration situation: certainty or irritation through cast shadows, reflections, reflected glare, surface and color identifiability and readability of print and patterns at different room positions.

This wakes the interest in the modeling strength of the light which has always been valued in painter studios and strived to newly exploit when building photography studios around 1900 by including generously dimensioned side windows and skylights with shadowing, distribution and reflection measures in combination with ingenious background constructions. Even a small obstacle like an upright pencil supplies a wealth of information about the illumination conditions: the modeling of vertical surfaces becomes recognizable from the nuances of the shaft facets and from the own-shadow. And what does the cast shadow which envelops the light flux lee with the own-shadow tell us? The number of shadows is equal to the number of effective light sources. The various colors of the shadows are caused by the different illuminant chromaticity of the participating light sources. The shape of the shadows reveal the shape of the light sources. The length of the shadows indicate the height of the light sources and, with reference to a single light source, we even obtain information about the illuminance conditions of the side and ceiling areas.

In the illuminant chromaticity comparison boxes integrated in the window grille, it is possible to demonstrate the illuminant chromaticity of the installed artificial illuminants and the respective color rendering of inserted material or color samples; and to make a comparison with daylight which, although as we well know does not represent any constants, is for us historically a reference light source. Especially interesting and amazing are the changes in the metameric color patterns which can fall apart. The most similar color temperature of light sources can be measured. It is an important assignment quantity for the illumination level. Also important from a psychophysical point of view is the determination of whether the light source has a continuous spectrum or a band spectrum. A glimpse through an interference graded filter provides the answer.

The display window situation is suitable for merchandise presentation. This window is equipped with a variety of illumination types: spot, line and area-shape light sources produce their effects from the top, from the bottom and from the sides - with diffused and narrow beam light distribution characteristics. The front sliding glass plate illustrates the problem superimposition of mirror images creates for visual requirements. Position, noticeability and luminance in comparison to accidental light source can be defined. The glass plate also serves as virtual expansion of the daylight room.

The *white room* and the *black room* are similarly intended for the studying of the handling of artificial light. An elementary experience which every viewer should be familiar with but is rarely conscious of, is recalled as soon as we stand in the separating wall area of the two rooms and simultaneously look into these: the same volumes filled with identical light quantities from identical lamp positions result in fundamentally different effects. With the large difference in reflectance of 0.80 to 0.04 there is also little chance of realizing a visual compensation of the surface effects - e.g. through increasing the light quantity in the *black room*. The measurement of the illuminance distributions on the room shells permits objective comparisons. The subtraction of corresponding values produces the respective indirect percentages.

An analysis of the systematically measured illuminances provides the basis for all terms relevant for a lighting calculation, e.g. scalar illuminance (utilization method), point illuminance (point-by-point method), utilization coefficient, efficiency factor and lamp operating efficiency, - after prior measuring or determination of the lamp light flux -, reflection coefficient and luminance. Also informative is the comparison of isolux lines in the *white room* and *black room*. Observation of a sheet of paper moved along isolux lines of identical order in the mentioned rooms shows that identical illuminances and identical luminances do not need to give the same visual effects: surroundings luminances and light direction distributions are fundamentally different.

The modeling of a sphere can also show different results when only the illuminance distribution is defined on its surface. What about the surface itself, the light direction composition and the surroundings determining the adaptation? Just as in acoustics where the audibility of a tone is dependent on the prevailing noise level, the difference sensitivity respectively the visual perceptibility of contrasts, is dependent on the adaptation level to which our eyes have adjusted themselves. My visibility model which I have been working on in the framework of my dissertation is aimed at visual requirements, predominantly defined by luminosity contrasts and less by color contrasts.

The *black room* is indispensable for the following experiments: measuring the light intensity distribution of small light sources, verifying the cos spherical illuminance distribution around a point in space, verifying the illumination through a secondary spot and measuring the reflection indicatrix of surfaces having different color and smoothness. The *measuring track* serves for the measurement of more dispersed lights. As it is accessible and can be viewed from the *black room*, a measuring sequence can be followed with even a large seminar group. In this context, it is also possible to practically explain the significance and relationships of the basic quantities of light engineering.

The mentioned rooms also serve for different areas like the demonstration of the spectral breakdown of the light, the additive color mixture and the color perception, the simultaneous contrast, the light generation, the operating mode and the performance of lamps, the dimmability and the waviness. The mentioned rooms are also suitable for simulating spatial situations and providing work positions at which, for example, the relationship between reflected glare and contrast rendering should be demonstrated. It is also possible to test the suitability of lamp designs produced by project work.

Working in Scale Models

Working in scale models is obligatory for large dimensioned spaces. This manner of working is, however, also important for small-volume projects because models are practical, can be easily altered and are even challenging for influencing. In contrast to acoustic investigations, the model scale can be freely chosen for light investigations. Every miniaturization is possible when dimensional accuracy and surface relationship are observed: the wavelengths of the visible spectrum are extremely small in comparison to what we can see with the naked eye. When working with a scale model, a decision must first be made about which surroundings conditions appear favorable: white, metallic or black backgrounds, and whether or not these projected images should be used. The suitable space can then be chosen. Available as light sources are all fixed lights and all types of movable lights. Particularly popular is a lighting apparatus which transports the light into the model via optical conductors whereby the light can be color filtered, closely or widely bundled or dimmed. Useful is everything that was already employed in the early days of photography: masks, screens, diffusion disks, reflectors and backgrounds.

A simulation of a daylight situation can, as before, be carried out outdoors. However, the *artificial sky* is recommendable for comparison observations under standardized and reproducible conditions. It offers the luminance distribution of a completely covered sky increasable in three switching stages to an outdoor illuminance of max. 7,000 lux. and an artificial sun which automatically travels all sun paths for any location in the world. In simpler cases, the initial orientation using light boxes with uniform diffused light from all sides can also be practical.

In addition to the visual observation of the model, the documentation with the aid of photography and video technology, the latter especially for dynamic sequences is particularly important. In contrast to the observation in the model, which for dimension reasons usually needs to be carried out one-eyed and not always optimally adapted, the mentioned methods have an advantage: psychological uncoupling from the model scale so as if the picture was taken in real space. A trick that is also used by film studios. Large-format projections of the shots on areas reaching as far as the floor, as is possible in the *white room*, increase the impression of reality which can only be further optimized through the three-dimensionality of stereo-shots. The use of endoscopy is recommendable for very small model spaces and spatial areas which are difficult to reach. This conveys surprisingly realistic impressions when viewed directly and is also suitable for photographic documentation.

Receptive-constructive Phase of the Study Period

Just as we can analyze historical building, we should also not deny the roots of modern building. What appears to be new is usually an original combination of solutions which we have copied from nature and which have already often played a role in the history of mankind. In the new context, they receive a new relevance to the present and new acceptance - perhaps they have also only recently become technically achievable. It is therefore sensible to replicate, analyze and vary spaces which have been built. By experiencing that which is foreign to us, we can also discover that which belongs to us - or recognize without doubt the brilliance of a solution. For example, we take the model of the lobby of the IG-Farben company by Peter Behrens in Hoechst, gut the space to its quadratic outer shell, replace the supports and circling galleries, cover these through the fenestrated inner shell, then place on these the prismatic pilaster strips and then, finally, cover these with the original colors. After attaining the actual-state, we reverse the color sequence on the pilaster strips so that the dark colors reach upwards to the light and the light colors reach downwards into the twilight or we turn the prismatic pilaster strips so that they do not project upwards and envelop the light but, like gravity, form a projecting stable foot at the bottom. Although the mentioned variations in no way dispense with the logic, the fascination of the built solution would be lost in both cases.

An alternative exercise could involve the replication of a space by appropriately co-ordinating the spot-shaped, line-shaped, area-shaped and body elements of the target on its virtual shell. By adding or removing elements, it would be possible to interpret, negate or counterpoint the spatial effect, i.e. emphasize, mask or accompany the metrical dimensions. Changes to the arrangement and the shape of the light sources would have similar design significance. The perception of contours would be aided or the weights in the space displaced - perhaps also the formation of the fenestration given independence.

Variations in the illumination effect can also be practised on drawings of projected spaces, such as the hall of the Königswart Hotel by Joseph Maria Olbrich or on images of existing or already demolished buildings of historic importance such as: the Rabe House in Zwenkau near Leipzig, the Ernst Ludwig Studio House in Darmstadt, the Große Kunstschau in Worpswede, Bruno Taut's Glass House in Cologne, the Panaromas Mesdag in The Hague, the Titania cinema in Berlin, the Art Collection NW in Dusseldorf, the Bagsvaerd Church in Copenhagen and many others.

Constructive Phase of the Study Period

However valuable and indispensable the collected knowledge in the areas of light engineering and the design of spaces is, it remains unused until the moment in which the synthesis of the preceding analytical stages has taken place. The synthesis is the special intellectual performance of a design. This intellectual performance, also called creativity, is performed unconsciously but can be consciously performed when powers of memory, combination talent and imagination are trained.

Abstract Spaces

Utilization ideas easily tempt to the making of associations which are orientated to casually known similarly used spaces without their qualities having been questioned. Spatial ideas can be developed more easily when we use elementary spaces and illuminate these with the aim of entering these or spending time in them. Such elementary spaces consist of cubes, rectangular parallelepipeds, prisms, barrels, cylinders, ellipsoids and nestings and spatial sequences derived from these. The light can seep through the shell material or fall through slots and protrusions or intrusions. Desirable is that the light openings, individually or in total, are given an independent character, for example through the design of the reveals or subdivisions and by ensuring that an assignment quality exists between the light openings and the closed parts of the shell which can be compared with that of an ornament.

When the approach is correct, a spatial idea which was intuitively found or consciously sought will be readable: the articulation of the contours of the upper or lower room-half, of a light corridor or the sequence of spatial sections. Space can radiate tranquility or dynamically point a path. The desire for activation of the light wealth, for moderate light incidence or secretive darkening will be recognizable. The impression space gives also depends on whether or not the contrasts included in the design, such as large - small, long - short, straight - round, vertical - inclined, convergent - divergent, colorful - uncolorful, come into play. It is also very tempting to explore the extent to which the shell of a volume must be obvious or whether it could permit several interpretations. The latter can be achieved with the use of layered shells whereby the shells show different translucence and coloring. Just as interesting is the experimenting with mirrors that can create virtual lengthening, widening, heightening, deepening or anamorphoses. It is possible to work with entirely virtual spaces, like in a kaleidoscope. A technique which has already been employed in the Baroque period to simulate large garden and park facilities.

Concrete Spaces

In reality, we will predominantly deal with concrete spaces intended for a defined usage. It is possible to optimize and test spatial ideas, measure light engineering values in a model, track sunlight times and sequences in the model, check the effectiveness of antisun and shading measures, activate light transportation and light steering and discover further variations. In the majority of cases we will assume several approaches, respectively, a series of preliminary designs. The multiple solutions for static problems are brought to mind here: there is not just one bridge design with which we can cross a specific span. Similarly, there are also several ways to fulfil functions and find suitable illumination solutions for the concrete design of space.

The confidence for being able to design spaces which enrich architecture and not just fade into ordinariness will awake slumbering forces in us. And regardless of whether the spaces are representative or more ordinary spaces like, hallways, wardrobes or wet units. The key to success will be the understanding that the spatial quality will not be guaranteed solely by the attractive ground plan shape and the intended volumes, not until the texture and especially the shape-giving force of the light have been integrated. Could we not also characterize Alvar Aalto in this way? Influenced in the early years by the clarity of classicism, later captivated by innovative design and finally fascinated by the uniqueness of human faculties, sight, hearing, touch, feeling, smell and taste, he found a personal and epoch-making trademark as an answer to the challenge of modern building.

Conclusions

A shortened developmental summary which describes the perception and design of space may make it easier to classify the *lighting laboratory* institution as a didactic concept: deriving from the building tradition and trying out were the common methods of historical building. A calculable number of building tasks, modest sequences of the building events and the use of the familiar daylight as the dominating light source, not only permitted these methods but produced so fully developed and visually consistent solutions which are still a part of our repertoire today. The intellectual conflict with the laws of perspective, as they flowered in the Renaissance and Baroque periods, demanded the exact study of shadow casting and the modeling of objects and spaces. This knowledge was the basis for the design of space and his nature-true presentation as it was nursed as the ideal situation until the beginning of this century.

At the end of the 19th century, the pointillistic painting around Paul Signac brought new impulses. The possibility of partitive color mixture and the image creation through the addition of small color areas fascinated. The laws of vision and color vision were rethought. Photography, as a technology which also produced image effects by way of differentiation of small spots, joined around the same time: first supplementing the painting world as a tool, then competing with painting during the phase of increased perfection and finally displacing the naturalistic painting. There was an interest in photographically effective results and the exact looking was left to the camera.

The possibilities offered by electronic data processing and the projection on a monitor represented a new revolutionizing of the visualization and of the presentation technology which now competes with photography. The efforts to perfect the monitor/video technology raises a new the question: How do we see, what do we see, what do we know from what we have seen and what is decisive for a spatial impression? Legions of pixels are waiting to be so accurately directed that the results are photo-realistic images; incidentally, usually images of spaces which have never existed and only appear virtually before our mind's eyes.

Is it still necessary to build these spaces or is the actual experience the gaping at their simulation? This newly stimulated research into viewing delivers a by-product, this being that seeing is an information flow which unconsciously controls the entire organism and thus also has an influence on our mental equilibrium. It is not until the information has reached the vision centre for evaluation that we finally become image conscious. To be derived from this is that when viewing in a real space - and into a model space - we not only obtain a visual impression but also a feeling which in the coupling of all faculty impressions leads to a real experience. Attempts to replace the complex interplay of sensations and perceptions through computers or instruments will remain unfinished unless someone wanted to withdraw into the world of monitor reality. Even under inclusion of all possibilities which the computer media today offer (and we should of course use), the need to develop concepts for the illumination of space will remain. Concepts which only strive quantitatively for equalization of the visual performance at all spatial locations will remain design fragments despite computer precision.

Design requires visual comfort. Visual comfort only exists when a qualitative differentiation, a hierarchy of the visual requirements, is wanted, because not everything has the same level of importance to us. The determination of priorities, the discovery of pre-opinion, the avoidance of errors, all these become possible through experimentation and analysis of real and simulated situations. The *light laboratory* will thus in no way become redundant through the surprising technological developments, instead it will maintain its relative importance as a place of spontaneous experience and controlling. PR, lectures and external contacts, like on Open Day, will additionally ensure updating. [2]

References

[1] Schultz, Volkher. *Lichtführung im architektonischen Raume*. München: TU München (Diss.), 1975.
[2] Schultz, Volkher. *20 Jahre Lichtlabor*. Detmold: Schriftenreihe der Fachhochschule.

Openings and Natural Light: Experiences in Full-scale Models

Tobi Stoeckli (stoeckli@lesomail.epfl.ch)

EPFL, Switzerland

Keywords: Light Chimney, Daylighting Research, Anidolic Daylighting System, Computer-controlled Heliodon, Diffuse Light Simulation

Abstract

On the EPFL-campus two experimental laboratories are located just side by side: the LEA (Laboratoire d'Expérimentation Architecturale) and the LESO (Laboratoire d'Energie Solaire et de Physique du Bâtiment). The research work on daylighting performed by the LESO will be presented in the framework of this contribution and finished with a personal statement about openings.

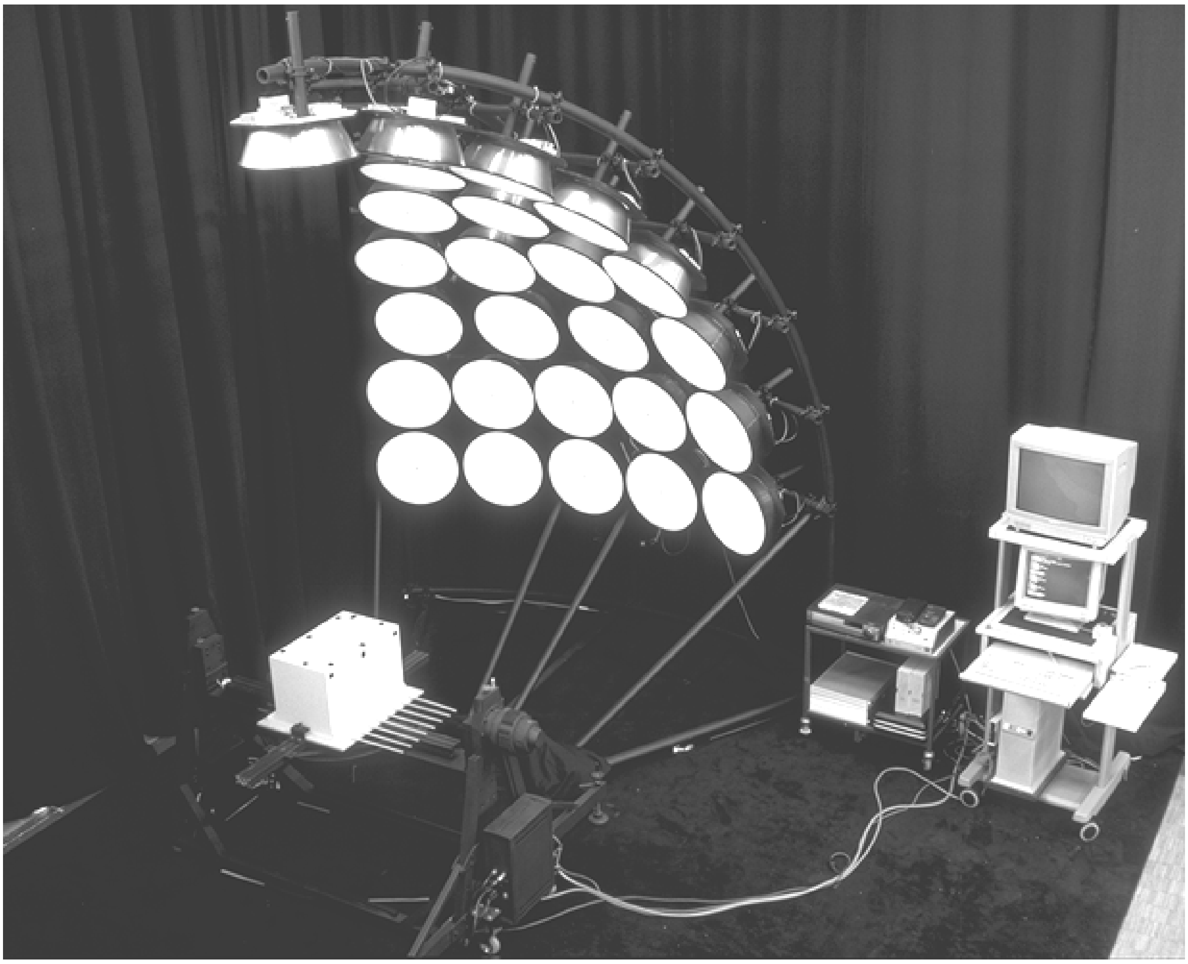


Fig. 1 View of the diffuse light simulator and the equipment.

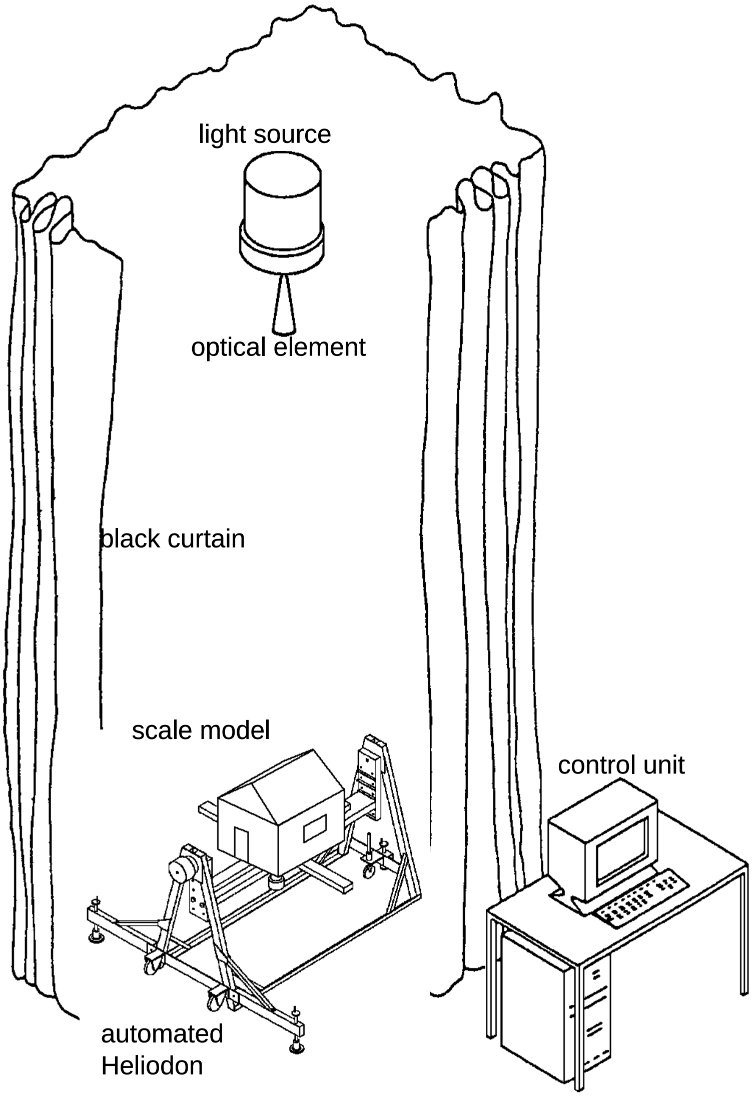


Fig. 2 Principal components of the direct light simulator.

The Daylighting Laboratory

In the main experimentation area of the LEA parts of the daylighting laboratory of the LESO are hosted, which is a result of the available ceiling height and the possibility to install a light source which simulates direct sunlight. Further principal components are:

1. A *heliodon*, which enables to turn the scale model in the exact position (latitude) of the site and to simulate the course of the sun during a specific day (summer/winter);
2. A control unit (computer), which presents the indications to move the model, stores up the measurements and visualizes the luminous conditions perceived within the model;
3. A black curtain, which protects the measurements against other light sources.

As Switzerland has more days with overcast sky and diffuse light than clear days with direct light a *diffuse light simulator* was also built up. For the diffuse light simulator, 1/6 of the whole hemisphere (diameter: 5 m) was built. This surface is big enough for the measurements. A computer program allows the control of the entire light simulation. This basic installation is completed by additional equipment such as:

- photometers to measure the illuminance inside the scale models;
- endoscopic objectives and a high-definition CCD-camera;
- image digitizer;

The installation allows:

- to measure the daylight penetration inside the scale model;
- to evaluate the visual comfort under given, simulated daylighting conditions;
- to visualize the luminous environment perceived inside the scale model.

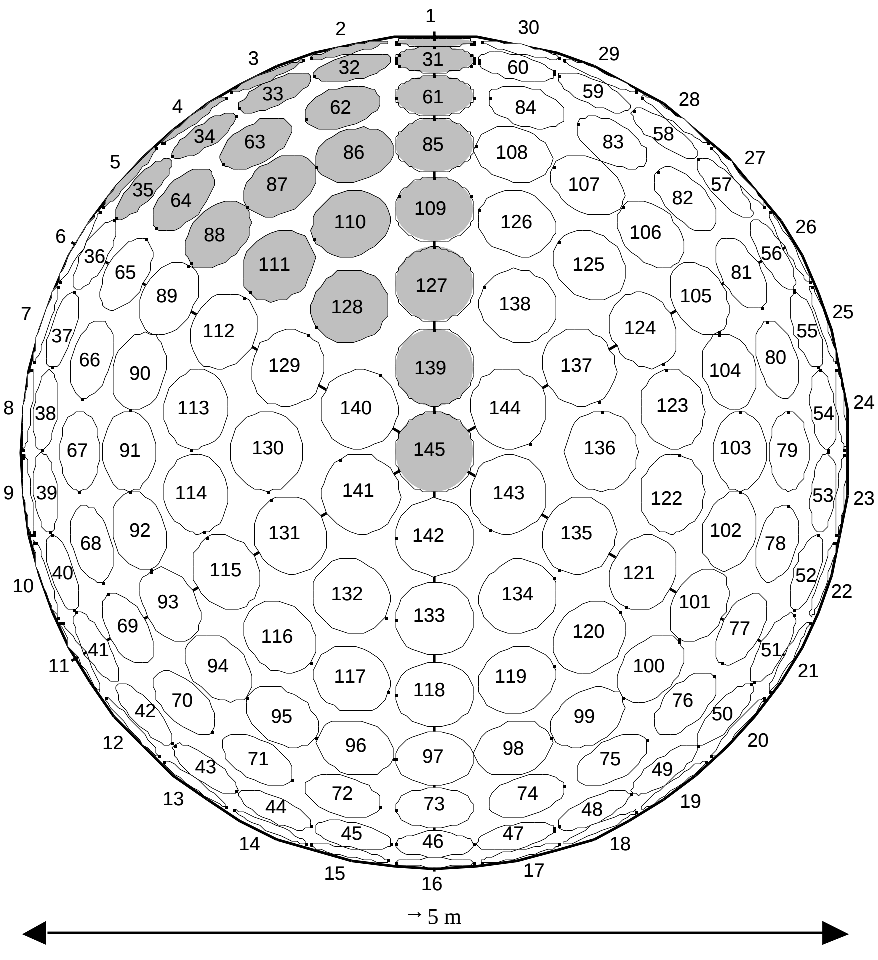


Fig. 3 Top view of the diffuse light simulator. The built lighting zones are 1/6 of the whole diameter.

Research on Light Chimneys

Daylighting chimneys allow bringing natural light in the back-area of deep spaces. This aspect was further studied in the course of a specific research program. On a theoretical basis daylighting chimneys were examined, especially the influence of changing dimensions (width from 60 to 90 cm) and the form of the openings on top (light-catcher) and below (light-diffuser).

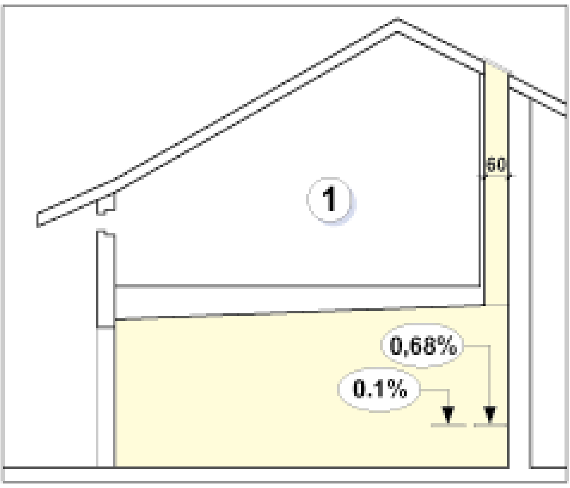


Fig. 4 Basic Project
Width of the chimney: 60 x 80 cm
Surface: white paint

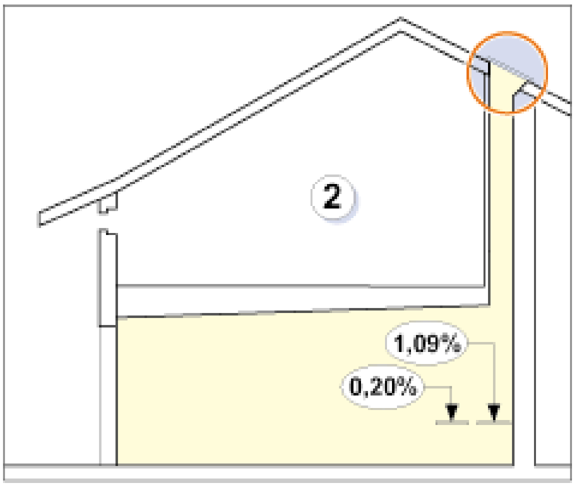


Fig. 5 Variation 1
Enlarged top opening
Surface: reflecting polycarbonate plates

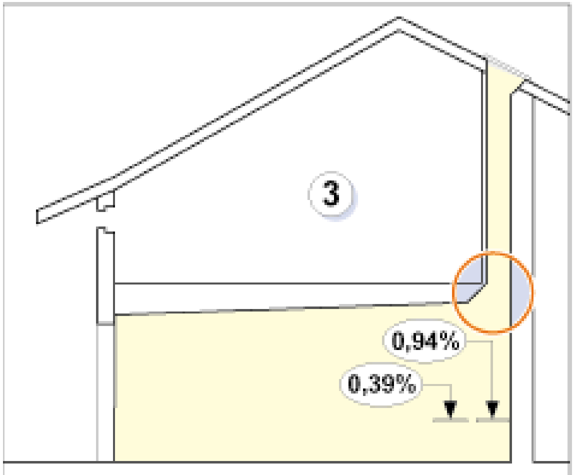


Fig. 6 Variation 2
Enlarged top and bottom opening
Surface: reflecting polycarb. plates

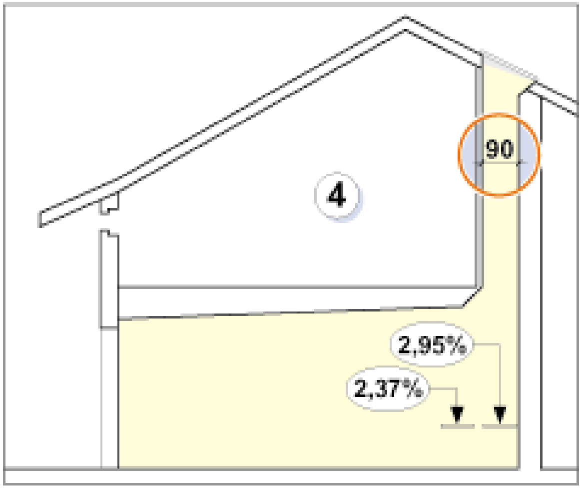


Fig. 7 Variation 3
Width of the chimney 90 x 110 cm
Enlarged top and bottom opening
Surface: reflecting polycarbonate plates

The daylight-factor directly under the chimney increased through this optimization process from 0.7% to 3%, and in a short distance from the chimney from 0.1% to 2.4%. The results were verified through the real construction and were found to be close to the previous values.

Research on Anidolic Daylighting Systems

Based on a theoretical approach, the LESO built three spaces, equal in size and dimension (3x3x6.5m), with the entrance door on one short wall and the windows on the opposite side. The three spaces had the same window surface. In one parameter they were treated differently. They made different alterations and could finally compare four variations:

- grey painting (surfaces);
- white painting (surfaces);
- white painting (surfaces), increasing the window height by 1/4 of the total height and shifting the front part of the ceiling;
- white painting (surfaces), application of anidolic devices in the upper part of the window resp. on the ceiling.

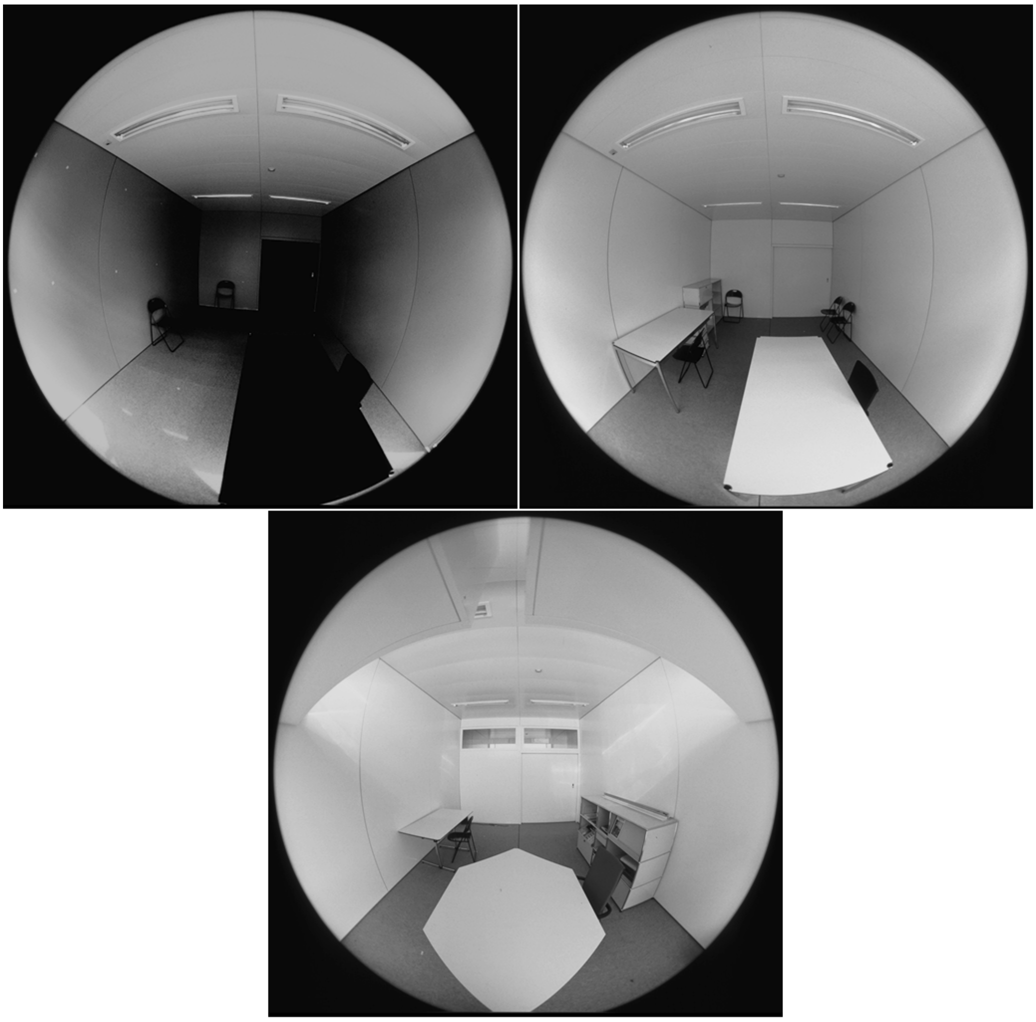


Fig. 8 Interior view seen from the same point near the window into the back of the room [Top left: Daylighting conditions in the room painted grey. - Top right: Daylighting conditions in the room painted white. - Bottom: Daylighting conditions in the room painted white with anidolic daylighting system.].

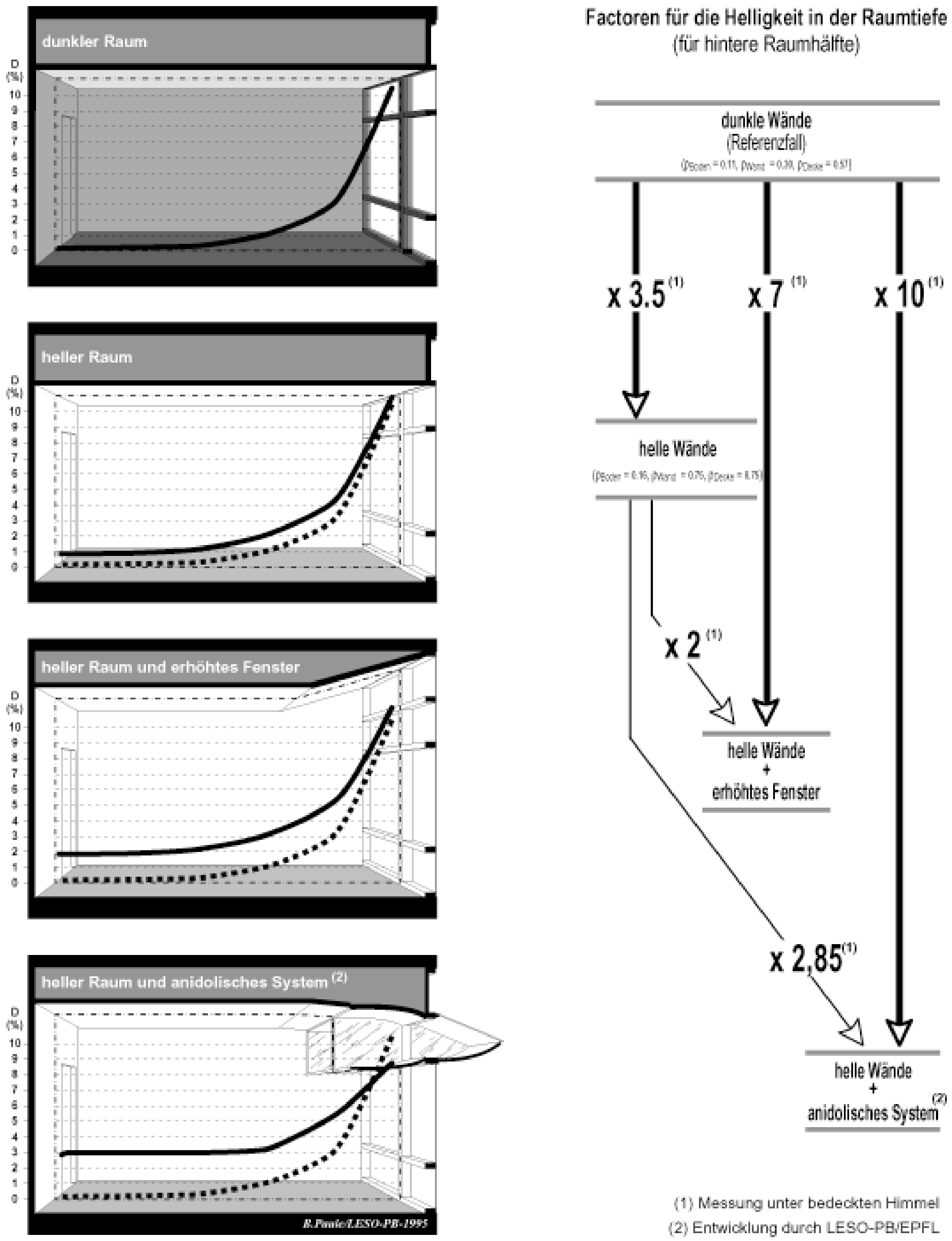


Fig. 9 Configurations and results of the full-scale model.

The measurements were performed during a day with overcast sky. Compared with the grey room, the daylight illuminance in the back half increased:

- for the white room by a factor of 3.5;
- for the room with the enlarged window front by a factor of 7;
- for the room with the anidolic reflectors by a factor of 10 and reached a daylight factor value of 3%.

The anidolic daylighting system proved to be an effective device in re-directing daylight in the back of a deep room. At the same time it changes consequently the appearance of the window area from the inside of the room, as well as the appearance of the façade.

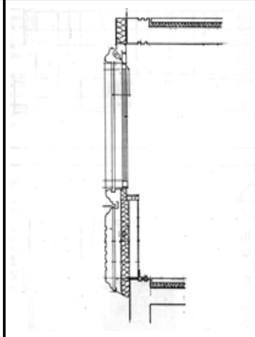
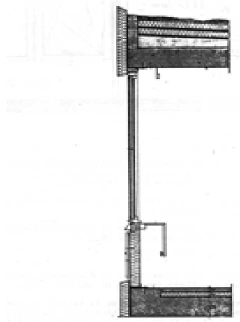
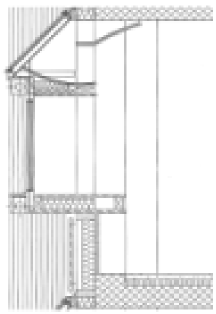
	EPFL - 1	ISAL	LESO - 1999
			
Glazed area (%)	39%	52%	48%
Average U-value (W/m2 K)	2,16	1,19	0.84
Heat requirements (MJ/m2 floor area)	239	154	(93) 86
Mass (kg/m2)	123	29	(42.5) 122,5
Embodied energy (MJ/m2)	1933	1476	(675)

Fig. 10 Measurements of energy savings.

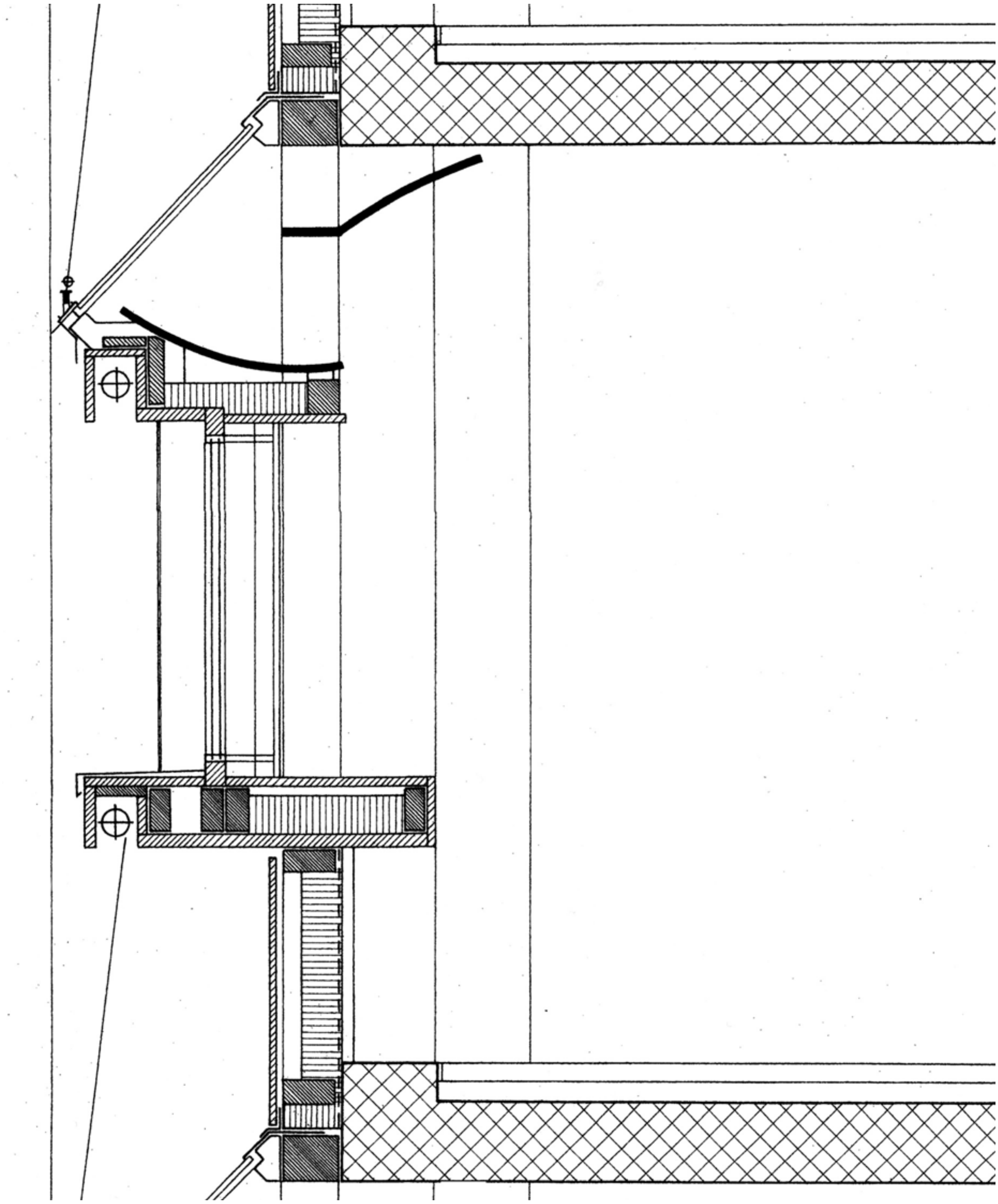


Fig. 11 Section of one floor of the façade.

In the beginning of 1999 the LESO-building got a new façade with anidolic reflectors, which are much better integrated in the overall appearance. This new façade was compared to the existing façade of the EPFL-campus resp. to a conventional metal-facade-system approved to be superior in saving energy (heat requirements and embodied energy). The façade will now be tested and evaluated by the researchers of the LESO themselves.

As these works show, the researchers of the LESO apply simultaneously different tools to these topics. They have developed a number of computer simulation tools. These results are continuously compared with studies on reduced scale models and within full-scale models. All the three levels of research are necessary to be able to compare and to take advantage of the potency and the effectiveness of each tool. Furthermore, confidence is reached about the computer simulation, which finally approves to be the quickest and the fastest tool to compare different solutions for a given problem.

Research on Computer Simulation

For architectural projects it is necessary to control the different aspects as early as possible. For daylighting problems LESO developed sophisticated software with fuzzy logic techniques, which allows the user to get comprehensive results when the first draft of a building is made and many parameters are yet not fixed. Moreover, the software can be used by architects without help of a lighting specialist. It allows to work with “unprecise” data and gives recommendations for improvements to be made in order to realize an improved daylighting strategy. Furthermore, comparisons with reference cases are suggested. In this respect architects have the opportunity to control the effect of daylight within the space at an early stage of the project, when necessary corrections and modifications can be made easily.

The Architects Point of View

Although this research work is useful and significant, as architect one has to combine this convincing knowledge with many other aspects of an architectural case and to integrate this in the basic concept of the architectural project. Considering this task one may raise several questions:

1. Remaining within the topic of light, the question remains: "what is the appropriate quality of light in a room?" It is evident, that insufficient light or dazzling light is embarrassing. It is also evident, that *light and shadow* create the atmosphere within a space. What is, in consequence, the convenient contrast of shadow and light to feel comfortable?

2. The quality of light is only one aspect of a window. Apart from the light, an opening has to serve for both viewing through and ventilation. For the user the view might be the most important aspect. It shapes the relation between the world outside and the interior. It shapes the connection to others and gives the inhabitants the feeling of belonging to a place and to be at home (even in an office space). The necessary technical devices of the anidolic daylighting system like reflectors and sun protections are influen-

cing the view and have to be integrated in the shaping of the relation to the outside and to the others. This integration increases the complexity of the architect's task considerably and it is unfortunately very often under-estimated or even neglected.

3. The opening itself is only one element of the building, but a decisive one. It is a constituent part of the façade, which itself is a fundamental element of the architectural concept. The integration of technical devices influences or even determines the architectural expression. It can be regarded as a basic question, whether it is appropriate to let a technical device - like a light catcher - dominate the composition of the façade. This can be observed f.i. at the back side of the Shanghai Bank in Hongkong (Norman Foster). What are the gains and what the losses?

Conclusion

Technical devices should not have the power to dominate resp. to determine the architectural concept. Many other aspects are even of more importance and responsible for the “building quality”. An architectural concept should reflect profoundly on daylighting requirements and energy savings problems being able to integrate them in an overall view of a sustainable development. This is doubtlessly an extensive task and waiting to be taken up.

Full-scale Modeling for the Lighting Design of a New Pavilion at the Venice Biennale

Giovanni Traverso (traverso@keycomm.it) and Paola Vighy

G.Traverso - P.Vighy Architetti Associati (Vicenza), Italy

Keywords: Lighting Techniques, Full-scale Experiments, Daylight Control

Abstract

The research which is presented in this paper is related to a lighting topic and part of an architectural project for a pavilion at the Biennale of Venice, used for modern art exhibitions. The building is located along a Venetian canal: the roof form is curved in a way to allow daylight, reflected by the water, to penetrate in the lower part of the building, determining the atmosphere for the sculpture exhibition. In the upper part of the building, where the rooms have a barrel-shaped roof, we want to provide good diffuse lighting to emphasise the quality of the materials and colors of paintings. Starting point is a study of lighting techniques related to a temporary exhibition of modern art. Special attention will be paid to some considerations concerning the question of conservation, the integration of artificial lighting and daylighting, the modeling effects of light and its color performance as well as the effect of light. The study has been carried out testing (full-) scale models in the Lighting Laboratory at the University College of London.

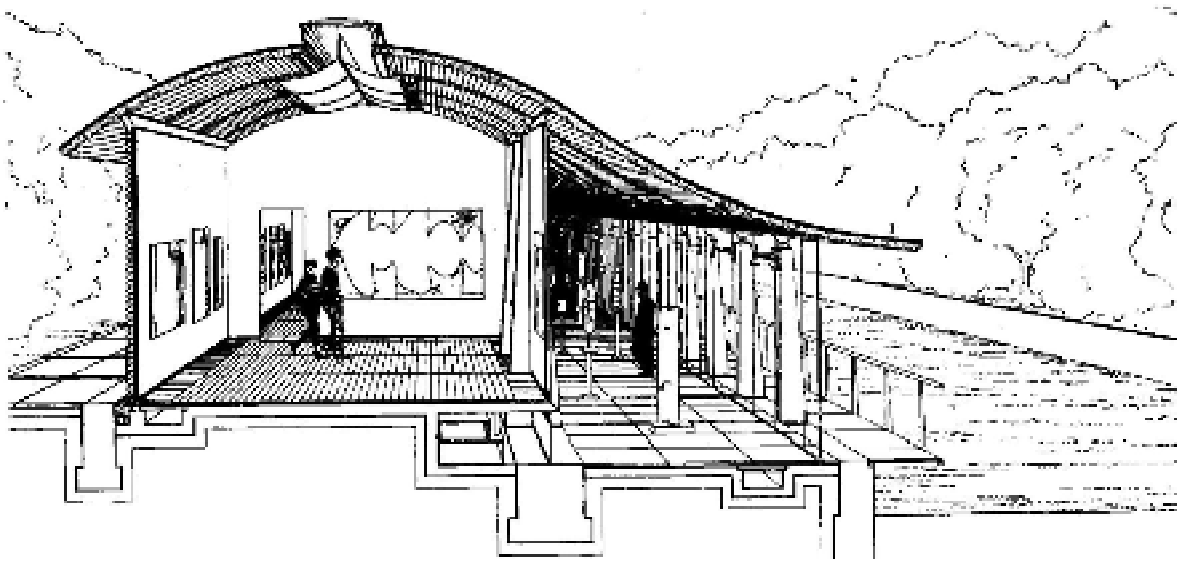


Fig. 1 Cross-Section of the Building.

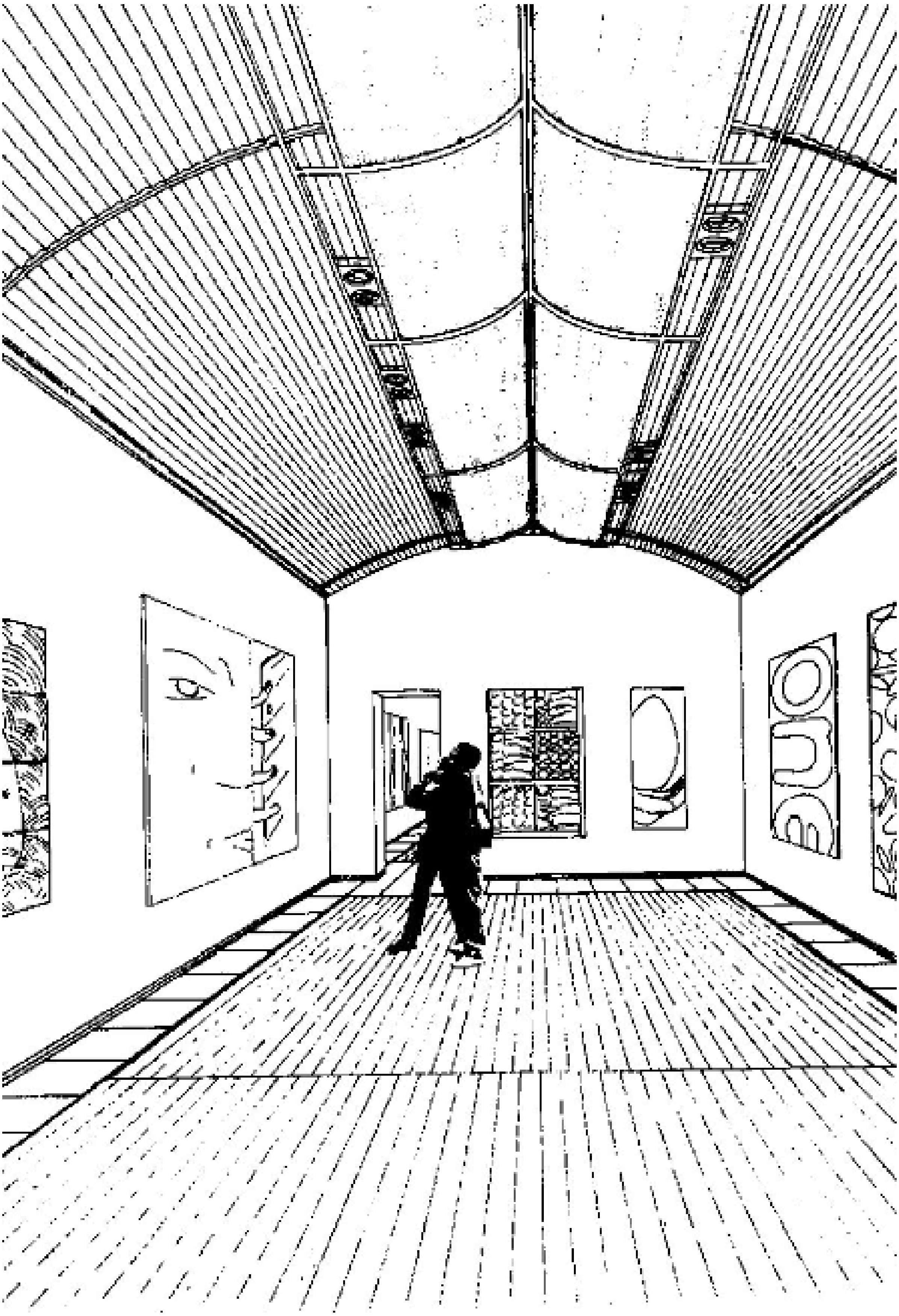


Fig. 2 Exhibition space.

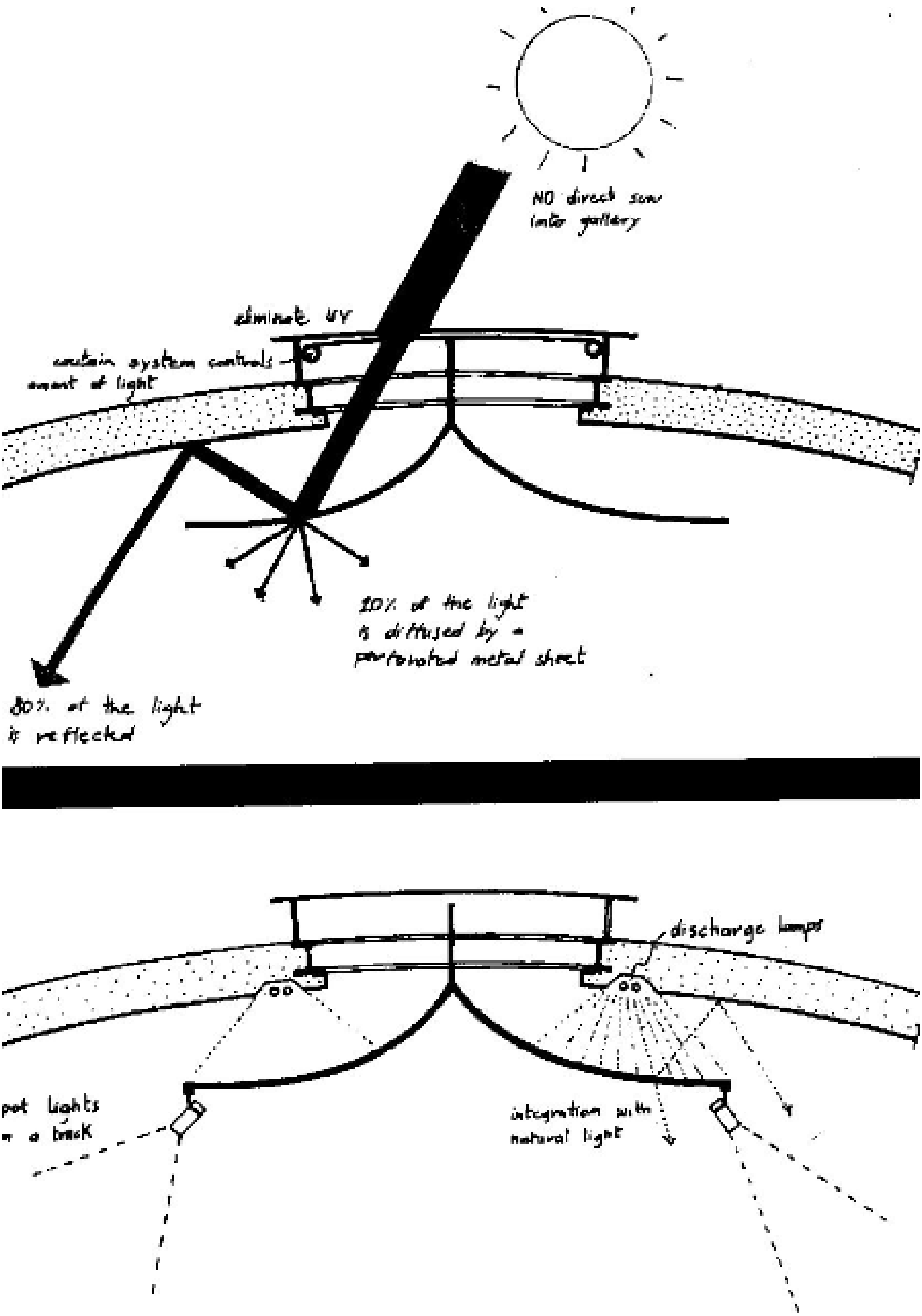


Fig. 3 Daylight control system and artificial light integration system.

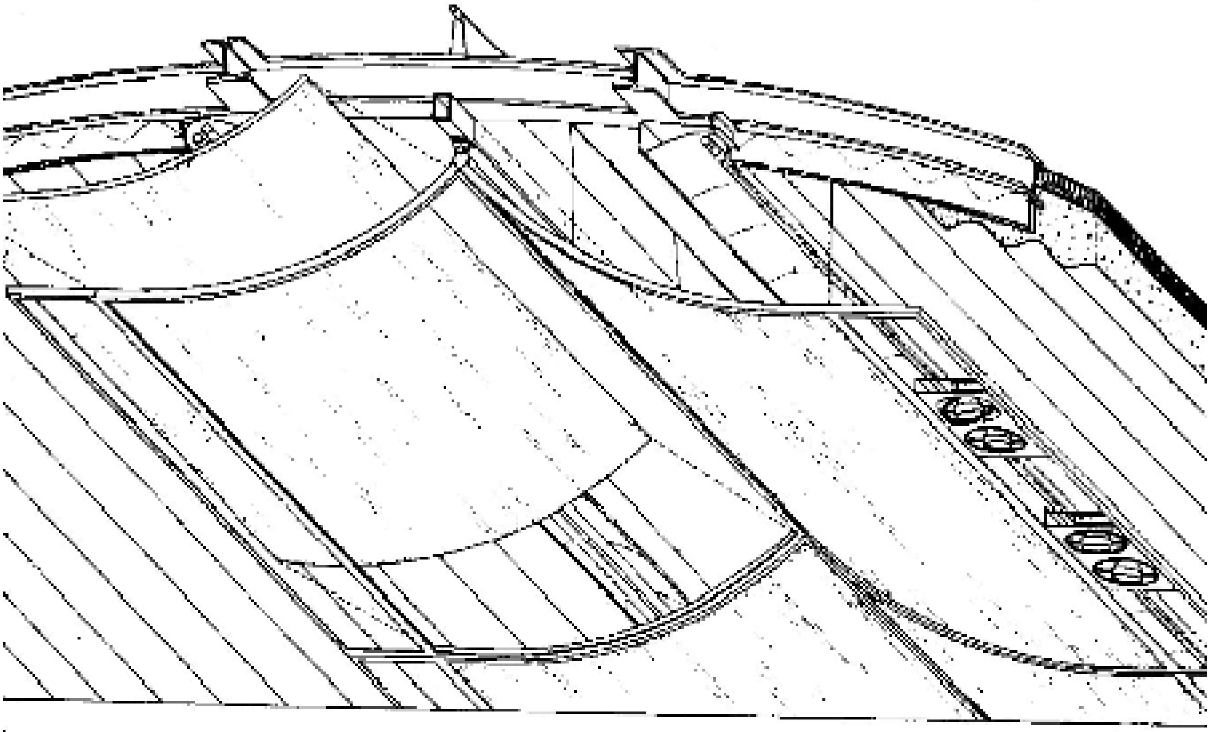


Fig. 4 Diffusing element construction detail.

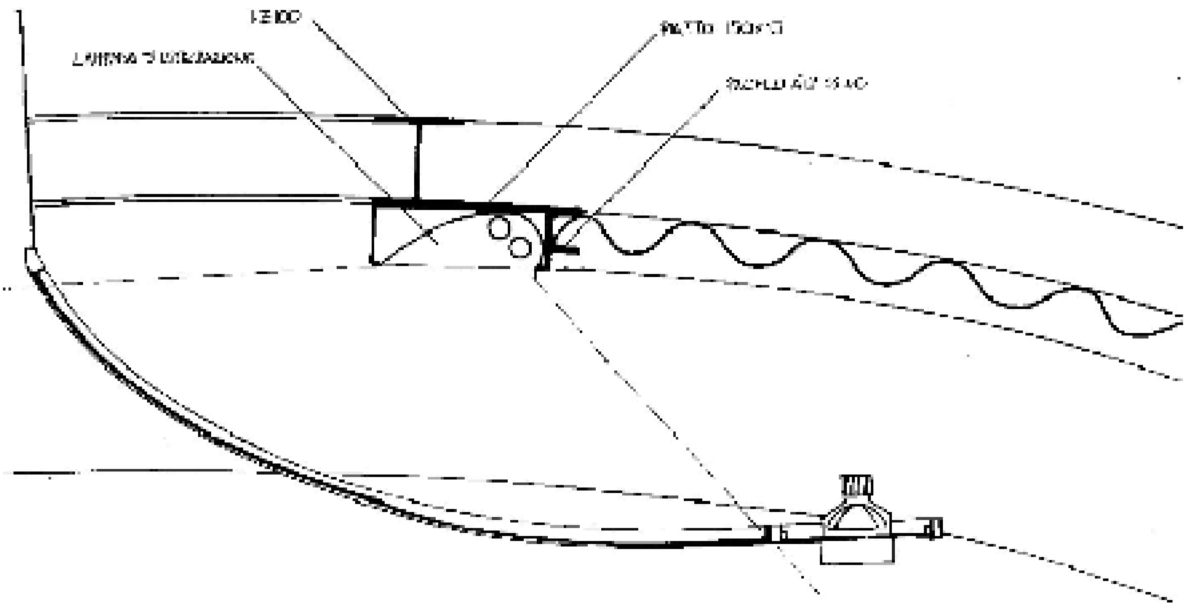


Fig. 5 Artificial integration light and spotlights.

Lighting Project

The project consists in the study of an element to diffuse and reflect the direct light from the sky, coming from a slot at the top of the barrel-shaped roof. Our work was based on the study of lighting techniques related to temporary exhibitions of modern art: we would like to pay attention to some considerations concerning the question of conservation, the integration of artificial lighting and daylighting, the modeling effects of light and its color performance effect of light. The study has been carried out by testing scale and full-scale model in the lighting laboratories of the University College of London. The research explores the following details: the design of the element that acts as a diffuser and a reflector of light, contributing to the architectural value inside the building. This system for daylight control consists of an element to diffuse and reflect the direct light of the sky, coming from the slot at the top of the barrel-shaped roof:

- The design of the optical reflection system was developed testing on a scale model different solution: the choice of the final one was guided by the direct eye evaluation and the analysis of the data;

- Six samples of different papers were used to simulate the real material: the papers were tested to choose the right transparence and reflectance proportion to give a good performance on the daylight control system;

- Full-scale experiments were utilized to investigate the possibility of using perforated metal sheet for the real material of the reflecting and diffusing element;

- The study of artificial lighting with the task of integration of daylight: the idea of our design is an artificial light system that simulates daylight in the way light penetrates in the space and in the characteristic color of daylight during the different hours of the day. The design of the new daylight integration luminaries was carried out with full-scale experiments;

- The design of a spotlight system combined with the diffuser/reflector element: the idea is to show that a real integration in the design of daylight control system, artificial light system and architecture itself is desirable. The new spotlight system has been tested in a full-scale model of the painting room where it was possible to simulate the illuminance level of natural light and the different spotlights optical system.

Conclusion

The use of models in the design process helps not only to control the amount and the quality of the light, but also to control how the space and the materials change with the different light penetration.

References

[1] Traverso, Giovanni and Vighy, Paola. “Testing Scale Model to Study Light in Environmentally Friendly Cities”, in: *Proceeding of PLEA 98*, London: James&James, 1998.

[2] Traverso, Giovanni and Vighy, Paola. “Luce e architettura”, in: *La uce* (1996)5. Teniche Nuove, Milano.

[3] Traverso, Giovanni and Vighy, Paola. “Sistema di controllo della luce naturale per un nuovo padiglione della Biennale di Venezia”, in: *La scienza e la tecnica oggi e domani, atti del convegno nazionale Aidi*. Sanremo: 1996.

1:1 Simulation in Architectural Practice

Kurt Ofer (kofer@altonview.com)

Altonview Architects, USA

Keywords: Full-scale Modeling, Architectural Profession, Education, Spatial Experience, Architectural Environmental System

Abstract

Full-scale mock ups have a long and successful history within the architectural profession. There is consensus that future users as well as professionals are better able to make design decisions in full-scale and in real time. Full-scale analogue simulation must be implemented as part of a typical design process for the sake of our clients as well as the sake of the profession: the cost of doing anything less is enormous. Altonview believes it is possible to develop an economical, flexible and utilitarian architectural environmental system (AES) which can be used, with modifications, by all professionals. Additionally, the media needs to take an interest in the AES movement, which will change their focus from the building image to the user. American architectural schools need to increase their interest in AES as well. The AES movement can be closely linked with the zeitgeist that will define the next century as seen in further examples and references from the popular press.

The Right Question

We will start with the concept of "designasaurs". It is solely because of the internet that I am here. We have been doing this environmental work off and on for about 10 years. It was only as a result of a hot bot search that I came across the EFA site, and a few e-mails later, here I am. So this is truly a web moment. On the internet, there are some great sites dealing with the future of us as designers. The Design Intelligence site deals with the future of us as designers. They take the crystal ball approach and try to define the future of the design profession from a business standpoint. Recently, they have begun emphasizing the fact that we have to ask the right questions. The new book "Smart Thinking for Crazy Times: The Art of Solving the Right Problems" emphasizes asking the right questions before we begin to solve any problems. If we don't ask the right questions, we will be increasingly marginalized as designers which is what has been happening. In the US, the role of architects is increasingly under question and revision. What is our duty as architects to clients? In what ways do buildings effect people, and how can we optimize that? We have been asking the wrong question in the architectural profession.

The questions that dominate the dialogue are something like, "what is the most marketable style or most familiar or formulaic or formalistic thing that we can do to keep everyone interested?" The works of everyone from Gehry to Eisenman to yourselves are all relevant architectural expressions. But what is the relevance to the user? That is the right question. How can we bring the wonderful architectural expressions that we are all capable of to a more pertinent level for the building's users? If we can demonstrate that we are bringing the relevance, the rigor, back to design, then we will be getting back on the track of what it is we are doing on a daily basis...relating to our clients... educating them...empowering them...and increasing the chances that they will be happy and actualized in the spaces that we design for them.

People

This is really very simple. You can make better decisions if you are operating in a less abstract medium. The costs of doing anything but what we propose are enormous. If this is truly the information age, then we need to empower our clients to make the best decisions that we can. In the increasing marginalization of the practice, introducing a "mold breaking" technique into the profession will start to introduce a new vigor into what we can offer. This is not a system for all scales of projects. Obviously, skyscrapers can't be mocked up. But the spaces inside them, including the lobby, can. We believe that there is a real need to get beyond style in the profession. Instead, let's have an architectural process which corresponds to client needs.

We feel that there is an enormous untapped potential in our clients' design understanding. Many people say, "I can't envision things in 3-D, or some such statement". And it's true, they can't. But they do have very strong spatial sensibilities, and we feel that it is possible to go farther with clients using the AES than it is without it. By going farther, we mean that, the AES gives them the realtime and realspace ability to make decisions about their space. At the same time, clients bring to the design process, many times, a conservatism. As part of our practice is in Upstate New York, we live in an architecturally traditional area. So many times, our clients come to our office with blinders on...they speak traditional and conservative architectural values. And these are extremely intelligent people. What we will be able to say to our clients is this...your precepts and attitudes are fine. However, give us the latitude to present you with some solutions that, on paper, you might reject. However, once you are in the space, you will understand the need, say for skylights there and windows here, even though these moves might violate architectural precepts.

One Example. We are working with a father and his daughter on the renovation of an existing Greek Revival house. They brought a very eclectic set of precepts to the design process...they are traditional but willing to consider "modernist touches". We started construction, demolition really, with a set of finely wrought plans with a very conservative room arrangement for the house. Because the second floor of the house had to be reframed, it was removed. Well, when the clients walked into the house after the floor was removed, they were overwhelmed by the newly created two story space. And right then, the design changed from a historical room arrangement to open plan living. It took their full-scale experience in the space to truly make them feel that another solution at variance with their initial precepts would be acceptable to them. Had we been able to mock up the space using AES, I believe that we would have reached this more liberal solution sooner. But they had to see it to believe it.

Process

The AES is a tool. It works best in the design development phases of a project. There are two versions: scrim and opaque. The scrim version has the following materials and qualities: X, Y & Z distances roughed, scale, proportion, rough views, furniture, circulation, axis, entry/exit. The opaque version has all of the above qualities plus sun, lighting, color and opacity. Before an environment is roughed typical schematic drawings are developed in the usual manner. Any number of floor plans are developed and studied and the most likely plan or two is resolved so that it can be taken to the scrim level of the AES. After this AES test and further manipulation, further typical studies can be created using computer 3-D imaging as well as elevations and floor plans.

Fig. 1 The Altonview AES in action.

Cost

A full-scale experience is mandatory for all clients who participate in design services from an architect. Just as the computer sketch pales in its ability to allow the client to internalize information, people need analogue experiences to assist them and form part of the decision making process. We are at the cusp of the 21st century, and we are still asking our clients to essentially decide on how they are going to live via abstract drawing formats.

We at *Altonview* have done the following regarding implementing an AES system: we believe that all clients should be afforded this ability. We believe that this is affordable to essentially all income levels: if you can afford an architect to design your whatever, you can afford a bit more to have a meaningful full-scale experience in the space. We believe that the time is right for the wholesale implementation of this system, examples of which we will discuss later from the popular press. The architectural schools in the US need to wake up, as well as the architectural press in the US. We believe that there is not a broad commercial appeal for this: it can't be mass-marketed, it is a specific service for select clientele (10% of the housing starts in the US involve an architect, so really it is self selecting to begin with.). The materials for a cloth version of an environment can be executed for about $400 in materials and about $2000 in time. Space rental is not included.

Architectural Press

We need to educate the architectural press. The architectural press continues to focus narrowly on the image: what can be marketed and what can be packaged as an identifiable consumerist identity has been absolutely paramount in their own initiatives. The absolute desultory situation of the press in the 80s, in which there was a style of the month, served to place the architecture education and societies impressions of the art back. This seemed to match the social milieu, in which no one was too concerned about the long term effect of what they were doing, as long as they met their goals of making money and actually surviving. What is the purpose of the press in the near term? How can the press become more sensitized to the true needs of the profession, and actually modify itself so that it starts to serve more of the public good?

I enjoy making all kinds of comparisons of the EFA industry to the computer industry. Both are information centric, although one involves digital formats and another analogue. There are all kings of university based think tanks, government supported as well as private incubators designed to foster the development of these industries. The reason that I heard about them is because they are in the popular press. There is big money involved...fortunes can be made...then talk of revolutionizing the world. Well, without going over the top, I believe that the efforts of what we see here are just as important, just as empowering, just as democratic, but we aren't going to get rich...the inability to mass market this from the store shelves prohibits that...then again there are franchises. But we need to bring in the media on this. Because if people start to learn that there is a segment of the architectural industry slated to empower, democratize, and inform during a design process, then it will bet attention and keep our efforts. Possibly even actual money...

Education

The educational experience is more abstract in that the majority of learning occurs in segregated environments away from the realities of both the professional realms and the marketplace. The design focus is based on a tradition of focusing on a single design solution, and the tendency to focus on the plural of both input and solutions is neglected. This fosters the "architect as God" mentality resulting in the single best solution being offered rather than a respect for the culture of the users. There is also an overarching focus on the appearance of the architecture rather than a focus on items such as program and user needs.

The general nature of the architectural curriculum is very fuzzy. There is an absolute lack of intellectual rigor in place. The locus of the intent of the design cannot be isolated, as it is drawn from the student's scattershot efforts to balance the myriad of components comprising architecture: history, materials, details, program, form, etc. This lack of rigor has led to the non-specific nature that the architectural profession has become. We are continually defining what it is that we do, and the lack of specificity in the information that we produce enables us to be challenged by clients at will, putting us at a power disadvantage, which translates into a compensation disadvantage.

Appendix: Examples from the Popular Press

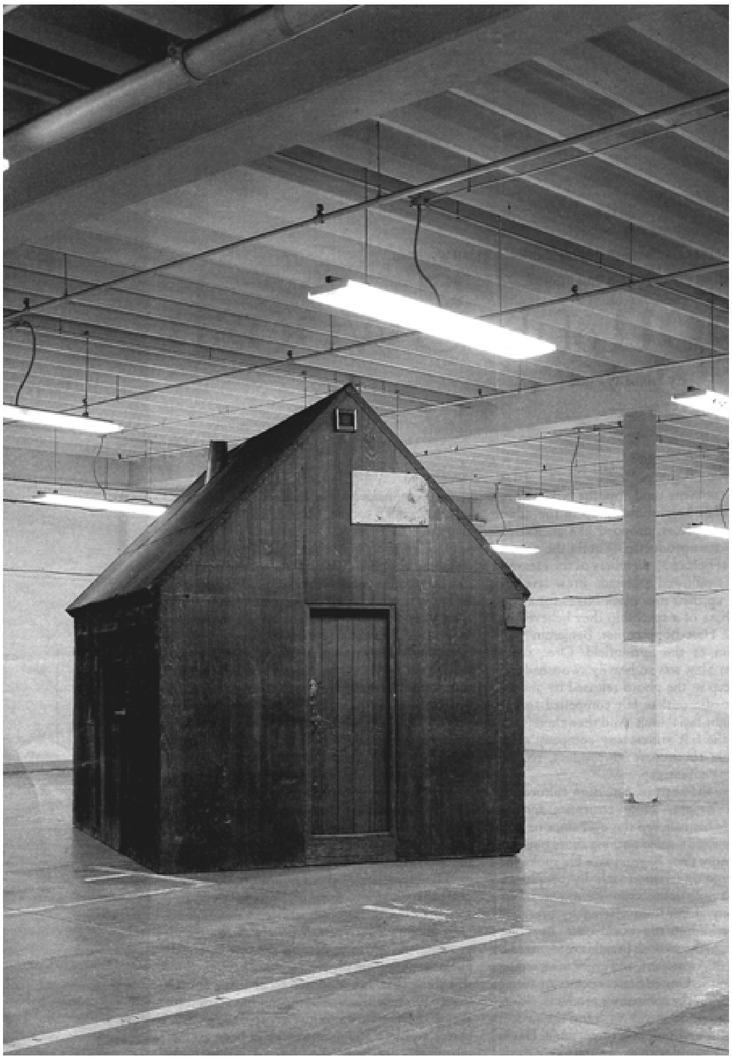


Fig. 2 For the trial of the *unabomber*, his cabin was removed from its site and assembled in a warehouse. This was done so jurors could experience what it felt like to live and work in this structure. What is incredible is that it was deemed necessary for jurors to experience the spatial qualities of his cabin to fully understand the conditions leading up to his crimes.

Architectural Record - February 1999, p. 241:
"Challenged to get real and get personal, architects who respond with designs that improve the quality of people's daily lives will not only have more satisfied clients but will improve their profession's public profile." If we insert the word process after the words ..."who respond with designs" isn't this addressing what we all believe in?

Fig. 3 ASG is a software manufacturer who obviously believes that we need to walk around inside our buildings before we build them.

New York Times - October 25, p. 24:
Here we live in an age in which there has been created a new "profession" called "life coaches:..and they advise their clients on how to reorient their lives to attain that happy ending. I see AES experiences in the same context, that in a way architects and designers are indeed these kind of life coaches, and an AES immersion will fully apply to this zeitgeist in which concepts such as entertainment, information, performance, individual, transformations are related to and nurtured.

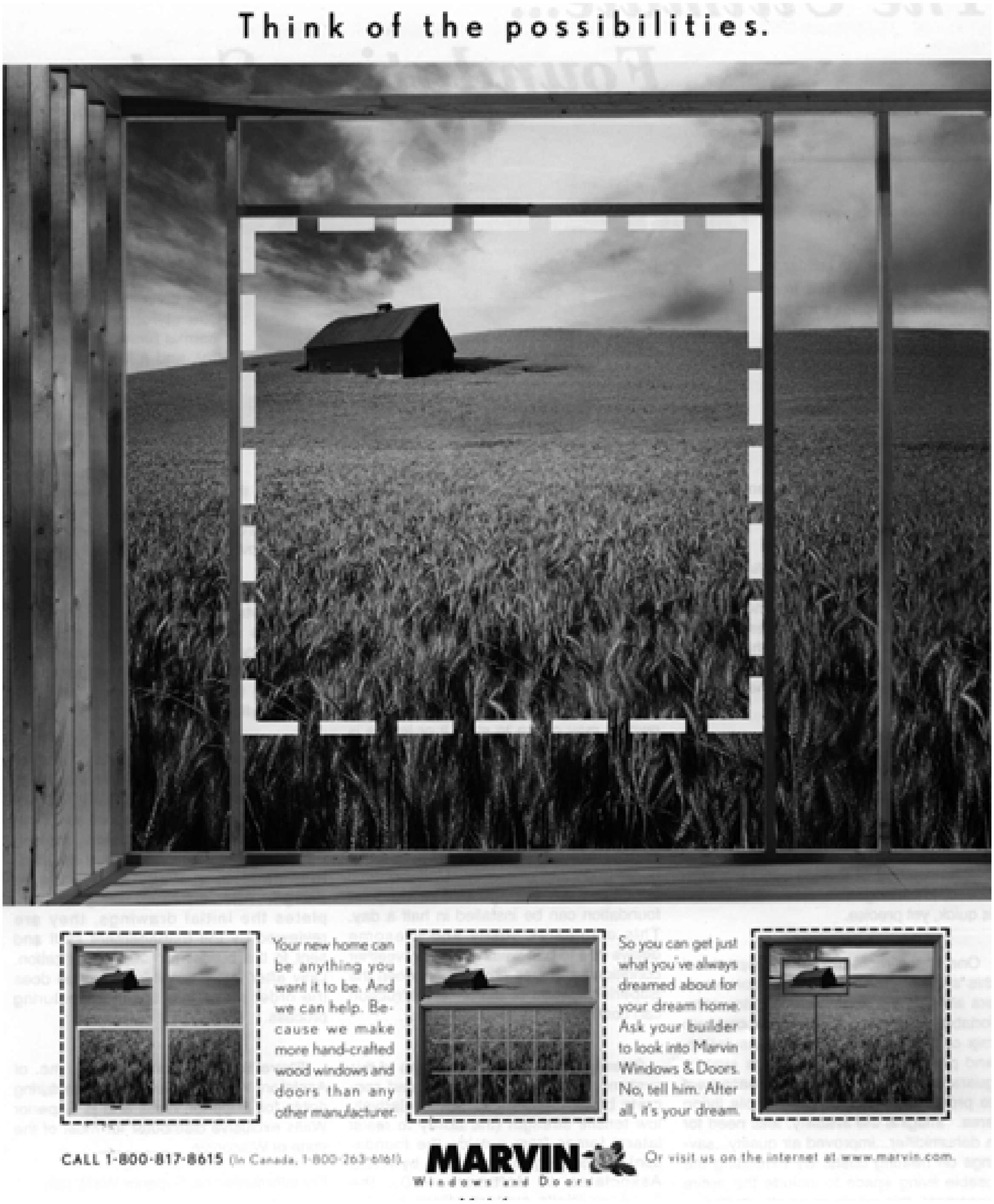


Fig. 4 Marvin Windows is a major US window manufacturer. They seem to believe that simulation of a window in a wall is the best way for their clients to decide on what to purchase. This image captures what all of our simulation efforts are about in a nutshell.

New York Times October 25 p. 24
Ralph Lauren has been cited as having given "the middle class what the upper classes and celebrities had always had: a conscious aesthetic." This aesthetic transference describes an AES experience.

Fig. 5 Roll the cabinets around. Arrange your kitchen any way you want. Understand what it is like to reach from the stove to the sink. All of this is possible at New Hearth's Protosite in Manhattan.

New York Times Magazine p. 66:
Jacques Herzog discussed his worldview, and the fact that he likes to run for exercise. And he notes the rise in the interest in bodybuilding , and goes on to speculate that this interest correlates with "the alienated state in which most people go through life-confined to their heads, cut off from their bodies." He states that architecture only has a future if it remains rooted in the physical. The AES is analogue, is physical, and is related more to architecture than is, say, quicktime walkthrus on a computer screen.

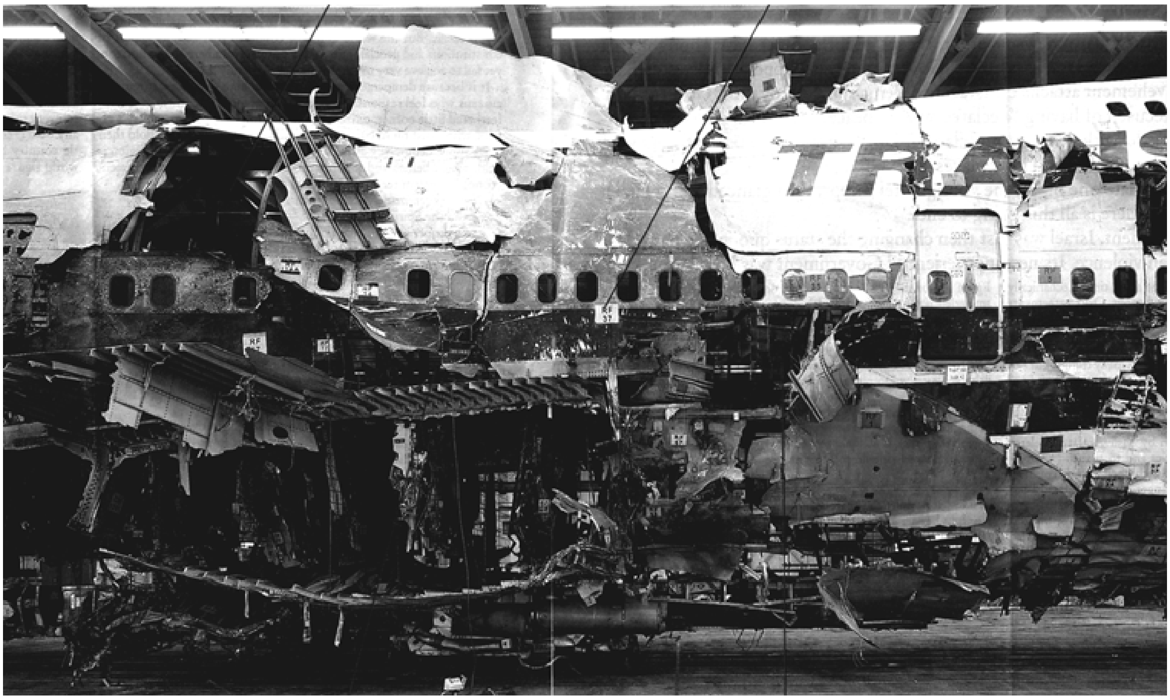


Fig. 6 Large photograph of TWA flight 800, reassembled in aircraft hanger in order to understand what happened to the airplane. Simulation to understand what happened vs. simulation to understand what is going to happen is the same [New York Times Magazine - 11 May 1997, pp. 38-39]

New York Times - 7 February 1999, p. 27:
Bernard Holland laments about the way that the performing classical music industry presents itself to the world. To more modern (and youthful) eyes, the classical tradition and concert looks ridiculous: where is the all pervasive entertainment aspect? He concludes that "Classical music has to trust in its material while at the same time divesting itself of the pomposity inherent in old rituals." Of course, the old rituals have an analogue in the architectural profession, and the AES will create the new formats. In essence neither the buildings nor the music will suffer.

James Marston Fitch:
In 1947 JMF wrote of the shortcomings of modern building. He saw the architect as being predominantly form conscious, principally as a result of technology...technology will solve anything so we don't have to worry about both nature as well as our sensory perceptions. He of course advocated the understanding of design in larger social and cultural contexts. I wonder what he would say about the potential of the AES system?

The Experience of Space in Full-Scale Models and Virtual Reality

Elisabeth Dalholm (Elisabeth.Dalholm@byggfunk.lth.se), Birgitta Rydberg-Mitchell, Roy Davies, Peter Warrén

Lund University (Design@Work), Sweden

Keywords: VR, CAVE, Full-scale Modeling, Design Tool, 3D-Modeling, Participatory Design

Abstract

Do we experience the size and character of virtual spaces in the same way as real spaces? What impact has the meaning of a space, i.e. furniture and other clues to the use of a space, on our experience of it? This paper describes an experiment where the participants could navigate through a room, first on desktop-VR, then in full-scale VR (in a CAVE) and finally in a full-scale model. In a first phase the room was empty and only defined through walls, windows and doors. Later on furniture was added as well as colors and textures. The experiment was a pilot study and threw light on some questions which we intend to develop in further investigations. It showed that the participants used building components like doors and windows and furniture in the presentation on desktop VR for their estimation of the size of the room. In the CAVE and in the full-scale model the participants' bodies were the measure for their estimations. The experiment also hinted at that color and texture had an impact on the experience of size.

Introduction

The experiment described in this paper was carried out within a research project called *Design@Work*, which contains a group of researchers and designers with a background in architecture, systems design, work psychology, educational drama and physical work environments. The project aims at developing design methods and techniques for participatory design. The common ground is that the methods and techniques should visualize aspects of present and future work situations and allow active user involvement. However, the main interest is not to develop new design tools but to test and combine existing ones. Various complementary tools are used like full-scale models, pedagogical drama and virtual reality. The research sheds light on how the tools should be combined, their main characteristics and qualities as well as their suitability for participatory design. The project is carried out through experiments and implementations in case-studies.

The main question addressed in this particular experiment was whether people experience a room in the same way on desktop VR, in immersive VR (here a CAVE1) and in a full-scale model. What cues do they need to be able to determine the proper size? Do they use building components, furniture and other cues differently in the three media? What impact has the meaning of a room, i.e. a known use of a room, on their estimation of the size? Does color and texture contribute to the experience of accurate size?

Design Tools in Participatory Design

Design@Work has its theoretical mooring within several research areas, one of which is design theory, in particular, the theory that describes learning and the design tool's role in participatory processes. According to Ehn (1988; 1995) the chief merit with participatory design lies in the fact that it is a learning process for all the participants. On the way, new knowledge is created and refashioned, aided by the designer's tacit design knowledge and augmented by the participant's tacit knowledge, which originates from the use of the environment.

The participant's experience is an essential ingredient in the design profession's development (Mitchell, 1993). The designer's task is to help the participants to specify their intentions and to clarify their choice of solutions in a shared discussion. The participants are aided in gaining insight about situations that are difficult to specify verbally. These experiences become a link to deployment and anticipation (Jones, 1978; Mitchell, 1993). The usage of a design tool is, according to Ehn, enlivened with its activation. The tool is a part of the design activity, a help in the verbalisation of the participant's expectations and to stimulate their creativity (Ehn, 1995; Stoeckli, 1995). The tool must allow both the contemplation of the design problem in an abstract way as well as being able to relate solutions to reality (Hornyánszky Dalholm, 1998). In the participatory context, this means that the design tools the participants use should help them distance themselves from the environments being used as the experimental backdrop as well as giving tools to build associations to them.

The insight that the tool gives depends mostly on how transparent they are, that is, how easily they can be understood. Ehn underlines the importance of the design tool in having a family likeness to the devices that the participants use in their daily lives. The success that has been achieved in projects where full-scale objects, mock-ups and prototypes have been used can be explained by this similarity. The deployment of this type of design tool means that the situation and environments which are forged are not merely attempts to verbally describe and picture a future usage of an environment, but rather a method of experiencing them through direct physical involvement. In the experiment described in this paper, the design tools were not used for design but for presentation. All the same the tools' qualities investigated were also adequate for this situation. Phenomenology underlines the great variety of people's perception and the impact of our bodies on how we experience the world. The body as the subject of perception implies that all our senses, not only sight, are important for our experience. The presence of our body gives the measure for the impressions that the surrounding supplies us with. The experience of architecture and space is complex and can't be represented fully by any tool/medium. Only when we enter the real space, move along in it, sense it with our body, we get the real conception of it and understand the nature of architecture. However, a combination of tools can give a more accurate view than each tool separately [7].

The Experiment

The experiment was carried out with four people with different professional backgrounds. All of them were experienced computer users and one of them was a professional designer. They carried out their tasks individually. The number of participants was due to the fact that the experiment was a pilot study. The tools used in the experiment was a desktop VR (with computer screen), a CAVE and the full-scale model at the school of architecture in Lund. The desktop VR was performed on ordinary PC- equipment and the spaces presented were modeled in a programme called Superscape. A 3D-mouse was used for navigation. The CAVE represents a type of VR called immersive VR. This type of VR allows the user to see the world from his or her own perspective with a one to one size ratio. The CAVE used is a room with size of 3x3x3 meters. The walls consist of screens where 3D-models are projected as well as on the floor. The subjects wear special high-speed liquid chrystal shutter glasses which create an illusion of depth. Navigation is performed with a dataglove. The rooms in the CAVE were modeled with AutoCad and 3Dstudio.

The full-scale model is a flexible modeling kit with wall-, window- and door-panels. The panels are easily put together by small pieces of metal. In addition to the building elements the kit includes kitchen fittings, bathroom equipment and some basic furniture. The hall used for full-scale modeling is 18 x 15 m. The room presented to the subjects was L-shaped and irregular in order to encourage them to move around to be able to form an overview of it. It had the size of a large Swedish living room (31 sqm) and the height of a normal flat in Sweden (240 cm). The subjects entered the room through a door placed close to one of the corners. There were three windows in the room.

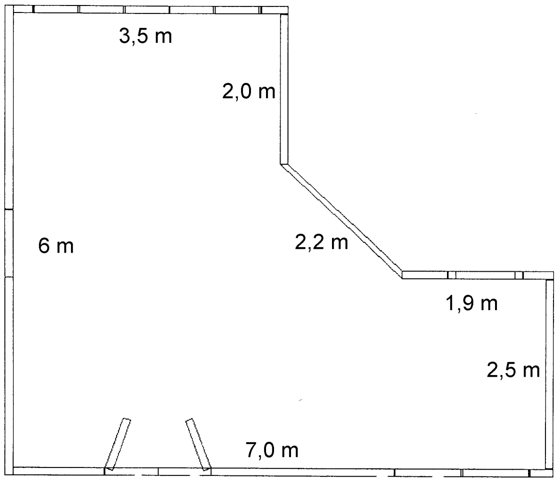


Fig. 1 The layout of the room used in the experiment.

The room-models in the CAVE were placed in an abstract environment which could be seen through the windows whereas no such view was visible from the rooms presented on desktop. The participants could experience the room first on the screen, then in the CAVE and finally in the full-scale model. The virtual presentations were made in four steps. In the first step the room was empty, in the second it was furnished for no obvious use (with a bathtub, a stove, a bed and so on) and finally furnished as a living-room with a dining table, sofa, TV and so on. In the last step color and texture was added both to the room itself and to the furniture. In the full-scale model this last step was omitted due to lack of time and appropriate material.

One of the researchers helped the participants to navigate through the room in VR. The participants could themselves decide the direction of the movement and when they should make a stop. They could also choose for how long time they wanted to remain in different parts of the room. Their movements were registered as well as their spontaneous comments throughout the experiment. Also the time the participants used to investigate the room was measured. After each step the participants were asked about their impressions and whether their estimation of the room's size had changed. Another question was how they decided the room size and what impact the furniture had on their estimation. They were also asked to indicate the dimensions of the room and the furniture in a simple sketch.

Results and Analysis

On desktop the participants tended to use building components like windows and doors as well as certain types of furniture (for instance the stove) to estimate the size of the room. Already at an early stage of the experiment they seemed to have a correct perception of the room's shape although their estimations of its dimensions were not quite appropriate. In the CAVE the participants were still more successful in their estimations of the dimensions of the room but they found it hard to decide the heights as well as the distance between pieces of furniture. In general they didn't use the furniture but their bodies as a measure. Some of them estimated the dimensions of the walls by stretching out their arms, others lay down on the floor to get the proper measure of the size. Some of the participants also mentioned that they used earlier experienced real rooms as a reference for their estimation.

Most of the participants estimated the room as smaller in the CAVE as on desktop. They also perceived the furnished rooms as bigger as the unfurnished ones. The measures of small parts of the room as well as the height of the windowbacks were rather difficult to estimate correctly on desktop.

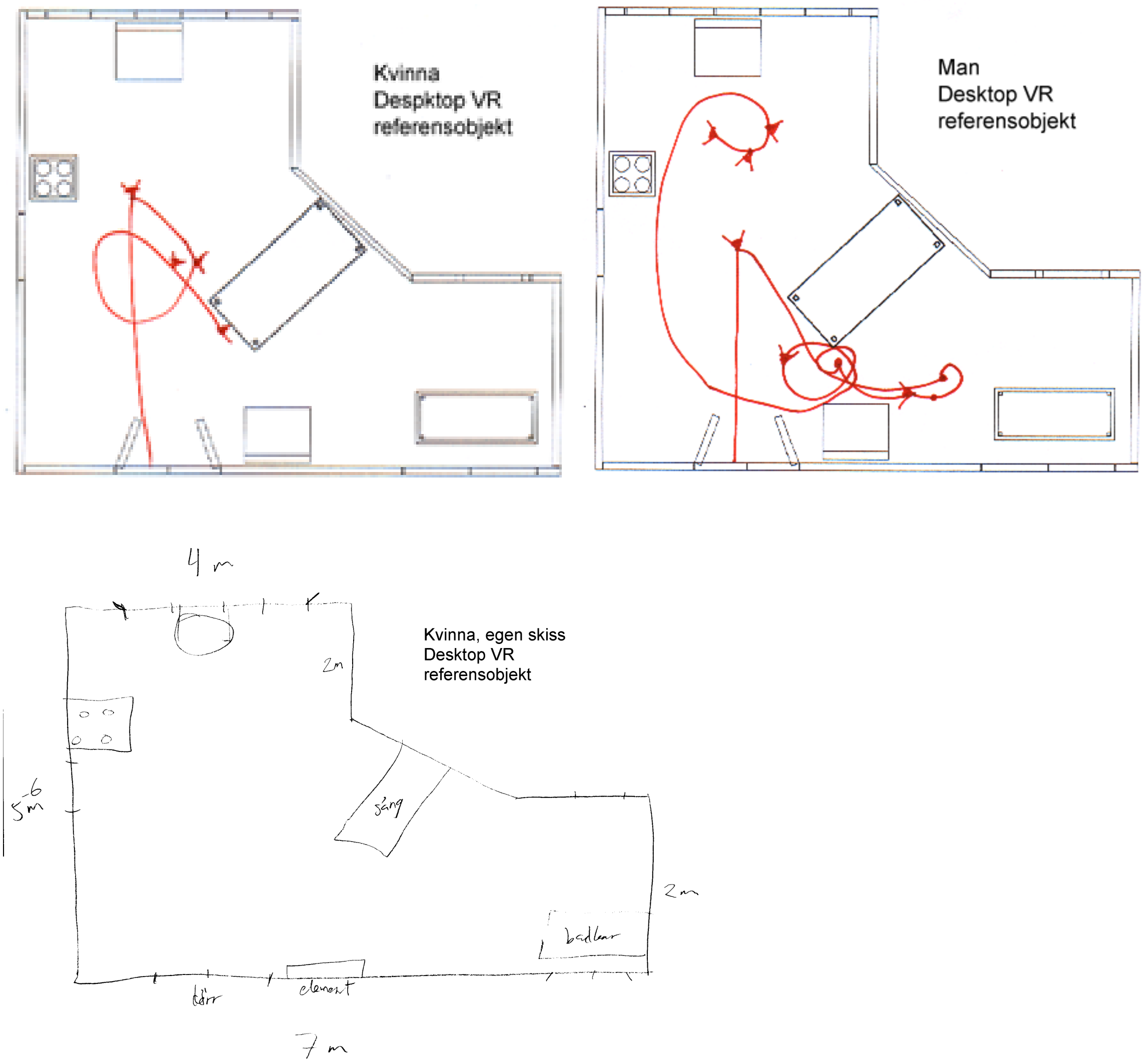


Fig. 2 Sketches made by two of the participants further to their visit to the room on desktop.

In the CAVE as well as in the full-scale model the participants' movement in the room turned out to be important for their estimation of its size. Also the empty space between pieces of furniture was more easily estimated whilst moving around. The individual pattern of movement varied. Some of the participants moved around in big circles while others remained rather stationary. Some turned around in the center of the room to get an overview while others stopped in certain spots for the same reason.

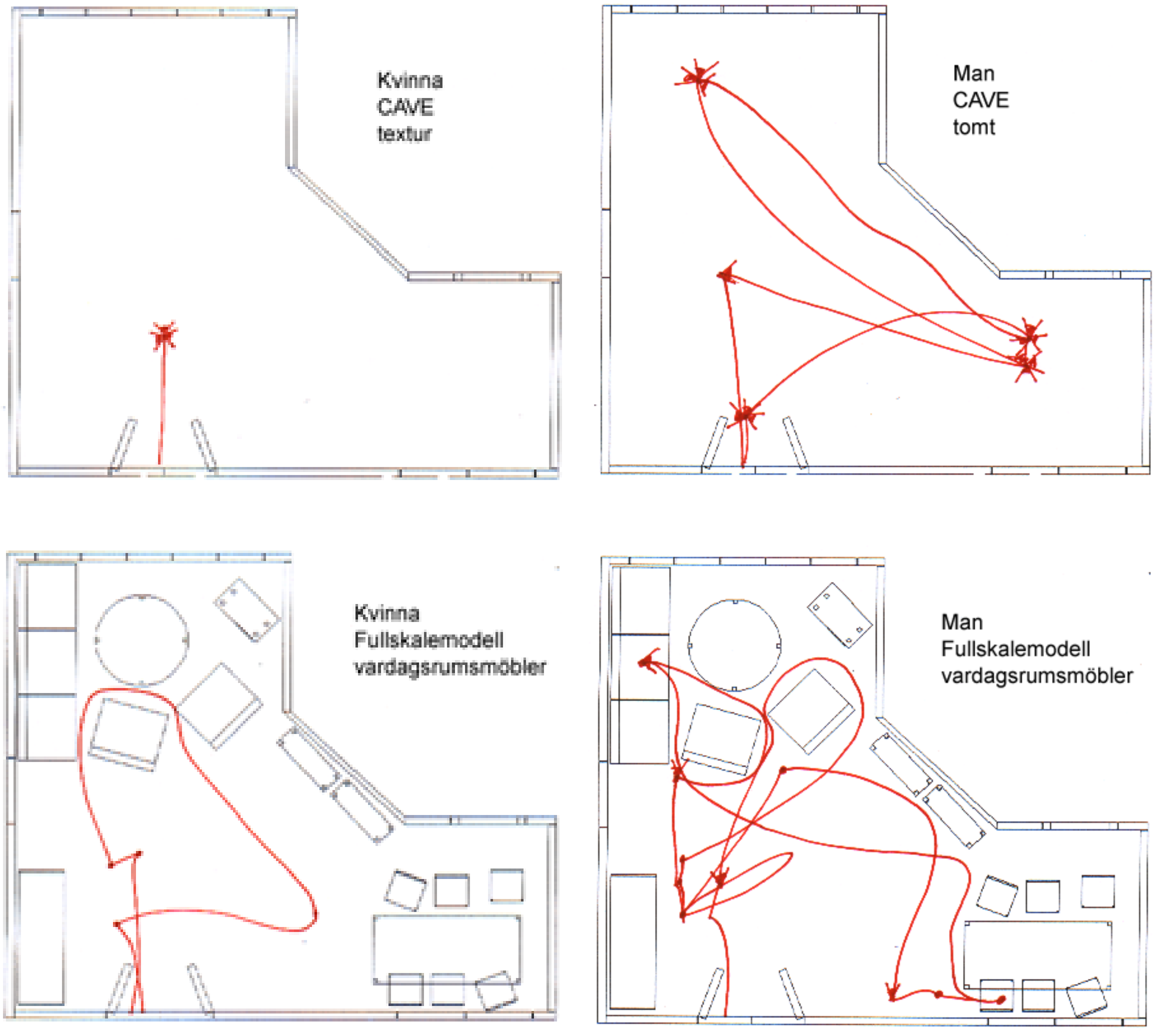


Fig. 3 Two of the participants' movement patterns illustrating the difference between individuals.

The participants identified the empty room on desktop differently. One of them suggested it to be an art gallery, others thought it could be a hotel room or a flat. As soon as the room could be identified with its use, the participants no longer used the pieces of furniture to estimate its dimensions but their knowledge about the reasonable size for that type of function, i.e. they used a conceptual idea of the space needed. Another experience from the experiment was that the participants' feeling of presence increased in the CAVE compared to desktop VR. However, the illusion of the virtual world was disturbed when they were confronted with elements from the "real" world like the joints between the screens or the researchers observing their actions. Additionally, the CAVE seemed to be a trigger for the participants' imagination and helped them to reflect on the use of the room. Some of them mentioned that they experienced it as "more real" than the room on the screen. They could sense the space not only visually but also for instance by listening to the sound of their own footsteps. The full-scale model gave their experience further dimensions, a feeling of substance. The room was experienced as a "real" room where they could sense the space like in the "real world".

Pieces of furniture presented on the screen sometimes were misinterpreted. In the CAVE the furnished rooms were estimated as bigger as the empty one. The pieces of furniture were perceived as more material than on desktop and the participants even made way for them when they were passing by. In the full-scale model the objects were loaded with meaning. Texture was less important, the objects still had substance. The design of the stove for instance gave the participants associations to a certain period. The pieces of furniture became more obvious and for instance the chairs were also used to sit on. The furniture was more material and gave the a more cosy feeling. The objects in the 3D-world were more obviously recognized as mockups and the participants didn't pay so much attention to them. Color and texture diminished the room on desktop and made it easier for the participants to navigate. In the CAVE colors and texture didn't change the experience of size but impeded navigation.

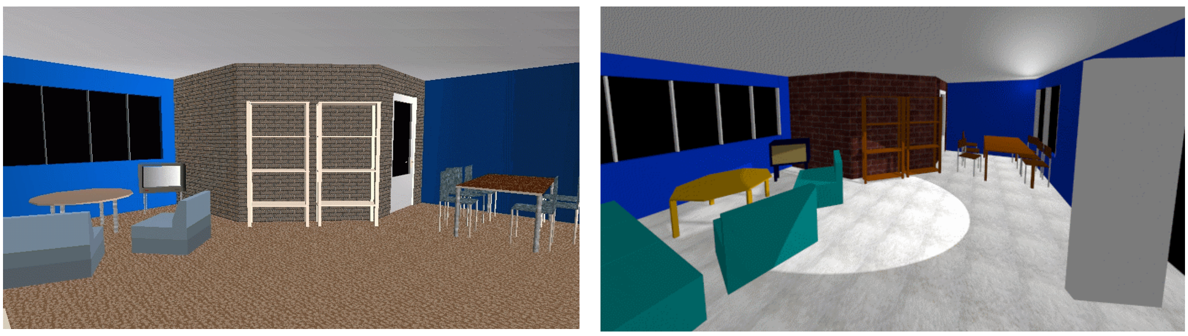


Fig. 4 The furnished room with colors and textures on desktop VR (left) and in the CAVE (right).

Discussion

Our conclusion from the pilot study is that the essential difference between full-scale modeling and the CAVE, on one hand and other design tools on the other is scale. They seem to allow the experience and usage of material and social space in a way that is very close to the experiences we have in "real" environments. Being physically present is not only vital for estimation of the room's dimensions, but also for comprehension of attributes such as proximity, connectivity and atmosphere. Participants have the chance to experience the modeled environments with "body and soul". Through visual experience and by moving through and acting in the environment, they tend to capture both the material and social aspects. In their judgement of the environments, the body can be used as a reference and the senses can be combined for the experiencing of various aspects of the environment such as form, lighting and roominess. If the design tool in participatory design shall promote experiences, action and reflection, we propose that full-scale modeling and CAVE ought to be combinable tools in these types of processes. Whether this is the case, we hope to explore in further experiments.

References

[1] Ehn, Pelle. *Work-Oriented Design of Computer Artefacts*. Stockholm: Arbetslivscentrum, 1988.

[2] Ehn, Pelle. *Design@Work - teori om deltagande artefakter, kompetens och lärande i designprocesser* [Bilaga 1 till projektansökan Design@Work - en förändringsverkstad för brukarorienterat gestaltande av framtida arbete och ändamålsenlig teknik]. 1995.

[3] Hornyánszky-Dalholm, Elisabeth. *Att forma sitt rum. Fullskale-modellering i participatoriska designprocesser* [Akademisk avhandling vid institutionen för byggnadsfunktionslära]. Lund, 1998.

[4] Jones, Christopher. In: Mitchell, Thomas (1993). *Redefining Designing. From Form to Experience*. New York: Van Nostrand Reinhold, 1993.

[5] Mitchell, Thomas (1993). *Redefining Designing. From Form to Experience*. New York: Van Nostrand Reinhold, 1993.

[6] Stoeckli, Hans Peter and Weber, Benz. *Zum Unterricht im LEA 1985-1993* [DA-Informations 149]. Lausanne: Ecole Polytechnique Fédèrale de Lausanne, 1993.

[7] Zevi, Bruno. *Architecture as Space*. New York: Horizon Space, 1957.

Application of Spatial Design Ability in a Postgraduate Course

Isaac Abadí Abbo (iabadi@ceea.arq.ucv.ve)

Universidad Central de Venezuela (LEE), Venezuela

Keywords: Spatial Design Ability, Architectural Space, User Evaluation, Learning

Abstract

Spatial Design Ability (SDA) has been defined by the author (1983) as the capacity to anticipate the effects (psychological impressions) that architectural spaces or its components produce in observers or users. This concept, which requires the evaluation of spaces by the people that uses it, was proposed as a guideline to a Masters Degree Course in Architectural Design at the Universidad Autonoma de Aguascalientes in Mexico. The theory and the exercises required for the experience needed a model that could simulate spaces in terms of all the variables involved. Full-scale modeling as has been tested in previous research, offered the most effective mean to experiment with space. A simple, primitive model was designed and built: an articulated ceiling that allows variation in height and shape, and a series of wooden panels for the walls and structure. Several exercises were carried out, mainly to experience cause -effect relationships between space and the psychological impressions they produce. Students researched into spatial taxonomy, intentional sequences of space and spatial character. Results showed that students achieved the expected anticipation of space and that full-scale modeling, even with a simple model, proved to be an effective tool for this purpose. The low cost of the model and the short time it took to be built, opens an important possibility for Institutions involved in architectural studies, both as a research and as a learning tool.

Introduction

The Universidad Autonoma de Aguascalientes in Mexico decided to offer a Master Degree Course on Architectural Design starting September 1998. They consulted our web page describing the activities of the Centro de Estudios del Espacio Arquitectónico (CEEA) and showed interest in working together in the framework of the Course. Two members of their Centro de Ciencias del Diseño y de la Construcción visited Venezuela and appraised our work specially on the use of full-scale modeling as a research resp. learning tool. They proposed a joint venture choosing as a guideline to the Masters Degree Course our experience in relating *Environmental Psychology* and

Spatial Design Ability with architectural design, which means to consider the user as a decisive factor in the evaluation of the effects (psychological impressions) of architectural space.

Postgraduate Course and Participation of CEEA

This course, which is the first one offered by the Universidad Autonoma de Aguascalientes, lasts for four semesters. The first semester is intended to provide students with basic knowledge about the role of the architect as interpreter of the needs of the user, i.e. about the interaction between man and architectural space and about the importance of the user as a factor to be considered in the appraisal of spaces. The other three semesters consist of a series of exercises of growing complexity in which extensive research is carried out on spatial quality and character of buildings. There are a number of theoretical subjects and a Design Workshop (4 semesters) - in which theory and research are used - supported by appropriate models and evaluation techniques, in such a way that the students acquire competence in intentional design.

The CEEA was responsible to provide the theoretical background, relating architectural space and the user as well as the Design Workshop during the first semester, which took place between September and December 1998. The exercises proposed for the first semester the manipulation of different types of models in order to experiment with variables such as textures, openings, forms and details. Full-scale modeling was indispensable in exercises of *Spatial Design Ability*, because the evaluation had to be performed by people different from the designer and variables as real dimensions, scale, proportions and lighting had to be perceived as similar as real spaces as possible. A simple, rather primitive full-scale model was proposed and built in one of the buildings of the University. It consisted of:

- An articulated ceiling made of light wooden frames covered with canvas (6x6 m) and a maximum height of 3.20 m. Its movements are controlled by 6 pulleys and allow variations in height, slopes and shapes;

- A series of hollow wooden panels: 16 columns of 0.3x0.3x2.8 m, 8 panels of 0.3x0.9x2.8 m and 8 panels of 0.3x1.5x2.8 m. They were provided with wheels to make easier its manipulation. This model only cost $2500 and took less than a month to be built and installed.

First of all, psychologist Luis La Scalea (member of the CEEA-staff) gave a series of lectures on Environmental Psychology. The objective was to provide students with research methods (e.g. observation, interviews and evaluative research), psychological processes (e.g. perception, cognition and evaluation and regulatory processes (e.g. privacy, territoriality and attachment).

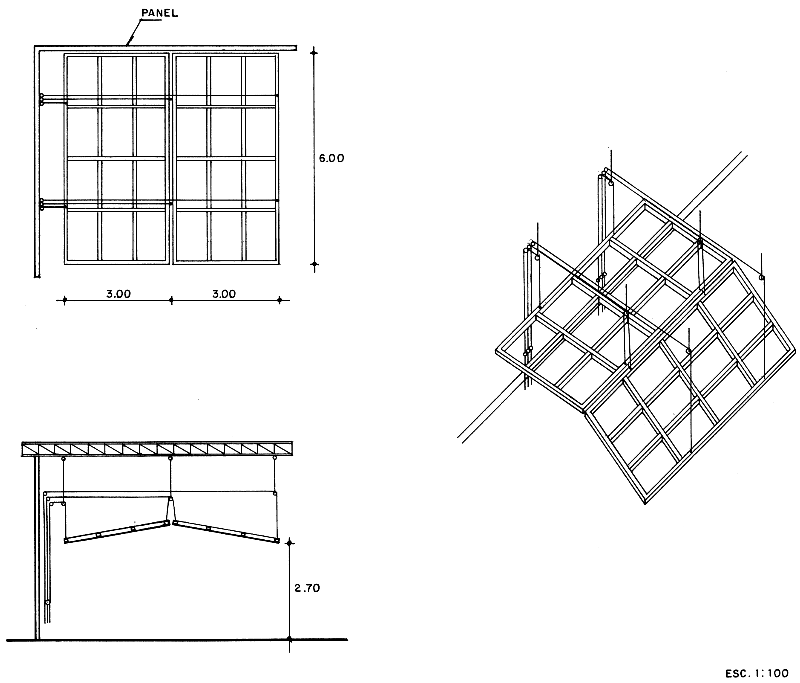


Fig 1 Articulated ceiling

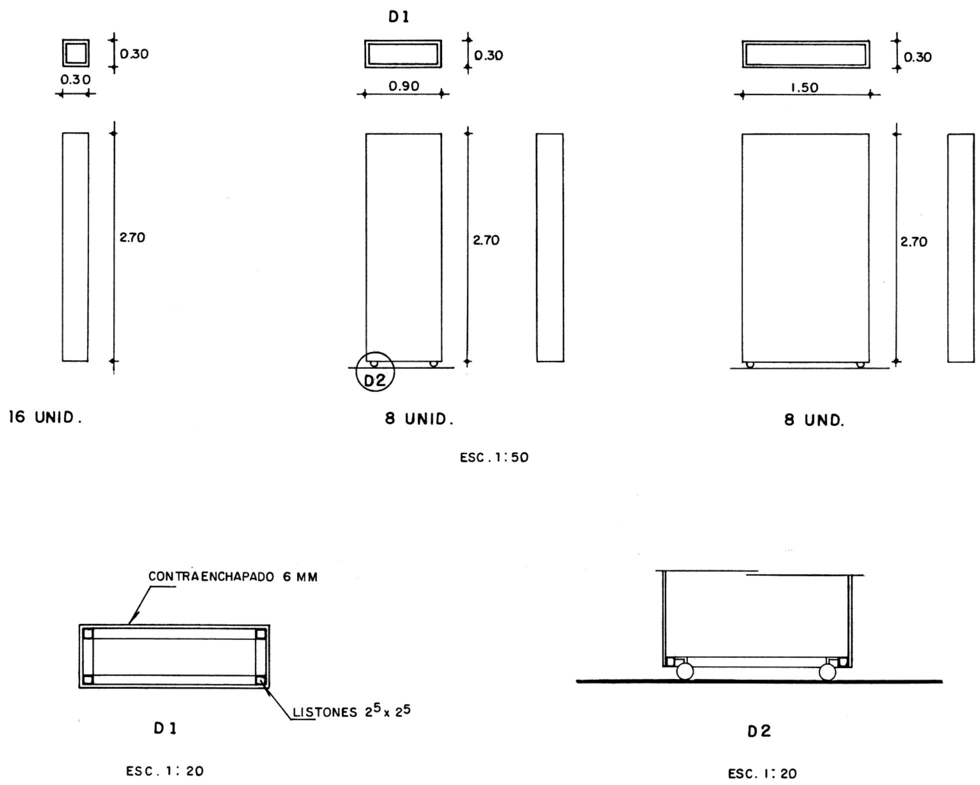


Fig. 2 Modules.

Then the author joined the team to continue with the theoretical background and to start the Design Workshop; Lesmes Castañeda joined him in the second week. The theoretical background referred to *Spatial Design Ability* in terms of visualization, evaluation, conjectures, experiments and concepts as well as architectural space with its components resp. characteristics. Two exercises were carried out on visualization using drawing as models. Then, the participants appraised the classroom using the IMIP (Instrument for Evaluation of Psychological Impressions) and modified it according to the evaluation. Later on research into four types of spatial character was conceived: serenity, dynamism, mysticism and chaos. Graphic material describing the character was presented and after that a space with this character and solutions were appraised by a sample.

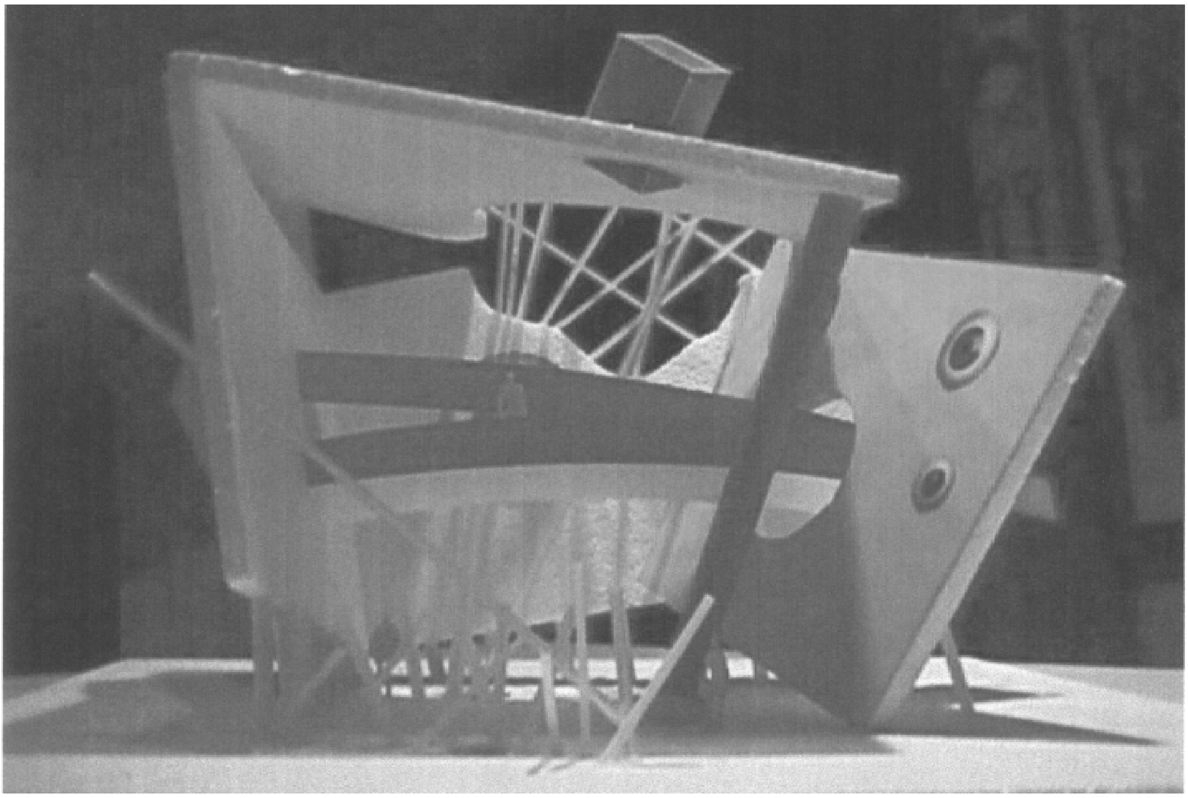


Fig. 3 Chaotic space.

Now the participants started to research on volume and proportions and had to counter following questions:

- Which dimension (height, width, length) affects more the impression of size or volume?
- How can one change the perception of a room so that it may seem lower, higher or wider?

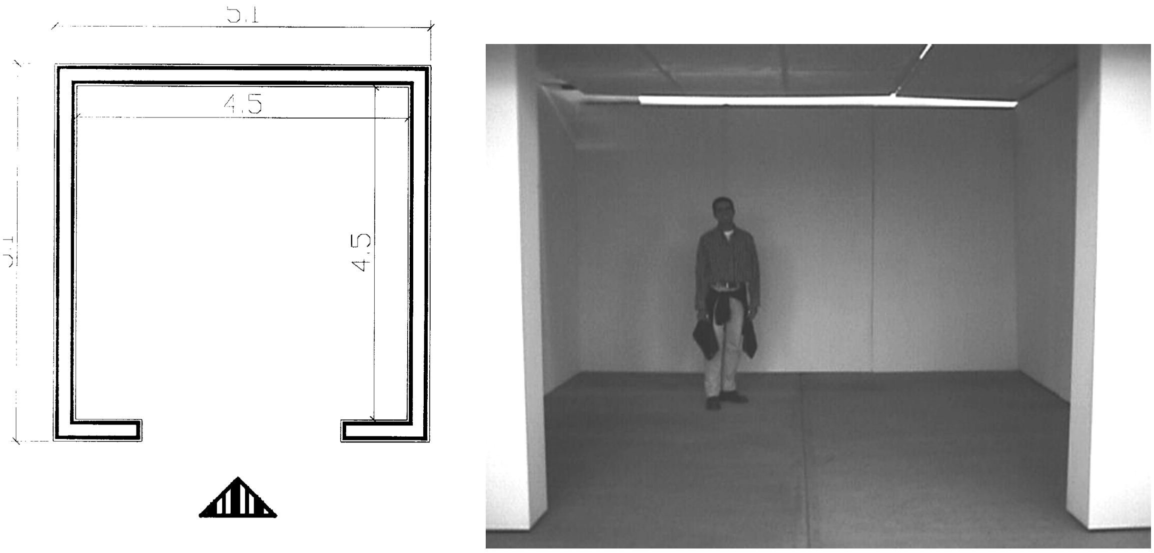


Fig. 4a-b Proportion 4,5 x 4,5 m.

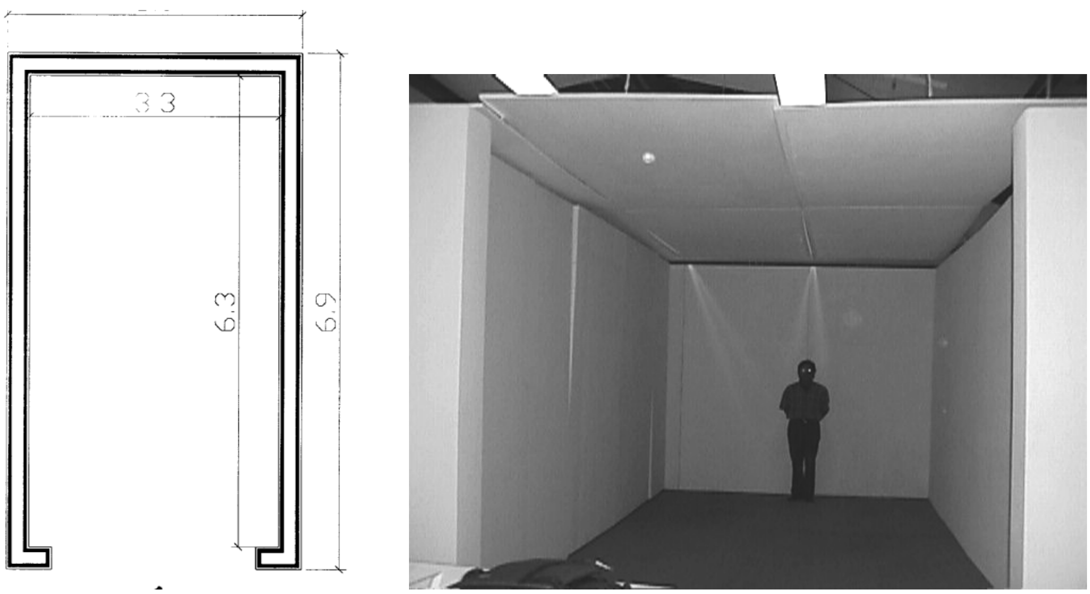


Fig. 5a-b Proportion 3,3 x 6,3 m.

Form and pressure were investigated by means of regular and irregular forms, corridors and virtual spaces. The participants finished three further exercises discovering thresholds and how they affect psychological impressions.

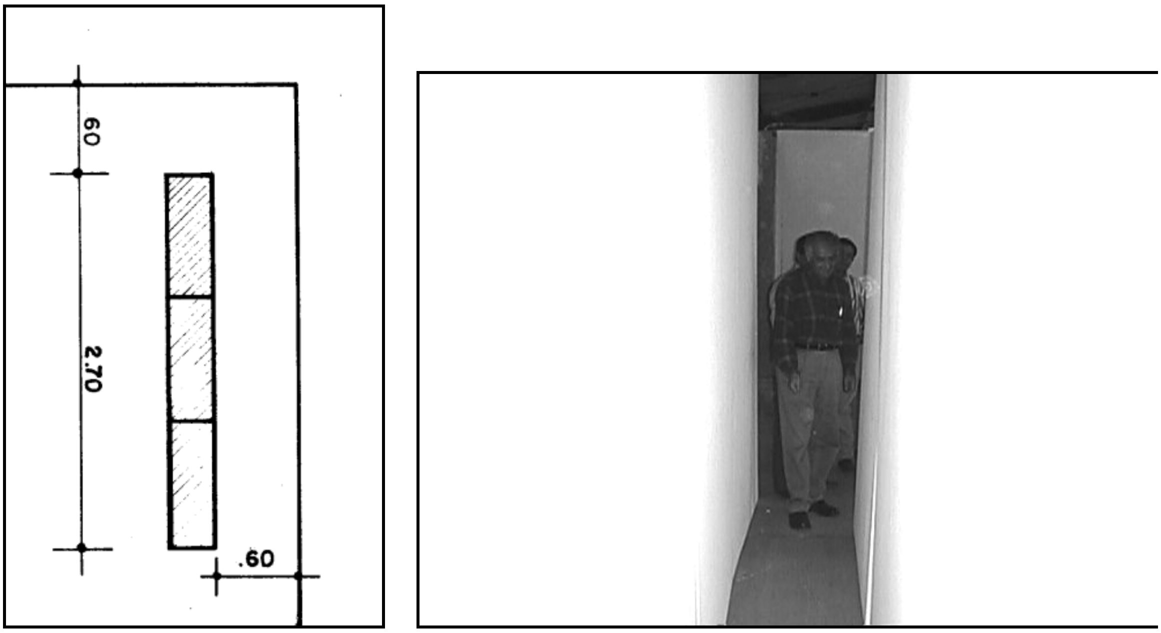


Fig. 6 Corridor 0,60 m wide.

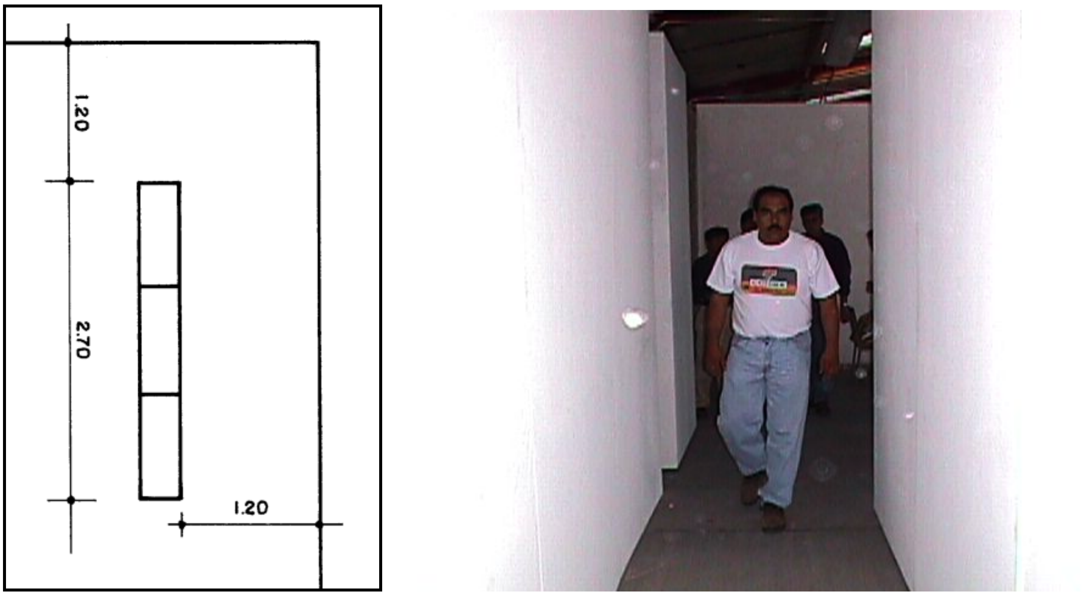


Fig. 7 Corridor 1,20 m wide.

After that spaces with different characters were designed introducing following topics: “dynamic and mysterious” resp. “static and mysterious”.

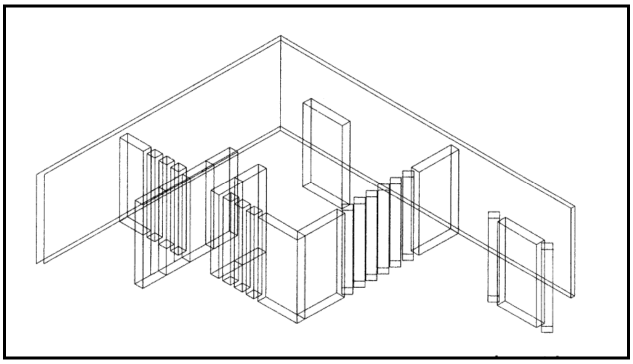



Fig. 8 Static - Mysterious.

As a summary of these experiences on architectural space and *Spatial Design Ability*, the participants had to design and evaluate a particular space, in this case a dining room in a Benedictine convent.

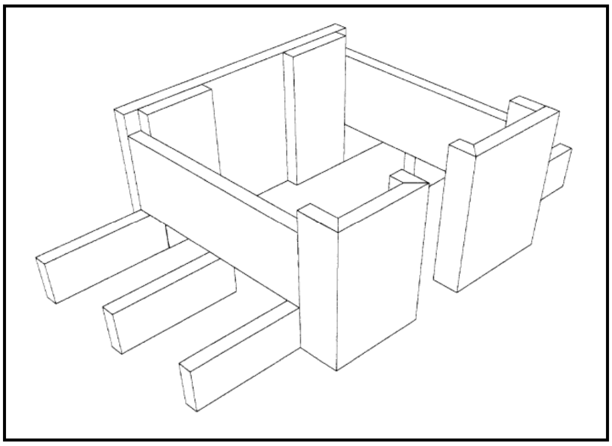



Fig. 9 Benedictine refectory.

Conclusions

Although the group of students (14) were all educated as architects, some of them (6) with already a Masters Degree diploma and extensive experience in architectural practice resp. teaching, they recognized that concepts such as *Spatial Design Ability*, *Environmental Psychology* and *Full-scale Modeling* were new to them. They, however, prove very useful for the purpose of evaluation of space by groups of people in order to allow constructive confrontation between their anticipation of how the spaces were going to be appraised and how the users actually perceived them. The exercises were rather simple but also very demanding, due to the need to elicit concepts that could be useful in their architectural practice.

The participants stated that the full-scale model, although primitive and with many limitations, acted as a powerful tool to investigate cause-effect relations between architectural space, its components and characteristics and the impressions they produce in the people's mind. At the end of the experience, they proposed certain changes in the model in order to make it more effective, mainly cutting the columns and panels so that they could have heights of 2.20 m and 2.70 m. Also to build other components as windows, doors, sills, beams. It would be very interesting to incorporate color by artificial lighting in the model. The low cost of the model and the time it took to be installed make it possible for many schools of architecture or research centers to possess this effective and indispensable tool.

Working on Icons - Learning from Simulation

Wolf-Michael Tschuppik (tschuppik@hotmail.com)

Vienna University of Technology, Austria

Keywords: Full-scale Simulation, Architectural Design, Perception

Abstract

This contribution aims at making simulation understood as an interpretable medium. To this end the individual components of simulation are regarded as three-dimensional icons, which issue a "blurred" and thus interpretable image when put together. The title-providing learning potential has been developed in line therewith by the author.

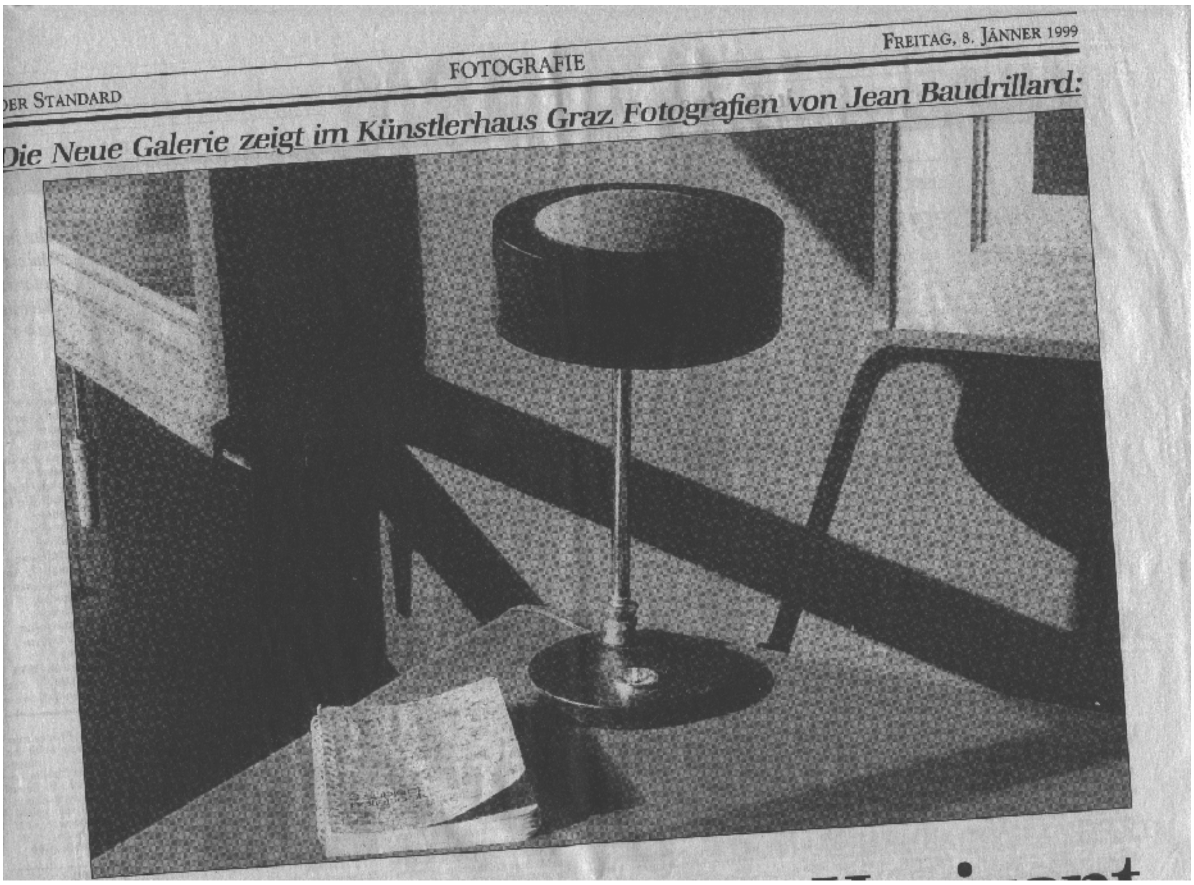


Fig. 1 Baudrillard Table/Lamp.

On preparing this contribution the culture pages of magazines were full of photos by Jean Baudrillard, hitherto only known due to this philosophical writings. According to Baudrillard photos are the only means of releasing motionless objects from the hectic and noisy world. The selected pictures doubtlessly impress by their contemplative, stoical tranquility. Time seems frozen in the pictures.

Fig. 2 Baudrillard Car/Mast.

Photography is simulation, both in accordance with a reproduction, a reproduction of reality - in this special case an American suburban scenery - and with making-belief, here in particular being completely motionless. Simulation always results in parallelly providing less information. Simulation represents merely a special segment of reality we know. In viewing the world through the windshield of a driving car we experience a simulation of our world. Baudrillard`s pictures show us on the one hand well known things, simultaneously, however, disclose completely new interrelations. In their distant artificialness and restriction things of everyday life are governed by a new world order, naturally under the provision that we are willing to register these. In semiotics the term simulation represents icons. In the world of our symbols the category becoming readily comprehensible by means of affinity to an other known object is referred to.

When we spot a so-called icon on our Windows or Mac-User Screen the entirety of our perceptive faculties are activated. We immediately rely upon all our experiences made, all perceptions gained in order to grasp the meaning of this “tiny” symbol. It can happen that the one or the other little icon remains untouched in a corner, as we do not manage to grasp it or no resemblance to a reference object occurs to us. By the way: this problem the NASA had to deal with, too. Let`s leave our well-known planet earth and enter into the world of ideas of possible extraterrestrials.

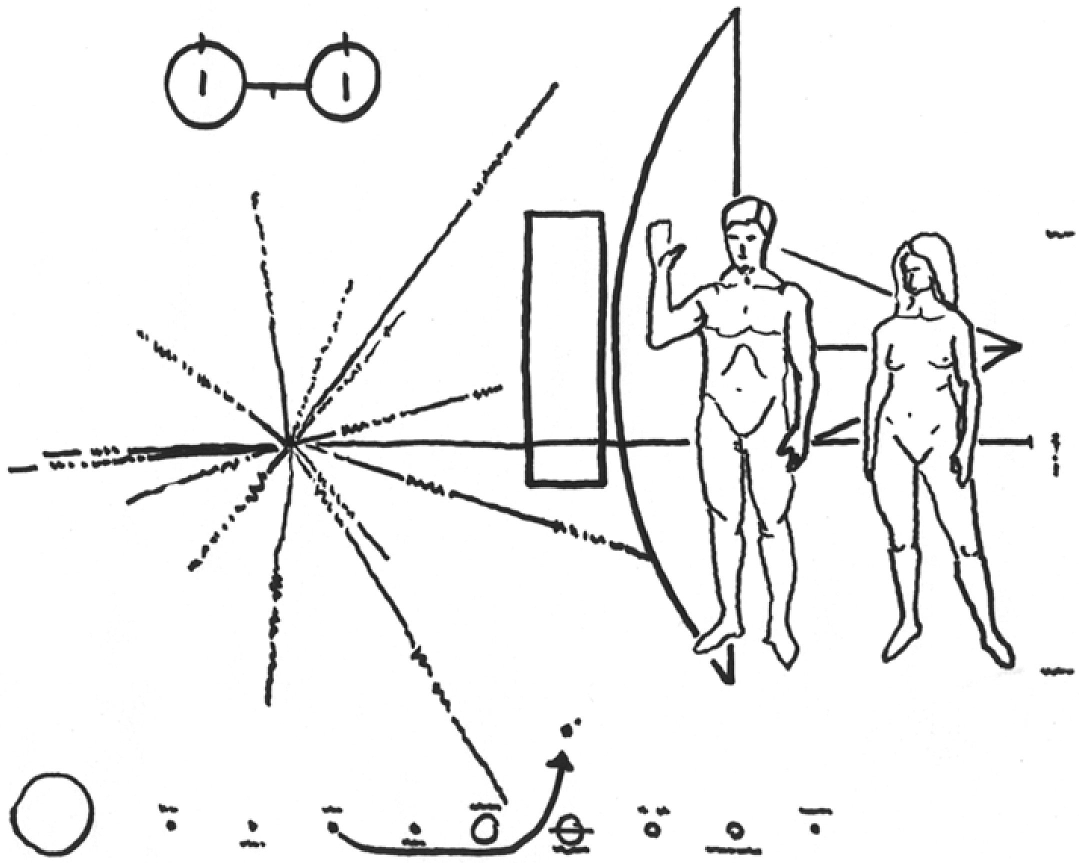


Fig. 3 Nasa Message.

Here is the visible message sent into space by scientists with every confidence, - but alas! -it also includes a very interesting detail regarding the symbol category of icons apart from various other problems in illustration.

May we hope that extraterrestrial cultures are familiar with hunting using bow and arrow, otherwise the depicted sign, an arrow head with curiously a damaged bent arrow rod could surely not be understood, thus the allocation of the human being to the appropriate planet would not result. It would, however, clearly explain why we still are lonesome in going round in circles through the solar system.

Dealing with icons requires fore-knowledge or experience in order to make head or tail of the scope for interpretation. But even relying on such previous knowledge we can readily be manipulated thinking we are aware of what others want us to see. This factual situation is clearly pointed out by a simple psychological demonstration.

In an experiment an X with a horizontal line above and below it was furnished together with one of the two terms: table and hour-glass. In reproducing the symbol it was observed that the sign differed in shape according to the term indicated. The term table made the lower horizontal line disappear, the hour-glass turned the crossed lines into curves. Consequently, dealing with simulations is subjected to the complex processes of perception, influencing and subjectivity thus seem inherent. Creation of simulation calls for a certain degree of abstraction whereas reading simulation requires interpreting. The weapon made up of arrow head and rod became a horizontal line with a triangle at its end. In two-dimensional representations of simulation the outlines of a weapon were readily available for simulation purposes, regarding three-dimensional representations this is not achieved as easily. The three-dimensional outlines of a house, i.e. a kind of a wire model, would only be made out as a house with difficulties. After all, a house consists of a certain number of walls, equivalent to surface, equalling heaviness, thus all in all a haptic experience. A house invites to be walked around and spatially and sensually impresses on our world. The architectural 1:1 simulation thus has taken on a great challenge. A brief survey through the world of simulation in full scale might prove meaningful in enumerating the tasks attached to this endeavour, would, however, quickly reach beyond the scope of this paper.

Therefore, let`s pick one example to demonstrate the basic problems involved: Here we are dealing with a simulation combining two leading architects from, however, different epochs, one being Mies van der Rohe and the other one the Dutch urbanist, theorist and star-architect Rem Koolhaas. A peculiarly anecdotic essay “The House That Made Mies” is included in his extensive work and theory-report “S,M,L,XL (Small, Medium, Large, X-Large). The title first suggests a possibly varying relation between objects and their creators, but that’s not all. Behind the play of inversion Kohlhaas develops the notable theory that Mies van der Rohe had anticipated elements characterizing only his significantly later works such as flowing, disappearing and continuance already in a true-scale architecture model of his early years. The ideational experiment culminates finally in a practically evolutionary deduction of the “curtainwall”, at the beginning and origin of which the above canvas model is said to have been. A 1:1 simulation thus is pronounced the trigger for one of the most sustainable developments of our century. At first sight the considerations seem too daring to be taken seriously, the excitement accompanying such a theory, however, encourage us to look into the possible misleading configuration. One surely would assume that an object of such major significance had already been subjected to a series of analysis, but far from it!

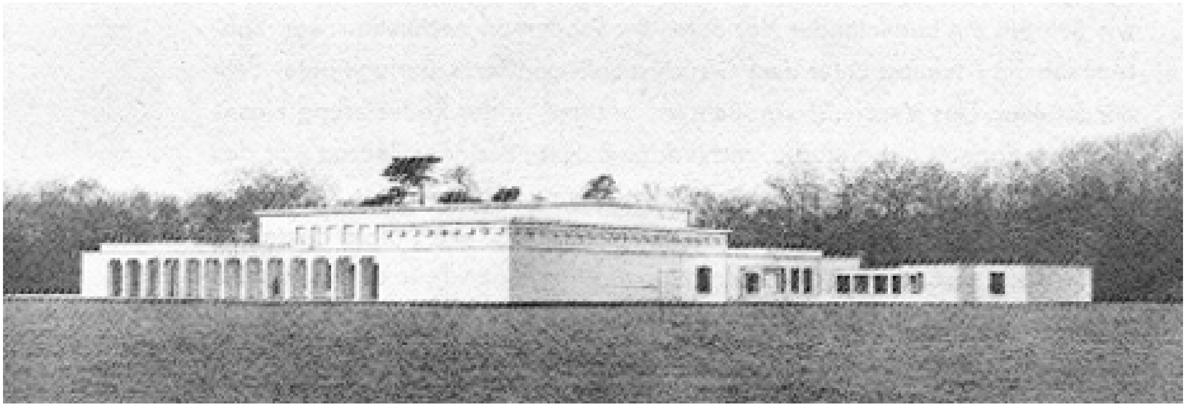


Fig. 4 Simulation in True-Scale/Mies v. d. Rohe.

The early project, Mies being no more than 26 at the time, has received hardly any attention. The only useful document thereto is a photo of the 1:1 simulated design, now owned by the Museum of Modern Art. Koolhaas registers the first "fleetingness" and "ease" famous for Mies' later buildings in the described architectural "Fata Morgana". On looking at the well-preserved black-and-white photo nowadays it seems amazing that the depicted object obviously never really existed, i.e. in reality in stone, as architecture is used to . Let us imagine ourselves back 85 years to the spot where the photographer must have stood to take the picture. In our thoughts we slowly approach the building. The silent photography gains in liveliness with every step. We may assume that spreaded canvas blows in the wind even if very well attached to the wood scaffolding. A look at the trees in the background tells us the season of year. The natural environment looks bleak, practically inanimate. Thus the cloth construction will seem far more lively to the viewer. The wall continues its silent struggle to get away from the supporting frame. Did this metamorphosis of such significance to architectural history begin on a misty, rainy day in fall?. Let's have a look at the relevant circumstances. The photographer could not help but suppress the external marginal conditions of simulation. The soft cloth walls turned into stone outside walls in his eyes and the wrapped up slat cage to elegantly proportioned rows of colonnades. How did the young Mies perceive the construction, did he also register to any extent what was being simulated or did he enjoy the peripherally existing simulation parameters. Mies surely delighted in good workmanship and he knows as to the processes of building and thus is capable of aestheticizing the individual intermediate steps.

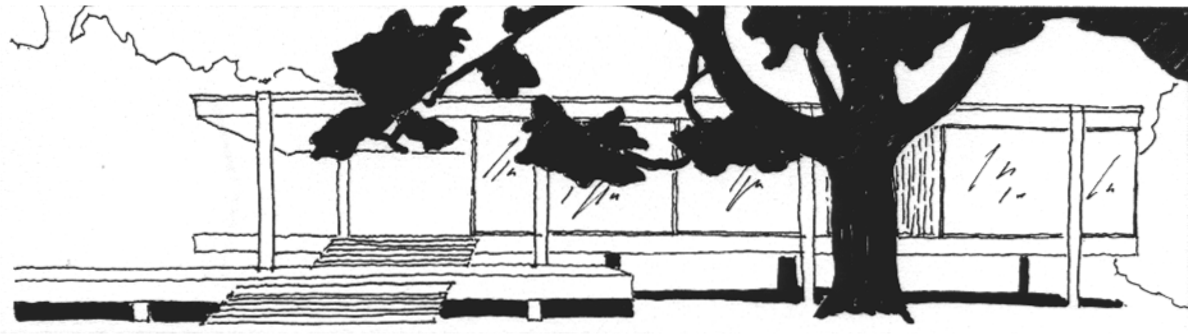


Fig. 5 House Farnsworth.

Later in chronology: Having a look at the later work of van de Rohe, the House Farnsworth, we would surely discover the results of creative processes throughout the years aimed at simulating architectural configurations. The scaffolding is now completely exposed, whereby the challenge of interpretation regarding the object existing merely for a short moment in time is even more likely to take its course. We delight in analyzing and certifying the same sensitivity to our prototype as to the temple of residence based on the pedestal. Regarding the rather peculiar story the question as to the actual significance of a simulation of “reality” as described above arises. Considering the fact that Mies continued building for a decade after the model of the House Kröller-Müller without taking a single of the supposedly discovered aspects into account ideas of changes resulting from a solitary case seem insignificant. It cannot be denied, however, that certain characteristics of that peculiar prototype might have produced specific consequences of a certain nature regarding the architectural work of the architect. As explained in above simulations of Baudrillard it is the interpretability that matters. To discover the “curtainwall” in the model involves a distant and somewhat neutral approach in viewing the simulation. Strangeness is required. As already pointed out by Philostratus nobody would be able to understand a painted stallion of bull without knowing about the actual appearance of such. And we have learnt to read the Impressionists` patches of coats of paint as a picture, the same as we are capable of identifying the arrow nowadays, as we know of its origin.

We always approach simulation with our full range of experience. We enter the site of reproduction and make-belief with a varying knowledge of rules and icons. As has been observed, simulation comprises working with icons, and, consequently the interpretation space related thereto. Finally, simulation does not exclusively take place in line with the specific preceding abstraction. In the course of the final interpretation of simulation just as much meaningful potential develops. The fuzziness and the omnipresent ambiguity of signals add to the development of creative interpretation and association.

The procedure described above deals with an approach to the challenge of interpretability of simulations in true-scale acting as a basic guideline to the subject of the publication “The Other Reality - Gestalt of True-scale Simulations in Architecture” [1].

Reference

[1] Tschuppik, Wolf-Michael Oliver. *Die andere Realität - Zur Gestalt der realmaßstäblichen Simulation in der Architektur*]. Vienna: Österreichischer Kunst- und Kulturverlag. 1998 (IRIS-ISIS-Publications at ÖKK-Editions - Vol. 6).

Appendix I - Workshop "The Erection of a Full-scale Laboratory at the University of Florence"[1]

Bob Martens and Wolf-Michael Tschuppik

Vienna University of Technology, Austria

Frame Conditions

The planning work erection of a full-scale and light laboratory principally is to be regarded rather a prototypical matter. The workshop was aimed at defining the basics regarding the many questions arising as well as those not even properly identified, thus issuing a pool for ideas to carry on with and consequently to be made available to those concerned with the erection. The more open-minded the thinking tank the more potentials would be furnished to the “next generation”. The interactions of space, light and color could be finally studied and checked in full-scale within realistic conditions. The participants to the conference all of which being well-acquainted with the work in and at such a lab inevitably concentrated on the question as to the planned focus of work and subject scope. The cooperation between a lighting company and the university seems to narrow down the subject matter from the very beginning. As the prime interest is the work with light the proportion dedicated to building as such would bound to be lower . But what is light without the accompanying room. The language of light certainly requires the “paper” where the plot is to be written.

Florence is a city full of history practically making erection of such a laboratory impossible within the city center. Thus is seems pretty logical to consider the re-utilization of a disused building. Erection costs would be affordable also living up to the omnipresent preservation of historical monuments.

Location and Facilities

Which position within the urban structure should such a laboratory obtain? The restrictive regulations regarding protection of historical entities force a lab to be erected in the down-town area behind the walls of an already existing building. Thus the lab would certainly have to be integrated into present substance. A new building would doubtlessly have to be drawn up at the

---

[1] The local Florence lighting company Targetti was particularly interested in the idea of arranging a workshop in order to gather the basics - more or less basic parameters - for a laboratory to be erected in Greater Florence to be financially supported by the Targetti company, the administration and teaching aspects of which to be taken over by the University of Florence. This Appendix attempts to briefly document the discussion topics. Special thanks to Volkher Schultz whose suggestions submitted in writing were gratefully integrated in this paper.

outskirts of the city. Due to the fact that the university in the city center would act as the operating authority of such an institution, the alternative at the outskirts does not prove wise, as it is the direct vicinity to the operating authority that makes for intense utilization. Considering integration of the lab into existing buildings only few buildings would lend themselves to re-utilization due to the required cubic volume and clear height. A former factory building or a church might most likely meet these requirements.

Purpose of Utilization

Once the location of the laboratory is determined the future users are to be defined considering that a top-quality representation will be provided. With regard to post-graduate education particularly teaching purposes based on empirical experience in the course of experimenting will be treated. Concerning evaluation and validation of simulation findings a vast field of research so far has not been tackled. Beyond university research activities such a laboratory can also prove useful to the local architects e.g. in simulations of lights and its impact. The lab thus serves as an object to be rented and for providing of services. Remarkable new ground for all involved is broken particularly regarding the resulting feedback to practical work: the productive combination of teaching, practical work and research are bound to make for a promising lab environment and the undoubtedly resulting interactions will issue an accordingly vast scope for performance.

Personnel and Budget

An issue of major importance is who is to be in charge of such a lab, as the same will also handle conservation of the findings and their analysis providing for appropriate integration of work into the suited context. Processing of knowledge finally is required granting its adequate transmission. A lab also will not work without regular financial contributions. The expenses, however, are always to be in proportion to the object. The complexity of planned work defines the expenses and thus the financial requirements. Simulation in the 1:1 scale causes comparatively high costs which could be cut down somewhat by implementation of basic elements. In the long run acquisition of small devices and utensils results in setting-up a (semi-) permanent storage calling for extra care. Limitations concerning personnel and financial resources, normally a matter of fact, does not have to be a disadvantage, as over and over again spartan equipment may contribute to creativeness: necessity is the mother of invention. A minimum of personnel resources has to be provided, to be in charge of general maintenance and electro-technical and electronic assistance as well as with regard to skilled technical support apart from the pure didactic work. This help also makes for the required safety and smooth execution of work.

Equipment and Technical Infrastructure

Simulating in the 1:1 scale often calls for no surrounding buildings. In the history of simulation several examples of execution right at the site or simply in the backyard are known. In order to keep expenses low and to avoid climatic influences at the simulation site the suited building facilities prove wise. A green patch will rather only lend itself to a one-time experiment than to an economically drawn up test series. In the case of internal simulation experimental fields relying on the natural daylight differ from those of simulation carried out so to speak in the blackbox. Moreover, manipulation of heavyweight parts is easier with the adequate devices. The integration of mobile stages or a crane trolley surely will be useful. A deposit facility will be prove meaningful as a secondary spatial requirement and furthermore suited facilities for presentation and filing are necessary. A connection to the model workshop certainly would be beneficial as the parallel work in differing scales results in an instructive course for those involved in experimenting. The stepwise feeling one`s way straight to the 1:1 scale is valuable considering a meaningful genesis of design work.

External Relations

Relations to extra-university institutions promoting outside contacts would also come in handy. New approaches would thus be opened and possible synergy-effects might result from the situation. As particularly in the field of 1:1 material availability is of importance resulting in considerable expenses donations of the private industry should always be welcome and any wishes from the private industry should find a willing ear. What is to be considered in this context is that a purely commercial thinking in line with the private industry`s interest is to be regarded carefully: the university might likely become the matchball of private interests acting rather discouraging considering the variety of opinions. Awarding of open-market subventions, rewards and scholarships might be a promising approach. This enabling the "open market" to acknowledge remarkable work at the university level and also to make for an exchange and close relation between theory and practical work.

The presented aspects for erection of a future full-scale and light lab are merely to be regarded as global recommendations for further decisions considering the erection of a 1:1 lab. Advanced studies and detailed planning will be required in order to develop an appropriate lab not only being in line with the specific circumstances, the strong points being ideally based exactly on these parameter. May we hope that the "dream" of a cooperation model will be translated into reality in the course of the erection of a 1:1 laboratory.

Appendix II - Daylight and Artificial Light: Simulation and Realization

Alexander Huber (Alexander.Huber@bartenbach.com)

Bartenbach LichtLabor (Aldrans), Austria

Bartenbach LichtLabor has been working as a lighting designer for the application of natural and artificial light since 1976. The company is completely independent of luminaire manufacturers. Its head office is located in Aldrans near Innsbruck, Austria, with branch offices in Munich and Berlin, Switzerland and the USA. Partnerships have been established in the Netherlands and South Korea. Thanks to its 60 highly skilled employees who work in various fields such as lighting design, research and development (including perceptual psychology, physics, mathematics, optics and measurement), simulation and model-making, the *Lighting Lab* has the talent to resolve highly complex visual tasks. This pool of expertise allows the company to achieve an extremely high standard of design which encompasses both natural and artificial light from preliminary design to project supervision and includes competition support, analyses of actual situations and expert opinions. Furthermore, *Bartenbach LichtLabor* has the know-how to develop special daylight and artificial light systems, satisfy the specific visual requirements of modern workplaces, i.e. visual display terminals, and optimize the use of materials in the context of surrounding surfaces. One important tool helping to optimize the effects of natural and artificial light in different environments is model-making.

The *Lighting Lab* executes model simulations in full-scale as well as scaled-down models (1:5 to 1:50). Full-scale representations are mainly installed in a "glass cube" sized 8x8x8 m, which permits the simulation of daylight situations in a given space. All types and orientations of daylight openings may be realized here (skylights, windows admitting light from the side, windows facing south, resp. north and east). The module structure of the spatial installations allows a quick modification of the spatial geometry and the daylight solutions. In addition to the precise measurement of all relevant lighting-engineering parameters, any environment is assessed both subjectively and objectively. The objective assessment is based on perception tests performed with approximately 50 test subjects per environmental situation. In particular in view of an interference-free work at VDUs (EU Guidelines) any symptoms of fatigue shown by the test subjects as well as the number of mistakes made and the rate of work are measured for very diverse tasks. The results of these tests are evaluated and compared statistically and scientifically and are a fundamental help in the decision-making process. Moreover, full-scale installations of novel natural and artificial light concepts are continually installed in the offices used by the *Lighting Lab* staff in order to enhance awareness of the various effects. The "artificial sky", a spherically curved, artificially shining firmament approximately 70 m in diameter, permits daylight situations to be represented in a realistic way in models made to a scale of 1:50 to 1:5.

The appearance of a given space may be shown and measurements taken for an overcast sky as well as sunshine and for any geographical situation and time of the day. System solutions and influences of the materials used may be quickly changed and assessed. As compared to a computer simulation the model simulation has indeed fundamental advantages, such as the realistic and unadulterated representation of intensities, surfaces and three-dimensional spatial experiences as well as the temporal aspects of adaptation processes of the human eye. The same is true for the artificial light model simulation, which the *Lighting Lab* performs as well. These model simulations support the design process and provide a realistic visualization of the spatial situation, which is a meaningful help for decision-making.

The company is commissioned by private persons and state authorities alike. As a result, it concerns itself with all types of interior and exterior applications on both a small and large scale. The *Lighting Lab* is often entrusted with the chairmanship of international research projects (EU, IEA).

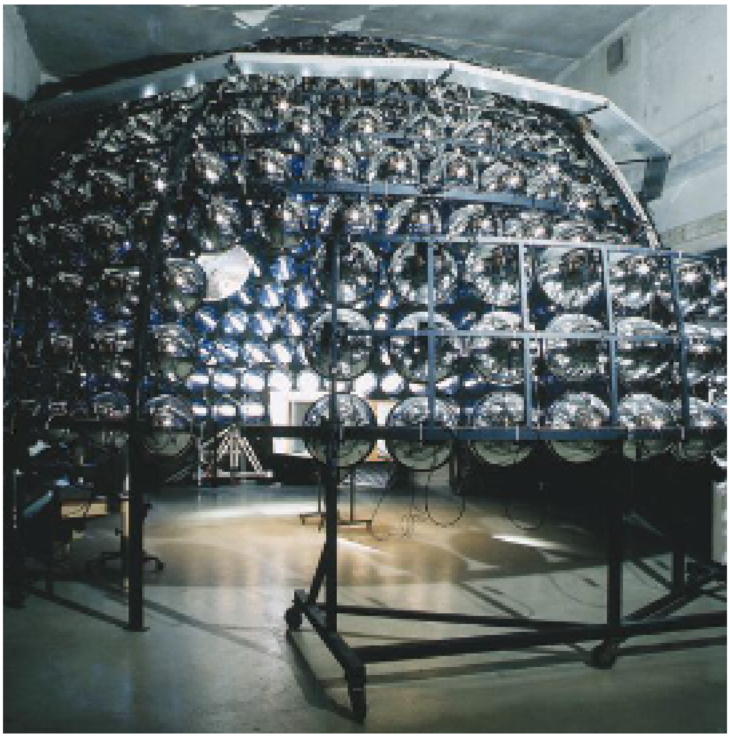


Fig. 1 Artificial sky.

Fig. 2 Model of shopping mall (scale 1 : 20 / artificial sky).

Fig. 3 Artificial light ambience in shopping mall (scale 1 : 10).

Fig. 4 Realization of the project.

Fig. 5 Model sun simulation (scale 1 : 20).

Fig. 6 Office with conventional blind outside (no daylight inside the room).

Fig. 7 Office with reflecting lamella system (no glare but daylight inside the room).

Fig. 8 Glass cube with installation of two standard office rooms.

IRIS-ISIS-PUBLICATIONS

URL: http://info.tuwien.ac.at/raumsim/iris-isis

Vol. 1: Bob MARTENS (Ed.): **The Future of Endoscopy**. Proceedings of the 2nd European Architectural Endosocpy Asscociation Conference in Vienna, Austria, 1995. ATS 198,--

EAEA '95 Vienna aimed at a critical investigation of today's endoscopic culture with regard to future developments. The Aspern-Workshop represented the highlight of this conference. Prior to the conference nine universities had submitted endoscopic and computer-assisted space simulations for this urban expansion area north of the Vienna Danube. The outcome was not to be regarded as a "noble competition" between the various institutions participating, but rather to sound out the actual potential of various simulation techniques and their combinations for future use. The conference proceedings contain the papers presented at the meeting by 23 experts from 15 universities. The papers cover such areas as the technical features of endoscopy and environmental simulation, theories supporting the use of endoscopy, practical applications, and discussions on the future of endoscopy and environmental simulation in comparison with other means of architectural representation.

Vol. 2: Bob MARTENS (Ed.): **Full-Scale Modeling in the Age of Virtual Reality**. Proceedings of the the 6th European Full-scale Modeling Association Conference in Vienna, Austria, 1996. ATS 198,--

In the early eighties the European Full-scale Modeling Association (abrev. EFA, full-scale standing for 1:1 or simulation in full-scale) was founded acting as the patron of a conference every two years. In line with the conference title "Full-scale Modeling in the Age of Virtual Reality" the participants were particularly concerned with the relationship of physical 1:1 simulations and VR. The assumption that those creating architecture provide of a higher degree of affinity to physical than to virtual models and prototypes was subject of vivid discussions.

Vol. 3: Bob MARTENS, Helena LINZER, Andreas VOIGT (Eds.): **Challenges of the Future**. Proceedings of the 15th Education in Computer Aided Architectural Design in Europe-Conference in Vienna, Austria, 1997. [CD-ROM] ATS 198,--

"Challenges of the Future" features the further advancement regarding computer-assisted design and planning processes with close consideration of research teaching throughout the design and planning professions. Recent novel technologies in the development are discussed redarding their impact. More than 65 contributions offer insight into the focal issues of Spatial Modeling, Digital Design Process and Collaborative Teamwork.

Vol. 4: Kurt RICICA, Andreas VOIGT (Eds.); Ulrike HASLINGER, Michael KOSZ, Helena LINZER, Rainer MADERTHANER, Rainer MAYERHOFER, Kurt RICICA, Jürgen RIENESL, Stefan SALHOFER, Sepp SNIZEK, Andreas VOIGT, Hans Peter WALCHHOFER: **Raumverträglichkeit als Beitrag zur nachhaltigen Raumnutzung. Ein Leitfaden**. 3 Bände. Wien, 1998. ATS 198,--

Spatial Impact as Contribution Regarding Sustainable Utilization of Space: The creative dialogue of "planning" and critical "reviewing" of planning work and projects with a relation to space fundamentally aims at a "sustainable utilization of space" in line with the key-pattern for "sustainability". Reviewing of spatial impact first will call for the model-representation of space. In addition, all effects resulting from planning and projects for the area under investigation are to be demonstrated clearly and thoroughly. The description of space therefore is accomplished according to system elements and system relations. The spatial impact analysis is to be regarded generally as a contribution for objectifying, adding transparency and comprehension to planning processes.

ÖSTERREICHISCHER KUNST- UND KULTURVERLAG
Freundgasse 11, A-1040 WIEN
TEL.(+43-1-) 5878551; FAX(+43-1-) 5878552