AIC Interim Meeting '96
June 15-18 1996 --- Göteborg, Sweden

Colour
&
Psychology

Organised by
the Swedish Colour Centre Foundation, AIC Member Body

Organising committee:  Sponsors:
Lars Silvik             Swedish National Building Research Foundation
Berit Bergström       Scandinavian Colour Institute

Saturday, June 15

17.00 - 18.30 Registration

18.30 Opening Session:
Lucia R. RONCHI          Mikaela ECKERED
President of AIC         Chairm. Sw. Colour Centre Foundation

Erling ZANDFELD - "Color as Messenger"
Swedish Fed. of Painting Contractors

19.00 Welcome Reception

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<td>09.50-12.30</td>
<td>Aspects of colour perception</td>
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| 09.50 | O-1  Patricia DA RE & Osvaldo DA POS (Italy)  
Costancy of Surface Colours in Light and Shadow in Children. |
| 10.10 | O-2  lan KELLY (UK)  
A Two Stage Evolutionary Model for the Computer Aided Design of Colour |
| 10.30 | O-3  Takashi NAKAGAWA & Yukitaka GOHARA (Japan)  
Perceptual Color Assimilation of Adjacent Strips Displayed with Dark Background |
| 10.50-11.10 | BREAK AND POSTER STUDIES                  |
| 11.10 | O-4  Gunnar TONNUQUIST (Sweden) Colour - What are we Talking about? |
| 11.30 | O-5  Lucia ROSITANI-RONCHI (Italy)  
Appearance Problems Related to Computer-generated Patterns on a Phosphor Display |
| 11.50 | O-6  Katsuaki SAKATA (Japan) Estimated Blackness and Whiteness in Achromatic Colors |
| 12.10 | O-7  Ken SAGAWA, & Yutaka SHIMIZU (Japan)  
Visual Comfort of a Colored Image Evaluated by Chroma and Categorical Color |
<p>| 12.30-13.40 | LUNCH                                   |</p>
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<td>Åke SVEDMYR (Sweden) The Aesthetics of Recognition - an Important Aspect of a Colour Harmony Theory</td>
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<td>Helle WIJK, S. BERG, B. STEEN &amp; L. SIVIK (Sweden) Can Colours Act as an Aid in the Environment of Patients with Dementia?</td>
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<td>Paul MARTIN (UK) The Elemental Aspects of Colour in Spatial Design</td>
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Archipelagic Get-together-party on M/S SANKT ERIK

19.10 departure from Lilla Bommen
19.30 departure from Hotell 11
19.40 departure from Novotel
Monday, June 17 - morning

08.30 - 09.00  Registration and Information

09.00  Invited lecture:
Emotional and Behavioural reactions to colour - Byron MIKELLIDES

09.30-12.30  Environmental Colour Design, continued  Moderator: Paul GREEN ARMYTAGE

09.30  O-16
Karin FRIDELL ANTER (Sweden)
Inherent and Perceived Colour in Exterior Architecture

09.50  O-17
Jan JANSENS (Sweden)
Individual and Contextual Factors in Urban Colour Perception

10.10  O-19
Charles TAFT & Lars SIVIK (Sweden)
Color Meaning and Context

10.30  O-20
Rikard KÜLLER (Sweden)
Preferences for Colours in Urban Places

10.50 - 11.10  BREAK AND POSTER STUDIES

11.10  O-21
Leo OBERASCHER (Austria)
Individual Colour Preferences - What do they Really Tell about a Person?

11.30  O-22
H. J. ALBRECHT (Germany)
Colour and Objective Shape

11.50-12.30 AIC Study Group of Environmental Colour Design - Meeting and Discussion

12.30-13.40 LUNCH

(O-18  Aziz KIRAN was not able to come)
### Monday, June 17 - afternoon

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Wade THOMPSON S. (USA)
Colour Illusion in Painting: Form and Space |
| 14.30  | O-24
Jeffery ARCHER & Lennart HÖGMAN (Sweden) Methods for Determining Perceptual Equal Brightness Ratios and their Effect on Perceived Velocity |
| 14.50  | O-25
Sten Sture BERGSTRÖM, K.-A. Gustafsson, & T. Jakobason (Sweden)
Colour Constancy Phenomenon Related to Perceived 3-D Shape |
| 15.10 - 15.30* | Discussion |
| 15.30 - 16.00 | BREAK AND POSTER STUDIES |
| 16.00  | O-27
Anna Maria GIANNINI, Paolo BONAIUTO, Valeria BIASI & Marino Bonauro (Italy)
The Serial Reproduction of Paradoxical Colours |
| 18.20  | O-28
Jose Lois Calvano (Argentina)
Semiotics and Cecia: The Meanings of the Spatial Distribution of Light |
| 16.40  | O-29
Cecilia HÄGGSTRÖM (Sweden)
The Shaping Properties of Colours |
| 17.00  | O-30
Giovanni & Dominique BRINO (Italy)
Color Illusions in Architecture |

*17.20- AIC Study Group of Visual Illusions and Effects - Meeting and Discussion*

*0-26 Shashi CAAN was unable to attend*
Tuesday, June 18 - morning

08.30 - 09.00 Registration and Information

09.00-09.30 AIC Tutorial Lecture:
Basic Color Terms and Basic Color Categories - Larry HARDIN (USA)
presented by Paul GREEN-ARMYTAGE

(Hardin has recovered well from an operation, but was not allowed to travel to Sweden)

09.30-12.30
Colour in cognition and language

09.30 O-31
Gunilla DEREFELEDT (Sweden)
The Content of Thoughts Includes Colour

09.50 O-32
Jose Luis CAIVANO & Liliana RIMOLDI (Argentina)
The Meanings of Color in Argentina

10.10 O-33
Miho SAITO (Japan)
A Cross-cultural Study on Color Preference in Japan, China and Indonesia, with Emphasis on the Preference for White

10.30 O-34
David BUSS (USA)
Colour as Idiom

10.50 - 11.10 BREAK AND POSTER STUDIES

11.10 O-35
Steve GUEST & Darren VAN LAAR (UK)
All Colours are not Created Equal: the Psychology of Categorical Colour Naming.

11.30 O-36
Vive SARAPIK (Estonia)
Lilac, Violet and Purple in Estonian. A Comparative Research

11.50 O-37
Danica SKARA (Croatia)
Color Terminology - Collocations and the Word Association Responses

12.10 O-38
Ian SUTHERLAND (UK)
The use of colour in the literature of Samuel Becket

12.30-13.40 LUNCH
Tuesday, June 18 - afternoon

13.40 Invited lecture: Colour in Folklore - John HUTCHINGS (UK)

14.10-17.20 Colour in art and in cultures

14.10 O-39
Roy OSBORNE (UK)
Colour-Preference Versus Form-Preference in Art Teaching and Criticism

14.30* O-41
Magenta YGESIEAS (USA)
Color preferences in children Folklore

14.50 P-5**
Michel CLER (France)
Chromatic Chart and Public Spaces in Urban Development - Concept for three projects

15.10 O-43
Christopher WILLARD (USA) Constructs of Color Evidence: The Psychological Ordering of Color Relationships in the Teaching of Color Theory

15.30 - 16.00 BREAK AND POSTER STUDIES

16.00 O-44
Guy ROUX (France)
Colour and Art in Psychiatry

16.20 O-45
Margareta TILLBERG (Sweden)
Colour and Psychology - Controversial Issues During the Early Soviet Era

16.40 O-46
Paul GREEN-ARMYTAGE (Australia)
Complementary Colours - Description or Evaluation?

17.00 Discussion

17.20 CLOSING SESSION - President of the AIC: Lucia ROSITANI RONCHI

*O-40, İlhan Altan unable to come due to illness
**Replacing O-42 Ravi HAZRA who was unable to attend
POSTER presentations

P-1
Åsa ABELIN (Sweden)
Compound Colour Words in Swedish (unable to attend)

P-2
Michel ALBERT-VANEL (France)
Psychological Experiments of Colour Groups

P-3
Kerstin BERG & Lena ANDERSON (Sweden)
How do ordinary people colour their homes

P-4
Krishna D. BROOTA & Osvaldo DA POS (India-Italy)
The Pleasantness of Green/blue Colour Combinations in Indian Adults

P-5 Yang CHUNFENG (China) Research on Traditional Chinese Character (not coming)

P-6
Michel CLER (France)
Chromatic Chart and Public Spaces in Urban Development - Concept for three projects

P-7
Osvaldo DA POS (Italy)
The Pleasantness of Bicolour Combinations of the Four Unique Hues in Indian Adults

P-8
J. J. EMBRECHTS (Belgium)
Colour Rendering under the Combination of Daylight and Artificial Light

P-9
Karin FRIDELL ANTER (Sweden)
Nature's Colour Palette

P-10
Fernanda GARZIA GIL (Spain)
Light, Colour, Matter and Perception: Application of Opacity-transparancy to the artistic perceptive theories

P-11
Paul GREEN-ARMYTAGE (Australia)
The Blue House

P-12
T. JAKOBSSON, K-A GUSTAFSSON & S.S. BERGSTROM (Sweden)
Impressions of Shape Distinctness In Various Chromatic Illuminations in Deutan and Normal Subjects

P-13
Elisa JIMENEZ MARTIN, A GARCIA-BELTRAN, M. M. PEREZ & A. YEBRA (Spain)
An approach to colour from different perspectives: the perception of yellow as a primary colour

P-14
Nina KORSCH & O. V. SAFUANOVA (Russia)
Denotative Meaning of the Colour Name
POSTER presentations, continued

P-15
S. KOSCIELECKI & Osvaldo DA POS (Italy-Poland)
The Pleasantness of Green-Blue Colour Combinations in Polish children.

P-16
Anders LILJEFORS (Sweden)
A Vision of Clear Terms

P-17
Grazieila MAGHERINI (Italy)
The Power of Images; The Stendahl Syndrome

P-18
Ruth MARRION (Australia)
Personality and Colour Preferences - Could Personal Colouring be the Missing Link?

P-19
Lucie ROSITANI-RONCHI & Margherita ABOZZO-HEUSER (Italy)
The "Palette" of Novel-Writers

P-20
Lucie ROSITANI-RONCHI & M. CETICA (Italy)
Wandering in a Museum: From Physiology to Beyond Psychophysics

P-21
L. R. RONCHI & M. ABOZZO HEUSER, S. SORIA HUGUET, T. KOTTOS & O. PIZZURRA (Italy)
Color Names in Journalism: An Inter-Country Comparison

P-22
Larissa SHAKINKO (Belarus)
Colors Education with Application of the NCS for Architects in Belarus

P-23
Karin FRIDELL ANTER & Åke SVEDMYR (Sweden)
Colour Scales of Traditional Pigments for Exterior Painting

P-24
J. R. TORRES (Spain)
Barragan: Colour and symbol

P-25
S. VILLANI, G. VILLANI & L. ROSITANI-RONCHI (Italy)
Color Communication in Childhood

P-26
M. VOEGELIN-WENDENBAUM & B. ELYASY-MEHDY (Italy)
Color in Tribal Carpet

P-27
Andrea URIAN - (Slovakia)
Attempt at Finding Factors Underlying Subjective Aesthetic Evaluations of Exterior Architectural Colour

P-28
Christophe CADU-NARQUET (France)
Colour Collection for Industrial Lime Plaster
COLOUR AS A LANGUAGE
COMMUNICATING CHARACTERISTICS OF COLOURS

1965 professor W. D. Wright gave the following three answers to his own question "What is colour for?":

1. To inform about the existence of objects
2. To give information about the quality of these objects and
3. To decorate

These three statements could be seen as basic concepts of colour ordering.

1. To order colours or colour stimuli according to equidistant principles so that either

   * adjacent colour stimuli differ from each other in terms of just noticeable stimulus differences (JNDs) or multiples of them (e.g. MacAdam / in some ways CIELAB) all over that colour space
   or
   - perceived differences between adjacent colour elements are equally large all over the colour space (OSA-UCS, in some respect Munsell, DIN).

2. To order colour percepts in a colour space according to their characteristic appearance depending on the various resemblance to the six elementary colour sensations white, black, yellow, red, blue and green and to determine the relationship between the colours by their visual content of the elementary attributes (NCS, in some respect Munsell's and Ostwald's systems).

3. To order colours according to aesthetic or connotative value relations (Color Image Scales)

The second concept appears formally to be the only that has descriptive or identification purposes and might probably form a platform for analysing colour as a language.

The ideas of colour as a language were formed after a revue of a book by Leonard Bernstein who had found almost direct parallels between music and Noam Chomsky's linguistic theories about "the human universals of language".

Fesliss', Hering's, Goethe's, and others (including our own) phenomenological analyses and psychometric experiments indicated structural analogies between the ordinary language and a language of colour like those Bernstein had found in the tonal world.
In the colour language

* the limited number of elementary colour attributes can be looked on as metaphors of the phonemes/sounds in the ordinary language

* the many various colour percepts, which differs by their various compounded grades of the elementary colour attributes, can be looked on as metaphors of the morphemes/words and their categorisation in NCS according to main- and secondary attributes to that of words in e.g. parts of speech

* the unlimited number of colour combinations in colour gestalts can be looked on as metaphors of sentences communicating meanings, emotions, poetry etc., from the most formalistic official messages to free human emotional kinds of information

* the "Outlines of a colour combinatory theory" that has been formulated might be seen as a metaphor to the syntax of grammar

It appears relevant to talk about human universals of colour as well as human universals of language (or music)

If we accept this as a formal analysis of the colour language this does not mean that it says very much of how the colour language should be used and colours chosen for a better environmental design.

One problem is that one might suspect that Man has lost his ability to read the colour language when he left a life in interaction with the nature and now has to survive in an industrialised world in which the colour of a product not necessarily says anything about its quality. A poor car might have the same colour as a high quality Bentley.

Unfortunately, more interest is today focused on how to produce and reproduce coloured materials in a precise way than on understanding the meaning of colours and colour combinations in order to create a better environmental colour design.

If it is so that Man has lost the faculty for reading the colour language maybe we can hope that new colour researchers will reconquer it so that colour will mean more than cosmetics in our man-made environment.
ENVIRONMENTAL COLOR DESIGN – HOW TO DEAL WITH REAL WORLD COMPLEXITY?

A central problem of decision-making during the design-process, particularly in architectural design, is an accurate prediction of the overall (aesthetic and psychological) effects of the (sometimes complex) interactions between colour and other environmental variables.

Despite the fact that colour is a fundamental dimension of (normal colour) vision - under most circumstances we (phenomenally) experience colour as an integral part of the (visual) world, together with form, structure, surface texture, gloss, transparency, substance, atmosphere, light and illumination. As Paul Green-Armitage points out in his article "Beyond Colour" "It is not often that we experience the isolated colour of a single light stimulus." [1]

According to my experience it is not only the non-professional observer who has difficulties to isolate colour conceptually from other environmental qualities but also the design student, designer and architect. A "change of colour" during the design process often implies a change of other qualities "beyond but including colour" [1]. The mutual interdependence of colour and other environmental qualities as well as the conceptual confounding of these variables contribute to the problem of assessing and predicting the concrete effects of colour in Environmental Design. A "general concept for all aspects of what we see beyond but including colour [...]" as suggested by Paul Green-Armitage [1] might be useful to conceptually separate different environmental qualities which in one way or the other contribute to real world colour appearance but the problem of predicting the concrete effects of colour in Environmental Design does still remain.

The Environmental Assessment approach - as already suggested by Kenneth H. Craik in 1971 [2] - to my opinion also provides a good conceptual and methodological framework for systematically investigating the problem of assessment and prediction of real world colour appearance (or environmental colour as opposed to what we could probably call abstract colour).

According to Craik any (psychological) research on the comprehension of environmental displays has to deal with the four issues;
(a) Media of Presentation
(b) Response Formats
(c) Environmental Dimensions, and
(d) Observers

[whereby] the nature of each of these components and their interrelationship embodies a basic research paradigm of environmental psychology [...].[3]

The issue of environmental dimensions - in particular the significance of behavioral attributes ascribed to environmental displays themselves, rather than what these responses reveal about the observer - to Craik subsequently become a central topic of environmental psychology. [3] He "[...] assumes that establishing dependable predictive relations between descriptive attributes of places and how they are evaluated and used provides the grounds for advancing our understanding of environment-behavior transactions and affords the basic for improving the planning, design, and management of our environment." [4]

In analogy to the term "Personal Assessment" he introduces the term "Environmental Assessment" which he defines as "[.] a general conceptual and methodological framework for describing and predicting how attributes of places relate to a wide range of cognitive, affective, and behavioral responses."[4] Three forms of Environmental Assessment are then distinguished:
(a) Evaluative Environmental Assessment,
(b) Descriptive Environmental Assessment,
(c) Predictive Environmental Assessment. Predictive Environmental Assessment is further specified in
(c.1) predictions based on empirical generalizations and
(c.2) simulation-based predictions.
"Simulation-based predictions make forecasts of a potential place's attributes and impacts possible at the prechange (e.g., preconstruction, premanagement) stage of the decision-making process [...] (assuming) [...] that responses to the simulated places are comparable to and forecast responses to real or 'actual' places with sufficient accuracy."[4]

In the field of architecture and design simulation-techniques (e.g. floor plans, sketches, renderings, perspective drawings, models) have been used for many centuries. [5,6,7]

Beside traditional forms of project simulation - advanced simulation-technologies (e.g. photography, film, video taping, modelscope images, holography, computer graphics and virtual reality) today offer a broad palette of sophisticated tools for professional communication and decision-making. Although most of these techniques allow colour manipulation the accurate prediction of real world colour appearance often does not work.
To determine what makes good simulations the psychological effectiveness of different techniques has to be evaluated and compared. The general question "How well do responses to the simulation predict first impressions of the real world?" which "[...] is central to the use of [any] simulation-based predictions [...]"[4,8] can be adapted to the specific simulation problems in environmental colour design.

At the Department For Spatial Simulation at the Vienna University Of Technology students (and professionals) have the opportunity to use and compare different simulation techniques. Beside the possibilities of computer aided design (CAAD, CAI...), video endoskopie, stereophotography and holography the department has installed an experimental laboratory for full-scale modelling [9].

In 1995/96 under the title "Experimentelle Farbgestaltung" with students of architecture we have carried out 3 projects in which the meaning, effect and functions of colour in architectural design were explored experimentally. Each project focused on one of the 3 basic colour functions (indicative, symbolic, aesthetic) [10].

During the planning, simulation and evaluation of these projects - a detailed description will be given in the lecture - it became clear, that coloured sketches, scale models and the use of real colour samples do not allow a good prediction of real world colour appearance.

The most important conclusion was that the effects caused by interactions between colour and other environmental variables can be experienced and assessed only under the condition of full-scale modelling. Several times we noticed that even small changes of one environmental variable can cause astonishing changes of the whole setting. It also became evident that certain colour effects (e.g. simultaneous contrast effects, illumination effects) which were seen under the condition of full-scale modelling could not be reproduced by other means of simulation such as video-taping or (stereo)photographic representation of that same model.

Summary:
The problem of evaluation, description and most of all prediction of real world colour appearance in environmental design can be analysed within the conceptual and methodological framework of Environmental Assessment. Our experiments at the Department For Spatial Simulation suggest that full-scale modelling is an appropriate media of presentation to study the complex interactions between colour and other environmental variables in architectural design.

Remarks: 1) "For ease of exposition" Craik suggests using the term place as a general designation for an environmental display or environmental unit.
References:


EMOTIONAL AND BEHAVIOURAL REACTIONS TO COLOUR

Colour plays an important role in satisfying man’s biological, psychological and spiritual needs and, as such, it has a direct emotional and behavioural impact. Colour vision almost surely evolved along signal coloration to enable animals and man to detect and interpret nature’s colour-coded messages (Humphrey 1984). Painting different parts of the body for various rites and ceremonies symbolizing the different stages of human development and activities is an attempt to satisfy man’s need for identity and differentiation from others of the same species.

In a recent BBC wildlife programme (April 1996) by David Attenborough on one of nature’s most beautiful creatures, the elusive birds of paradise, the potency of colour was spectacularly shown. The more beautiful and colourful the male birds are, the greater their chance of attracting the female birds for reproduction. Furthermore, in the case of the New Guinea paradise birds which are less spectacular than their other relatives, they make up for it by becoming architects and interior designers by decorating their habitat on the ground of the forest with beautiful and colourful objects.

It is one thing, however, to point out the importance of colour in animals and humans, and another thing to identify the precise emotional and behavioural reactions to it in different contexts and different cultures.

The aim of this paper, therefore, is to consider three areas of research which it is generally agreed that emotional and behavioural reactions to colour can be discussed in a meaningful way:

1 Whether colour influences our perception of warmth in body and mind
2 Whether colour speeds up the perception of time.
3 Whether colour, apart from its signalling properties, creates an arousing state in the organism.

Each of these three areas will be considered separately by listing the various physiological and perceptual studies reported in the scientific literature and then making a critical appraisal based on the evidence considered.

In addition to these three areas, there are other important reactions to colour that Lars Sivik identified in his introductory notes about this conference. For example, the symbolic meaning attached to colours in various cultures, and the question of colour preferences in various countries and age groups. Over the past 25 years, I have been collecting colour preferences based on six colour samples of equal "chromatic strength" and "blackness" based on the NCS system. These preferences have been related to a host of educational and psychological measures in order to find out whether any of these independent variables were related to final performance in design and academic subjects over the years. It is interesting to
report, at this stage, that of the very few significant correlations, the colour of red for girls and green for boys were statistically significant linked with performance!

Colour preference also appears in various guises in a variety of contexts in the popular media all the time. A fanciful saga in this area was recently witnessed by the amount of coverage in all UK newspapers and TV stations regarding the colour "grey" in footballers' shirts. As Manchester United lost to Southampton on 13th April, 1996 it was not the easy excuse of "unlucky 13", but the grey colour of their "away strip" which was to blame. This was not just an excuse for the defeat but went out of all proportion costing retailers £2m after Umbro's recent kit deal worth £50m. First of all, the manager of Manchester United attributed the team's first half problem to their grey strip which was changed at half-time. They still lost. He later on explained that "the players say they find it difficult picking out team-mates against the background of the crowd, especially from one wing to the other. We have a very good relationship with Umbro and I don't want to upset them, but enough is enough. The players prefer the blue and so I" he said. "Of the six games we have lost this season, we wore it on four occasions." The funny thing is that the grey shirts have proved highly popular with the fans - because they are complemented by jeans - helping to persuade the Company to bring grey for the new England change outfit for this year's European Cup!!

In the sphere of cognitive psychology, using colour in the external environment in the forum of paint, wall paintings and murals or colour coded floorscope signals enables the users not only to know and understand the environments they live in but also to have an impact upon it. This is particularly important these days when we are exposed to drab and, in some cases, alien or hostile environments. Children normally identify with the environment through graffiti or even supergraffiti. They create and good murals act as landmarks and facilitate orientation in the environment. However, the concepts of "impact", "cognition", "competence" in the environment proposed by Friedman (1976) have not been addressed in any systematic way as far as I know. In Davidoff's book Cognition Through Colour (1993) he comments on children's early difficulties with colour - their inability to link colour words to visual stimulation. At first, children use one of the four colour names (red, green, blue, yellow) corresponding also to the opponent colour theory by Hering. Interestingly, at the beginning of the century, the reliable basic colour naming of these four colours represented in Binet's tests the average achievement for the eight year old. By 1950 it was the average achievement for the five year old, dropping down to the average achievement of a three year old nowadays. One wonders what impact colour in the environment has in children's cognitive development.

The Hue-Heat Hypothesis

The anecdotal reports that Red is considered a warm colour and Blue a cool colour, is strongly supported by the vast majority of the perceptual studies. Previous studies (Hogg, Mikellides et al 1979, Kuller 1972, Sivik 1974) using colour samples and colour simulated spaces - in the form of colour slides and drawings - are supported by the full scale Oxford and Lund experiments, using both colour pigment and colour light in a variety of contexts on a longitudinal basis over ten years, showing that taste or other inter-
venering variables could not have been responsible for the consistency of the findings.

However, none of the five laboratory studies to date, which attempted to measure the difference by means of behavioural, physiological and temperature estimation techniques, succeeded in finding a measurable difference of any practical importance.

What are the implications of these studies to the designer? Has the Hue Heat conflict been resolved? There is no doubt that the inducement of visual warmth by exposure to Red light or Red paint is elicited in a variety of contexts. Men and women from various cultures and various ages report this apparent warmth consistently, and as such it has direct design implications for the professional. Architects are involved not only in designing buildings but in creating spaces with certain perceived qualities and atmosphere. By manipulating the hue dimension they can create a space which people will perceive as warm or cold at the cognitive level. Whether designers want to provide an immediate impression of warmth or coldness as people pass through a space or spend some time, the impression of apparent warmth is real in the sense of being consistently reported as so by people. However, the implications of the hue-heat hypothesis for the practising engineer as opposed to the architect who is interested in direct measurable differences in comfort rating is not there. As such it cannot be used for energy conservation in any serious way and scepticism of heating engineers is understandable.

Colour and Time Estimation
The review of the literature on colour and time estimation does not resolve the conflicting reports regarding the hypothesis that Red accelerates the subjective passage of time. The experimental evidence from all published studies to date using both colour light and colour pigment at various exposure times have shown no consistent differences in the estimation of time intervals. Neither is the hypothesis that greater physiological arousal causes the acceleration of subjective time supported by Caldwell and Jones (1985) using 30 and 45 second intervals (colour light) or Mikellides (1986) using 25 and 95 minute intervals (surface pigment). The various direct implications of this work reported in books and design manuals is not therefore borne out by our knowledge of the subject based on perceptual and laboratory studies. Whereas there are consistent differences between perceptual and laboratory studies in hue-heat, for time estimation there are conflicting reports within the perceptual studies, as well as within laboratory studies. The likelihood is that other variables, such as individual differences, arousal, preferences and context mediate in these findings. The interaction between and interdependence among these variables may prove a formidable task for future research. This is illustrated in the experiment by Humphrey and Keeble (1979) who found that background noise decreases the time monkeys spent in Red compared to white lights but only to those monkeys who find the noise aversive in the first place!

Colour and Arousal
The question posed by Sivik in his "call for papers" for this AIC interim meeting, ie "whether there are any differences between connotative and physiological responses" is illustrated vividly when one considers the published literature on colour and excitement.
For example, Robert Gerard in his classic study in 1958 concluded that the two wavebands of radiant energy at the opposite ends of the visible spectrum, ie blue and red, exert a differential biological influence on the organism as measured by general activation in the central and autonomic nervous system (EEG, blood pressure, palmar conductance level, respiration, and heart rate). Further support is given to Gerard's work by an experiment carried out by Ali (1972). On the other hand, 25 years ago Lars Sivik demonstrated with a technique of photostimulation that it was not hue which affects how exciting or calming a colour is, but the chromatic strength of each hue. Aching and Küller (1972) showed with the use of perspective drawings of interior spaces and, later on in full-scale spaces, that weak colours give a room an impression of calmness while strong colours make it appear exciting.

One may be tempted to say that as far as physiological measures are concerned (Ali, Gerard) there appears to be a significant difference between red and blue lights affecting our organism. On the other hand, in studies using cognitive-affective measures (Sivik, Aching and Küller) it is the chromatic strength or saturation of pigment which is the most important factor and not hue. Mikellides (1984), and Caldwell and Jones (1985) found no significant differences between red and blue pigments of the same chromatic strength and coloured lights respectively which gave further support to the notion that chromatic strength is the key dimension affecting how exciting or calming a colour is perceived.

However, the experiments by Küller (1976) and Mikellides (1986) and the study by Küller and Mikellides (1993) where both physiological and connotative measures were experimentally manipulated and evaluated, a rather different picture emerges. For example, "alpha" and "delta" waves which are a measure of relaxed wakefulness and drowsiness were found in significantly greater amounts in a specially constructed blue room compared to a red room. These results point out that we are dealing with a complex interaction between our central and autonomic nervous systems involving possibly a compensatory mechanism whereby the cortical arousal resulting from red stimulation is compensated by cardiac deceleration.

Conclusion
Both the evolutionary/biological approach as well as the ethnographic/archaeological approach can help to understand man's response to colour. In modern architecture, new designs, high rise, deconstruction, colour and the use of new materials is used in an arbitrary way to nullify or override man's natural responses to colour, with the sole aim to design something which is original or win design awards. In traditional vernacular architecture, on the other hand, we have many examples of how colour has been used for centuries to appeal to man's biological and spiritual needs. Colour observed and studied in nature is an excellent guide to man's natural and biological predispositions which, according to Humphrey, has been in the business of design for over 100 million years. However, it is through the systematic perceptual and laboratory studies that we will be able to tackle adequately the plethora of anecdotal evidence and heresy accounts and establish which is fact and which fiction.
About terminology and related problems.

My speech could look like a philosophical speculation of little interest to people working in the field of colour perception. Nevertheless I just want to make some observation on the terminology almost all people use speaking about perception and specifically vision. The awareness of the problems which such terminology poses is a starting point to become more cautious in defending a particular theoretical position. It seems that interest in perceptual illusions depends on the theory followed by the researchers. If one considers illusions as mistakes either of our senses or of our mind, his interest will be much less lively than that of people who consider illusions striking occasions to disclose the normal functioning of our mind.

To start with a psychological approach to illusions, the first distinction which I consider relevant regards perception as opposed to cognition, i.e. seeing vs knowing. At first sight one could have the impression that perceiving is in any case a sort of knowing, and especially in human beings, perception cannot be separated by higher forms of knowledge. One of the most well known scientist of our time who stresses the role of cognition in perception, and therefore in illusions, is R. Gregory. Perceiving means, for him as for other researchers, trying to solve some problems, making hypothesis, and deriving a conclusion on the basis of some more or less justified assumptions. On the other side different 'direct' approaches to perception (gestalt and ecological psychology, for instance), do not see perception as involving mediatory cognitive processes. It seems extremely difficult that people belonging to one tradition will ever be able to understand and accept the antagonistic one (Kuhn).

Nevertheless there are some well documented situations in which what we perceive is in contrast with what we know very well, and sometimes a firmly consolidated knowledge cannot change an incompatible perception. Some examples are given and discussed, especially with reference to Kanizsa's works and ideas.

Secondly there is a terminological problem which could make people reluctant to treat the argument. One of the most ambiguous word used in describing our experience is the term 'appearance', which has at least two completely different meaning: firstly it denotes the perceptive characteristics that objects show in our direct experience of the world. In this sense there is no difference in saying that one thing appears or it is simply perceived. On the other hand the word appearance has a long history both in western and eastern philosophy: appearance is the contrary of reality. One thing is the appearance and another thing is the reality: for many thinkers we have no access to the reality and are confined in a world
of appearance only. Most scientists, at least at the present times, consider themselves as realist, in so far reality can be grasped by our intellect. As often perception is not considered as an autonomous function of our brain, independent from abstract cognition, the same laws of functioning which are applicable to abstract reasoning are thought to work in perception too, because of the unity of the human being. This assumption just because it sounds logical, seldom becomes object of verification.

Another source of misunderstanding is the ambiguity of the term 'representation', which is often used to maintain that content of perception is not the reality but a sign of it, a 'very similar sign' (Caivano). In this context the discussion can be developed about the concept of image vs reality. Again the image is not usually considered reality, but only an tool to grasp the reality. This is why, according to many people, we should have 'to interpret the image' in order to arrive at the reality: still more, we should have to interpret the raw data of our senses to build an image, which already appears somehow structured, but is still only the appearance of the world. Were this point of view true, we never perceive the reality, because in our eyes we only have images and nothing else. Why then looking at bidimensional pictures is considered quite different from looking at 'real' three-dimensional objects? This question is central when the discussion is about visual illusions as regard to camera obscura and photography. The report prepared by the study group deals with the quality of the images, the reproduction of different effects (for instance glossiness, colours, contrasts, and so on). The relationship image / reality was treated by R. Evans (1943) under the assumption that good pictures should have to look like objects. This idea has been left apart not only by researchers, but also by professional photographers; the goal of pictures seems now limited to the recognition of objects and their characteristics, with the wide range of problems related to constancies of many kinds.

A rather simple question then arises: do animal perceive as we do? Of course not, according to most people, because they do not share the abstract knowledge which is characteristics of human beings. On the other hand animal behaviour shows that adaptation to the external world is greatly similar to the human behaviour, and a number of 'mistakes' are performed in the same way by both human and animal beings (size/distance illusions, movement illusions, and so on). We cannot ascribe to animals as low as flies or larvae the same kind of reasoning we perform when we fall in the same perceptual error as they do. Therefore it seems reasonable to hold that similar behaviours in animals and in humans obey similar laws, and these laws can, at least sometimes, work independently from abstract knowledge (formulation of questions, hypothesis, theories, and so on).

About a definition of visual illusion.

Visual illusions are so common that all people roughly know what they are. Nevertheless a plain definition of illusions would hardly satisfy all different theoretical positions. There are at least two different categories of definitions related to illusions: in one category illusions are considered as the results of specific processes (for instance physiological vs cognitive proc-
esses, distortion, displacement, overestimation, and so on; the second type of definition has its focal point in the phenomenology of perception, affirming that what is important is the experienced evidence of a contradiction (according to my definition, illusion is a perceptual experience conflicting with another experience about the same object, where experience is at the level of perceiving and not of thinking).

R.I. Reynolds (in his paper "A psychological definition of illusion", 1988) discusses six different definitions, expressing his preference for the following one: "An illusion is a discrepancy between one's perception of an object or event observed under different conditions" (where 'conditions' take one of three classified forms). According to him this definition (already formulated by E. Mach 1868) has the advantage that "it may help to reconcile the long-standing argument between proponents of the 'indirect' and 'direct' approaches, since the proposed definition does not make reference to truth or falsity, but only to different percepts occurring under different conditions". Many authors (Michotte, 1955; Richer, 1978; Bors & Silberman, 1993; Klymenko & Weissstein, 1987, just to quote the first names whose statements I can attest) along the history of psychology, expressed opinions in favour of phenomenological definitions (perceptual experiences sometimes appear illusory sometimes non illusory, i.e. they appear with or without opposing characteristics). On the other hand the relationship with the 'physical reality' is often mentioned by non psychologists (illusion = non veridical perception, a discrepancy between what is perceived and the physical reality), although the concept of which physics has to be considered is almost never specified.

Context is one (or probably the only one) critical factor which determines the different appearances of the objects in our phenomenal world. This topic deserves of particular attention, because there is no perception at all without a context. Boynton in his well known book on Color Vision affirms: "I have decided not to deal with the very difficult topic of chromatic context in this book". The statement means that Boynton is dealing only with very simple contexts (one or two patches of light in complete darkness), which can be reproduced easily, at least as far as the stimulation is concerned (on the other side, subjective attitudes, attention, adaptation and so on, although well determined, are not always so perfectly reproducible). Stating that some percepts depend on context is clearly redundant; nevertheless, the topic seems today in fashion. As always perception depends on the context, and therefore different contexts likely induce different perceptions, it is not a great discovery that visual illusions depends on context ('A context dependent illusion: ...' is the beginning formulation of many titles in recent papers). The problem is the identification of which contexts are relevant, which relationships between elements of the visual field are determining factors of a particular perception. From this point of view also the definition of illusion by Boring ('when we reach the conclusive explanation of a particular perception, illusions do not exist anymore') can be understood: illusions as phenomenal aspects of our experience can remain immodified, but their relationship with the complex pattern of physical stimulation and physiological response,
gives reason of all their characteristics, either veridical or not. Another argument against the relevance of the counterposition visual illusions / physical reality is the pluridimensional characteristics of perceptual variations in correspondence of only one-dimensional changes in the physical world (brightness and hue against intensity of a monochromatic radiation, and many other examples).

The attractive appearance of stained glasses and other optical illusions in arts is most often due to the rapid changes and instability of their perceptive characteristics as consequence of easy and frequent changes in the context (direction of observation, illumination, perspective, and so on). The observer becomes aware of the discrepancy between the flat surface and the three-dimensional object which is perceived at the same time. Variations in surface colour and illumination which are perceived as interdependent and as a function of subjective attitude, or direction of observation, or some other factors, are source of amazement and pleasure for the observer both when this happens in art, in architecture and in scientific research (papers by Caan, by Bergström, Gufström and Jacobson, by Häggström, G & D. Brino). On the other hand only scientific research can point out some effects which seldom appear at a conscious level, as the correlation of many aspects of visual characteristics and patterns of the correspondent stimulation (papers by Archer & Högman, by Giannini, Bonaiuto et al., and by Caivano).
Basic color terms are those that are both general and salient. In their influential Basic Color Terms (1969), Berlin and Kay argued that although the world’s languages have different numbers of basic color terms, ranging from two to eleven, the focal (best) examples of the referents of basic color terms in a language tend to cluster in Munsell color space with those of their counterparts in other languages. Furthermore, the number of basic color terms in a language predicts what the referents of those terms will be. On the basis of this, Berlin and Kay postulated an evolutionary sequence of basic color term development. In the last 25 years, the quality and quantity of data have been greatly improved, thanks largely to the Mesoamerican Color Survey (MacLaury) and the World Color Survey (Berlin, Kay, and Merrifield).

Although the details of the Berlin-Kay evolutionary sequence have been criticized by many scholars, and the sequence substantially revised, particularly by Kay and McDaniel, the basic claims have been confirmed, and those claims invite interpretation in terms of innate perceptual and cognitive mechanisms. That the mechanisms are indeed innate is supported by both infant and chimpanzee studies of color naming, which are consistent with color naming by adult native speakers of European languages, as studied by Boynton, Sivik, and others. The location of the foci of basic color terms and the order of their appearance in the Berlin-Kay evolutionary sequence indicate that the six Hering elementary colors have a central role to play. However, there are many features of the data and theory that are not explained by an appeal to simple opponent-process models. These include the naming of some but not all binary colors by basic terms, the failure of many salience tests to distinguish between Hering basic terms and the other basic color terms, the strikingly unequal size and distribution of basic color categories, and the early-stage formation and subsequent asymmetrical dissolution of macro-categories, such as "warm-light" and "cool-dark" in languages that have but
few basic color terms. The invariability of some of these sequences-e.g., the warm categories always break up into red and yellow categories before the cool categories are resolved into green and blue—suggests that they derive from biologically-based perceptual saliences. Some very preliminary-though provocative-work has been done to investigate these questions. One experiment seems to tie the warm-cool division to the levels of opponent-channel activation, and another suggests that color categorizations by individuals may replicate the Berlin-Kay sequence.

All of these questions merit the attention of psychophysicists as well as cognitive scientists. At stake is the possibility of framing a coherent account of how a piece of language is fitted to perception. Potentially, it is a story that reaches all the way from neurobiology to human culture; it is the only such story that now lies within our grasp.
COLOUR IN FOLKLORE

In general there are two reasons for our behaviour. We obey the law, whether it is statutory law, or perhaps the opinion of a group of designers on what colours are fashionable. The second motivation for our actions is driven by our personal customary way of life; our oral tradition. This paper deals only with the second motivation. Where appropriate, this account of colour in folklore will be supplemented with evidence from the disciplines of anthropology, ethno-logy and archaeology; all deal with human behaviour.

Although human beings may be able to distinguish over 20 million colours, only fourteen colours and colour related words contribute significantly to folklore. Folklore is dependent on the individual and the culture, and colour is used in three ways. It is a concept or symbol, or an adjective that describes, or is as a colour appears in most of real life, that is, in contr-ast with other colours. A number of principles accounting for these uses will be postulated.

In many cultures the major colours are used to symbolise both positive and negative emotions. For example, green symbolises, among other things, natural growth, resurrection, immortal-ity, as well as poison, envy and melancholy. In fact all normal connotations are derived from the appearance of green in spring and from the colour of natural decay. A Principle of Singularity can be postulated. This states that a colour, to one individual at any one time, can be a symbol of one emotion. At other times the same colour can have other symbolic meanings. This principle can also be seen at work in the supermarket – package colours mean what the marketing men say they mean. The customer has no problem when scanning from shelf to shelf and associating the same colour with a number of different products. This phenomenon seems to arise from the very nature of colour per-ception. Colour is not a concrete property of a surface, it occurs in the brain, and hence can be interpreted in any way personal to the perceiver.

The Principle of Adaptation of Physical Resources accounts for the choice of most mourning colours throughout the world. The Principle of Adaptation of Ideas may be postulated to account for regional varia-tions in folklore. This states that, in order for a myth to survive within a community it must have relevance to that community.

Colour has different functions. In amulets it acts as a visible declaration of belief, which no doubt acts as a psychological reinforcement of purpose. Where an omen or indication is concerned the function seems to be merely an adjective, a means of easily identifying the subject, e.g. “Red hat, no drawers”.

Colours are similarly used in narrative, certainly they are used to heighten atmosphere. The function of colour and appearance in custom and belief is to set apart an occasion (such as seasonal decorations), or site (such as a laying-out area), or an individual (such as a bride at a wedding). Some colours worn by the bride are displayed but some, interestingly, are hidden. Blackened faces seen in some festivals are intended to frighten. In some rites the use of specific colours is vital and every effort must be made even by the poorest of families to comply. However, in many customs the use of specific colours is irrelevant; any colours will do because it is the difference in appearance which is important.
The colour triad of white, black and red, recognised by anthropologists as occurring in all body decoration, can also be found in archaeology, linguistics, folk stories and folklore. Studies of primitive languages have established that they are always the first three colour names to be included in a vocabulary. The same three colours have their counterpart in human description; people are fair, dark or red headed. Where animals occur in folklore they are often white, e.g. snails and horses; or black, e.g. dogs, cats and cocks; or less often red e.g. cows. For some cures white metal (i.e. silver), black and red were once prescribed for cures. References to other specifically coloured objects are also found. Many relate to salt, soot, coal, coral and the red-berried rowan. Examples have been found in which a colour (say, in the form of thread) has been used to replace a cure (such as a specific plant). Black food, such as the traditional Scottish black bun and black pudding, reinforces the black or dark-haired@man tradition at New Year.

The choice of black and white as two of the three colours in the triad seems sensible. They are highly contrasting and easily available either as a result of fire or from clays. It might be argued that the wide availability of reds, from minerals, burned earth and vegetation, renders its choice as a third contrasting colour automatic. However, there is evidence that the choice of red is more than coincidental – it is the colour of blood.

The Principle of Caring Like with Like holds for colour. For example, cures for yellow jaundice may incorporate an infusion of the yellow sap of the barberry, or gin or beer containing saffron. Alternatively, the jaundice can be flushed from the sufferer into some suitably coloured animal, such as the yellow wagtail.

Colour forms only one part of the Total Appearance of an object. Colours are used in order that a message be communicated and/or to make the object look good. Aesthetics is a personal view of the perceiver. On the other hand, the message, such as the colour of the bride's dress or the meaning of a Bantu letter of coloured beads, is communicated using codes known to members of that particular cultural or family group. Colour forms part of the tribal code and hence is a method of bonding members and excluding strangers. As an extreme, there is evidence that in certain circumstances colour has a sacred nature.

Folklore is dynamic in nature and changes as we continually adapt to our environment and social situation. Conclusions as to the driving forces behind our customs and traditions are economic, historical and social in essence. Colour is a powerful stimulus and motivator that can be used in different ways to control our actions, direct our lives and to make life a joy, or a misery. This may have been the case ever since early man learned to hold a piece of ochre.

Bibliography


CONSTANCY OF SURFACE COLOURS IN LIGHT AND SHADOW IN CHILDREN

Usually we speak of colour constancy when the colour of objects does not change although some environmental modifications are introduced. The environmental changes which are most commonly studied deal with the spectral composition of the illuminants. Many theoretical models try to describe how the object colours appear unchanged although the spectral composition of the light reaching the retina is different, and the universal assumption is that our visual system can perform a series of calculations which lead to a constant result from different starting points. Often the phenomenological aspect of the colour constancy problem is shortly considered stating that constancy is not perfect. Deviations from perfect constancy are seldom investigated from a psychological point of view, and usually only well limited cases are considered to support a particular psychophysical model which is proposed.

In this research we wanted to describe how the same coloured object appear under different levels of illumination, i.e. what kind of colour shift an object shows passing from light to shadow. The main goal is therefore to study the effects of different illumination levels and not the consequences of differently coloured illuminations (and neither of different spectral compositions of the illuminants): in our specific case, we studied the colour changes as results of different expositions of an object with regard to light and shadow (considered both as conjoined and cast shadow). As there are two main schools dealing with perceptual phenomena, we wanted also to afford the problem of whether colour constancy is a direct effect of learning, as assumed by the empiristic view, or is a characteristics of our visual system, as pretended by the innativistic view. In this research we focused our attention on the performance of elementary school children, making few comparisons with adults tested in the same way. Results will be discussed at the light of the possible kinds of development which colour perception undergoes with age.

Preliminary observations were made by showing subjects the three faces of a cube, put over a table, and asking whether they were covered with the same or with different paper. If the answer was of different paper, we then asked which was the lightest and which was the darkest. Many different combinations of equal / different coloured papers taken from the Y30R hue, were covering the three faces of the cube and they were presented either equally illuminated or only two equally lit and the third in shadow. 42 elementary school children and 15 adults, all with normal colour vision, took part to the experiment. Overall results indicate that children often show an over-constancy, i.e. an over-estimation of the shadow effect with the consequence that colours in shadow are judged lighter than the same colours in light; the adults in general make correct responses, showing a fairly good constancy. Nevertheless for both groups of
subjects an interesting effect appeared, according to which the horizontal face was often judged different from the vertical ones although both were exactly the same in colour and in illumination, while two vertical faces, although differently oriented in the third dimension, did not show this anomaly.

A more structured experiment has been devised to study the effect of cast shadows on colour constancy. In a previous work, da Fos & Urelanda found that in a pictorial image, in suitable figural conditions, two sides of an object lying in different planes appear of the same colour, one lighted and one in shadow, if their hue is the same and their nuances lie either over equal whiteness or equal saturation lines; the two sides appear differently coloured in the other cases.

We wanted therefore to verify whether judgements involving colour constancy, given by children as regard to objects lying in light and in shadow, were in agreement with these results, and possibly along which direction inside the NCS triangle probable deviations from perfect constancy could be traced. In a first part of the research, three nuances of the R70B hue were observed in natural light, while twelve nuances of the same hue, included the three mentioned, were observed in a shadowed surface. The same subjects employed before had to identify which of the twelve shadowed nuances was cut from the same paper of each one of the three lighted nuances. For the less chromatic illuminated sample, answers were in good agreement with the hypothesis, i.e. deviations from colour constancy pointed to colours lying along equal whiteness lines, while for the two other illuminated samples the answers were quite spread around them. Deviations from colour constancy were shown both by children and adults; as consequence of the correction for the shadow effect, more colourful nuances were on the average chosen.

In the second part of the research the four unique hues have been studied, asking the subjects, belonging to a different elementary school, to perform the same task as before, i.e. to point at the colours which were judged cut from the same paper as the standard ones. In this case two standard nuances were chosen from each unique hue and compared with ten nuances of the same hue: the standard nuance was once put in light and the other nuances in shadow, and once the disposition was reversed. Two more cases have been examined in which the 20 50 nuance of the Green and Red hue has been compared with nuances taken from the hues B80G - G - G20Y and Y90R - R - R10B respectively, to reveal possible hue shifts along the axis of cold/warm colours. From the rough data it is presently difficult to individualize a well defined trend: the results of successive elaborations will be commented with reference to the general work and the previous results.
A Two Stage Evolutionary Model for the Computer Aided Design of Colour Combinations

Design that involves the selection of several colours in combination is problematic from a number of points of view. Two of the most obvious and troublesome problems are those of the combinatorial size of the task and the complex interaction between the colours making up the design. The proposed model of Computer Aided Design directly addresses both of these problems and largely circumvents the second problem.

We can discriminate a large number of different colour sensations and their possible permutation into combinations is vast. It is not feasible for a designer to consider every possible arrangement.

It is well understood in both the artistic and scientific communities that the appearance of a colour is strongly influenced by the colour of its surroundings. This poses a great difficulty for the designer since most design processes require them to choose each colour individually estimating its eventual appearance when integrated into the whole design.

The proposed approach is based on evolutionary computing techniques and employs human computer interaction techniques similar to those originated by S. Dawkins and developed for 3D computer graphics design by Latham. Here the program generates a selection of arbitrary designs that the designer evaluates and then makes selections. The program then produces more designs but which now take some account of the designer's previous choices. This process is then iterated until a satisfactory design is evolved. This circumvents the problem of colours changing their appearance with varying visual context since selections and evaluations are made between complete combinations at every stage. It also provides an effective way for artists to explore complex design problems and further it insulates them from the internal model used by the program. The program might manipulate psychophysical representations of colour but the designer is only required to appraise its appearance.

A weakness of this approach is that it may be difficult to find a starting point for the gradual evolutionary improvement of the design provided by this type of interaction. Even at the outset designers often have a hazy conception of the general type of design that they wish to work towards.

This suggests a two stage process in which the designer first arrives at some general characteristics that can be satisfied by a large number of designs and then in the second stage a single design is evolved within a search area that is confined to designs having those characteristics.

During this first stage the designer is presented with designs that are arranged in groups. Design evolution proceeds through evaluation and selection of these groups until a group is found that have some of the characteristics required by the designer.

The second stage is the same as the conventional one stage evolutionary process except that the designs presented are constrained to those that satisfy the characteristics arrived at in the first stage.

This raises a question as to how the program can devise groups of colour schemes that share some common characteristics or that seem to show a family resemblance. There are a variety of com-
puter techniques such as iterated optimisation, simulated annealing and evolutionary algorithms that can search for designs that have certain characteristics. These techniques require a method of deriving a numerical value of goodness based on the degree to which any given colour combination does or does not conform to the specified characteristics. It remains to be discovered which characteristics are most relevant to this early stage of the design process and whether they can be defined in a way that allows a measure of goodness to be derived.

For the two-stage model to be useful, the minimum requirement would seem to be that the designer can recognise the similarity between the designs offered as belonging to a group and that this categorisation is found to be useful. This suggests that it is reasonable to proceed by implementing some versions of the model based on very simple criteria for categorisation testing these and then proceeding to develop more sophisticated criteria. A prototype program has been produced and it is intended to test it using a number of simplified criteria for categorisation. These include the integral colour (simple averaging of RGB values), maximum and minimum lightness (CIELAB L*) and average chroma (CIELAB C*). It is proposed to trial these versions of the program with practising designers to establish whether they recognise the groups of colours as having common visual characteristics and if these characteristics are found to be useful. Preliminary informal testing indicates that even these very simple types of criteria have some value in identifying an area in which to carry out a more refined search for the final design.

A hypothesis of this research is that better criteria can be developed by employing the descriptions of colours in combination advocated by Häré. More ambitiously it may be possible to specify the groups of colours by their meaning perhaps using the dimensions of potency, activity, evaluation and warmth indicated by Štvik's research or warm/cool, soft/hard and clear/greyish arising from Kobayashi's work. This will probably demand techniques such as pre-trained neural networks in order to derive a goodness value based on this type of criteria. For this reason the work of Feldman who identifies a single dimension of magnitude that combines activity and potency may provide a useful starting point since magnitude has a relatively simple relationship to specification of the colours making up the combination.

Compromises may have to be made between type of categorisation employed and the computational expense involved. Designers may be willing to accept an imperfect method of categorisation in return for a fast response from the program. The main advantages are that colours are assessed in combination at every stage and the process can be embarked upon while the designer's ideas are as yet vague and unformed but the process ends with fine discrimination between subtly different design solutions.

Bibliography
COLOR ASSIMILATION OF STRIPS DISPLAYED TOGETHER ON CRT WITH A DARK BACKGROUND

Introduction
In a dark environment, we can observe color assimilation between closely positioned light-emitting color strips. For instance, if we see a red strip and a blue strip which are closely positioned against a dark background, both strips appears to approach purple. This phenomenon, curious from our daily experiences of color contrast phenomenon, could suggest an important aspect of visual information processing under the condition in which possible lateral inhibition caused by surrounding light stimuli is absent. We report on our experiments on color assimilation [1] of strips displayed close together on CRT against a dark background.

Methods
We used a 400 * 640 14" color CRT (NEC, PC-KD854 N). The color of each pixel was adjustable by varying the digital value of its R, G and B elements from dark (R, G, B) = (0, 0, 0) to the white (255, 255,255). We measured the luminance of primary colors R = (R, 0, 0 ), G = (0, G, 0 ), and B = (0, 0, B) at R, G, and B values from 0 to 255 with a test pattern wide enough to cover the view angle 2' of our luminance colorimeter BM-7. We used the obtained three calibration curves to convert digital values of primary color components to the intensities in terms of luminance (Cd/m2).

After dark adaptation, a pattern consisting of a strip induction field, a test field and a comparison field was presented for 1 s on a CRT placed 90 cm from the subject's eyes. The induction field and test field were presented in different primary colors selected from R, G, and B with maximal digital values of 255. The comparison field was initially presented in the same primary color as the test field, e.g. R = (255, 0, 0). The subject, with eyes fixed on the mid point between the test field and the comparison field, added the color component of the induction field (e.g. B = (0, 0, B) ) to the comparison field until the color of comparison field now with a digital value (R, G, B) (e.g. (255, 0, B) ) matched the apparent color of the test field. Then we evaluated the intensity of the assimilation by the intensity of the added color component (e.g. B) expressed by the luminance.

Results
With an adjacent induction field of a single pixel width, we observed the color appearance of the test field varying the width w of the test field. When we used the color B or R for the inducing field, we observed color assimilation in the test field; the color appearance of the test field changed uniformly within the field as if some amount of color of the inducing field invaded the test field and had uniformly spread therein. However, we could not see color assimilation when the inducing field was red and the test field was blue. Neither could we see assimilation when the inducing field was green.
In cases of \( w = 1 \) pixel (\( = 1.6' \), the test field is a single row of pixels) and \( w = 2 \) (\( = 3.2' \), a double row of pixels), the luminance of the inducing color component added to the comparison field to match the test field was equal to the luminance of the induction field. In these cases, the color of the comparison field was a mixture of the colors of the test field and the induction field at full intensities. For a wider test area, the intensity of assimilation decreased along with the width just as if the "invaded" induction color was diluted in inverse proportion to an effective width \( \omega = w - c \) of the test field where the values of modification term \( c \) are \( c = 1 \) for the blue induction field and \( c = 1.5 \) for the red induction field.

Our observation that the color assimilation occurred uniformly to the same extent throughout the test field and that the intensity varied with the field width suggests that the visual system, decomposing visual scenery into elementary uniform areas on the basis of primary visual information, assigns a perceptual color bias to each area calculating the spatial interaction among color signals.

If the visual system is to assign the extent of color assimilation to every uniform area according to the width and to the distance from the inducing field, assimilation is expected to change if the test area is divided by a dark line. In fact, when we divided the test field with a dark line, the assimilation of the half adjacent to the induction field was intensified while that of the remainder was weakened.

Using three single pixel width strip fields, we investigated the dependence of assimilation on the distance between the inducing field and the test field. At a distance of 1 pixel (\( = 1.6' \)), the perceptual color of the test field was the same as would be perceived when the color of the inducing field was wholly superimposed to the test field. With a blue inducing field, the assimilating effect reached a distance of 15 pixels (\( = 24' \)) which was greater than the maximal width (8 pixels \( = 13' \)) of the test field up to which the assimilation was observed. On the other hand, with a red inducing field, the maximal distance was 4 pixels (\( = 6' \)).

Our results show that each primary color induces assimilating effects reaching a distance specific to that color which is about ten times longer than the distance of the spatial sum. Hence, it seems that the process of assimilation is based on R, G, and B signals rather than on the opponent color signals.

References

Newton described his experiment with the prism in 1666 with the statement: "The Rays are not coloured. In them there is only a Disposition to evoke a Sensation of the one or the other Colour ..."

He also wrote: "... if at any time I speak of Light and Rays as coloured, I would be under-stood to speak not philosophically and properly, but grossly, and accordingly to such Conceptions as vulgar People ... would be apt to frame*. Try to imagine of this room filled with coloured rays crossing it in all directions from all objects to all eyes herein. No, we do not see any coloured rays, and no white rays either, but how do we then describe their 'Disposition'? Newton was reluctant towards the then very new wavelength theory of light and simply used terms like Yellow-maker, Orange-maker, Red-maker etc.

I do hope we will not have any vulgar speakers in this symposium. Being myself a physicist, I often feel ashamed for my colleagues who keep misinterpreting the prism experiment, talking about white sunlight being split into a spectrum of coloured compo-nents etcetera. They also define 'colours' by their wavelengths. Nevertheless, we have also seen many brilliant exceptions. The Young-Helmholtz theory of colour vision, Grassmann's laws for radiation mixtures and Maxwell's colour photographs, all showed that leading scientists very early realised that no direct causality exists between the spectral composition of the radiant flux and the evoked colour sensation. This is the result of these receptors stimulated by at least these kinds of stimuli transmitted by these differently filtered photographic plates. All this happened between the end of the eighteenth century and the midst of the nineteenth century. In 1874, Hering postulated that when thinking about colour, "we must disregard altogether the causes and conditions of their arousal. Neither the qualitative nor quantitative physical proper-ties of the radiation are relevant." In five words: "Colour is what we see". Based on seeing col-ours, Hering pointed to the polarity of greys between black and white and the existence of two pairs of antagonistic hues, yellow/blue and red/green, which he called Gegenfarben. These six colours are pure colours, and the only colours, in which there can be found no similarity with any of the others. All other colours can be described by their similarities to the pure colours.

Hering's idea was difficult to fit in with what one then knew about the three retinal receptors, and caused a long dispute between the physical and psychophysiological schools of colour. Its acceptance was eased, when von Kries described colour vision as a two-stage process. In the first stage of this 'zone theory', the physical stimuli generate signals in the receptors of the retina, which are sent to the cortex for further processing to the colours we perceive.
Recently I had reason to pick out my German textbook in optics, written by a physicist for an advanced physics course. The author sets out with a bedroom experiment. If you pull the blanket over your head and press the thumb in the corner of your eye, you will see light and colours, that are definitely not caused by any wavelengths or any 'coloured light'. The conclusion is that in the science of optics, the topics of light and colour are beyond the realm of physics. They belong to psychology and physiology. When Land was experimenting with the colour film for the Polaroid camera and a filter dropped from one of the three projectors, he still saw very much the same colours on the screen. This led him to the conclusion that spectral distributions of stimuli are less important for the colours we see than the contrasts between the elements of the visual field. The colours do not exist in front of the eye. They are produced in the brain, in the second phase of the zone theory.

Many less well-educated scientists and technicians still believe in the causality between stimulus and colour response, dismissing all deviations as illusions. All colours around us always interact, changing each other by simultaneous contrast. We can therefore know for sure, that all samples in a colour atlas look wrong, unless we pick them out and view each of them isolated against a neutral background. We also have a successive colour contrast. If we turn the pages in the NCS atlas, e.g. from -R towards -B, the samples on that page already appear greenish. But going backwards, coming from -G to -B, the same samples are purplish. Which are their true colours?

At the last pre-AIC congress in Lucerne 1965, W. D. Wright, professor in physical optics and one of the fathers of the CIE colorimetric system, spoke about 'The meaning of colour'. He had always been anxious to point out, that colorimetry is only able to predict, whether two or more stimuli may evoke the same sensation of colour in our mind. It cannot describe the appearance of this colour. In Lucerne he described, how, in spite of Newton's warnings about the coloured rays, we tend to perceive the colours around us as associated with the objects they appear to belong to, or to be the properties of. In daily life, we continuously profit from these relations between objects and colours, using them to judge the ripeness of fruits, the freshness of meat etc. Nevertheless, said Wright, "... colours cannot exist unless there is an observer to perceive them". By then, the physiologists had begun to catch up with measurements of the actual receptor functions. At the first AIC meeting Colour '69 in Stockholm, a new set of receptor functions were shown. Once these were accepted, the interest focused on the next stage in colour vision, with an obvious interest to explain the observations of Hering. Today the study of how the brain evaluates the receptor signals is at the forefront of science.
Appearance Problems Related to Computer-Generated Patterns on a Phosphor Display

The cut-and-patch procedure, used in visual laboratories some decades ago, is now progressively being replaced by the computer-generation of targets on phosphor displays. Through proper e-mail nets, it is possible to become acquainted with the softwares available in various laboratories on the face of the earth, and often meetings are organized, to discuss the advantages and limitations of computer generation, not last in relation to display "quality".

In this connection, let us recall that in the recent literature some "events" are quoted as undesired artefacts, from one viewpoint, while they represent a precious visual effect from another viewpoint, and, under some other respects, they are regarded as "illusions". Now, all it might be covered by the umbrella of appearance, by invoking the versatility of computer generation performance in the spatio-temporal-chromatic realms.

The "effects" which can be easily displayed on a color monitor have been recently discussed by J. Walsaven. The list of those which are more strictly related to color vision includes: small field tritanopia, degradation of color vision as a function of eccentricity, Bezold-Brücke shift, Abney effect, chromatic induction and/or contrast effects, chromatic adaptation, after-effects, McCulloch effect, "fluttering hearts", assimilation, visualization of the consequences of eye chromatic aberration, tests for defective color vision. All these and other effects are properly tackled by the VIAE (Study Group of AIC, Visual Illusions and Effects).

The present talk aims at describing, in a context different from the above one, an experiment performed by us, by the use of a simple software, which allows to generate a plethora of visual effects, in various transient-steady paradigms. In additional to the "educational" value, we think that the set of our stimuli may be of help in understanding the common root of some visual facts which, traditionally, have been investigated as quite distinct phenomena, and now they appear as facets of the same problem.

This is the case, for instance, of transluency (or transparency) versus discounting the background as well as of incomplete color mixing.

Briefly, our observers are presented with a uniform patch, subtending at the eye about three degrees, surrounded by dark gray, in a booth where general lighting is controlled. The stimulus consists of a sequence of pairs of pulses. One is of fixed luminance, while the luminance of the other is variable from zero to the maximum instrumentally available. From the viewpoint of appearance, the low frequency range is interesting at most, there-
before we limit ourselves to consider the frequencies in the range from 0.8 to 6 Hz. If, every other thing being equal, at, say, 2.5 Hz, we increase the luminance of the latter pulse in a pair, the flicker fusion, more or less biased by the "residual flicker" is reached. This peculiar condition is flanked, on either side along the luminance scale, by the flicker/swell range, where the eye may be treated as it would behave approximately in a linear fashion. However, the appearance becomes more and more variegated and complex when the flicker range is exceeded, and one enters the range where the non-linearity of the visual response results in a number of "effects" which have been attracting the interest of psychologists during the past decades and which have been investigated separately, while a simple software allows to visualize all them, sequentially, even by varying the experimental parameters in a broad range.

For instance, the "blackness" perception may be easily investigated, for monochrome sequences, in a narrow range for luminance/frequency combinations, between the borderline of "very strong flicker" sensation and the appearance of "stroboscopic patterns", in connection with the dependence of perceived hue with pulse duration and, for heterochrome sequences, with successive contrast effects. In turn, the equiluminous/non-equiluminous paradigm is easily met, so that the "silent substitution" may be easily identified. The various components of the temporal modulation transfer function may be thus easily investigated, at various distances from the fusion conditions. This renders easily accessible the manipulation of parameters, when studying "suprathreshold" vision.

Moreover, it can be easily demonstrated how to go beyond the early vision. For instance, the spatial structure of the patch may be rendered increasingly complex, e.g. by simply applying transparencies on the phosphor screen, and the luminance/frequency dependencies of various effects may be investigated. This is the case, for instance, of the "depth shift" of one of the components of transparency, by using Inglis and Grisby's illusory Necker cube, together with Watanabe and Cavanagh's patterns.


ESTIMATED BLACKNESS AND WHITENESS IN CHROMATIC COLOURS

1. Introduction

E. Hering said that we see six elementary colours; such as Yellow, Red, Blue, Green, White and Black, in which we cannot see any other colours but itself. And all colours we see are made up from these elementary colours, for example we can see Redness, Yellowness, Blackness, and Whiteness in a Brown, and we also can estimate the degree of these elementary colours. NCS uses this method to describe colours, then any colour can be described by estimation of all elementary colours which we can see in the colour. By NCS, elementary colours which are seen in a colour are able to be estimated numerically; and the sum of the numerical values of all the elementary attributes is 100, just the same as colour mixture by Maxwell disk. To make the sum of numerical values 100 means that an increase in an elementary colour is equal to a decrease in other elementary colours which we see in the same colour. Although this is of course in the Euclid space, we know many perceptual phenomena which are not able to be described in the Euclid space. It is necessary in order to understand our visual system that each numerical values of the elementary attributes is measured independently. In our experiment, the amount of Blackness and Whiteness in achromatic colours were measured independently.

2. Method

The experiment was done by the method of magnitude estimation. Observers watched achromatic colour papers, and they estimated Blackness or (not and ) Whiteness in compare with elementary colours in one’s mind. They were instructed to estimate either Blackness or Whiteness in the stimuli, never to subtract other alternative from 100. They also instructed that they should report in the case that they see any other elementary colours but two achromatic elementary colours. As stimuli, 38 achromatic colour papers were presented under the approximately 1000lx illumination of D65 simulator on a Grey background. The CIE Y(%) of these stimuli were variations from 87.49% to 0.3% (Tab. 1). The visual angles subtended by the stimuli were 1015. Three subjects were measured, all of whom had never known NCS.

<p>| Tab. 1 CIE Y of experimental stimuli. |</p>
<table>
<thead>
<tr>
<th>No</th>
<th>Y(%)</th>
<th>No.</th>
<th>Y(%)</th>
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<th>Y(%)</th>
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<tr>
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<td>43.16</td>
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<td>15.78</td>
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<td>3</td>
<td>78.24</td>
<td>13</td>
<td>36.29</td>
<td>23</td>
<td>11.89</td>
<td>33</td>
<td>2.05</td>
</tr>
<tr>
<td>4</td>
<td>73.06</td>
<td>14</td>
<td>32.98</td>
<td>24</td>
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<td>1.67</td>
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<td>9.16</td>
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<tr>
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<tr>
<td>10</td>
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<td>20</td>
<td>17.49</td>
<td>30</td>
<td>3.98</td>
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</tbody>
</table>
3. Result

The results obtained for the three observers were similar. Blackness which were estimated by observers decreased as Y of stimuli increased, and Whiteness increased with Y of stimuli (Fig.1). Neither the decreasing of Blackness nor the increasing of Whiteness was linear. Blackness which were estimated in a stimulus was equal to Whiteness of the same stimulus of which Y was approximately 25%. At this point, neither the estimated value of Blackness nor that of Whiteness was 50, however the achromatic stimulus in which the Blackness was estimated were same as that in which the Whiteness was estimated. None of observers reported to see any other elementary colours but Black and White.

At every 38 achromatic stimuli, the sums of Blackness and Whiteness which was estimated in the same stimulus were less than 100. There was no achromatic stimulus of which sum of Blackness and Whiteness was equal to, or more than 100. This differences between 100 and the sums of estimated Blackness and Whiteness were not constant (Fig.2); the differences were very small as long as Y of the stimulus were high, and the difference increased with decreasing Y of the stimulus. And the difference became largest in case that Y was approximately 25%; i.e. when Blackness of the stimulus was equal to Whiteness observed in the same stimulus.

4. Discussion

The fact that the sum of Blackness and Whiteness was less than 100 means Blackness and Whiteness were underestimated. There was no observer who saw any other elementary colour but Black and White. The 5000 of NCS notation means the appearance of Y5%. The data shows that observers see the same amount of Blackness as Whiteness when Y5%, however the amount of them are nearly 40. As a result, it is suggested that the percept of elementary colours are not described in the Euclid space.

The observer reported that when Y was high, Whiteness increased slightly with a increase in Y, but Blackness didn’t decrease anymore. This report suggests that Blackness and Whiteness are different from lightness. However observers could recognise the changes of lightness of achromatic colours, they could not see the changes of Blackness or Whiteness. It is, therefore, very difficult to indicate apparent lightness of achromatic colours by means of using Blackness and Whiteness. It is obvious that lightness of colour is accounted for inputs of retinal cells, i.e. retinal processing. But it can be assumed that percepts of elementary colours, e.g. Blackness and Whiteness, depends on higher processing than lightness. Being instructed to answer the ratio of Blackness and Whiteness simultaneously, observer may be able to divide 100 between Blackness and Whiteness. However it means much to describe apparent colours by estimating elementary colours, it seems to be different from human perceptual mechanism of colours.

![Fig. 1 The Curve shows the relationship between Estimated value for each stimulus and CIE Y of the stimulus. ■ shows Blackness, ○ shows Whiteness.](image1)

![Fig. 2 The difference between 100 and the sum of Blackness and Whiteness are plotted as a function of Y. The maximum value of estimation is shown at Y=25%.](image2)
1. Introduction.

Our perceptual world has become more and more colorful and this may sometimes impair our impression of visual comfort of environment. It is important to investigate a psychological method to evaluate our visual environment of a wide color distribution. There are few studies available on this point 1. In the present study we have investigated and proposed the following two methods for evaluating colored images in terms of visual comfort.

2. Number of categorical colors.

In this experiment, it was aimed to measure the number of categorical colors contained in an image and to correlate it to the subjective estimation of visual comfort. A total of 36 colored images of natural interior or exterior scenes taken by video camera from printed materials was prepared to be presented on a CRT display. The subject was presented each colored image for 5 second and was asked to report all the perceived colors in the image according to the categorical color naming technique 2. On the other hand, the subject was asked to estimate visual comfort of the image in a 11 point scale from 0 (most discomfort) to 10 (most comfort) and this estimation data was used to see the correlation with the number of categorical colors reported. A total of 25 subjects participated in the experiment.

![Figure 1](image)

In Figure 1, the correlation between the number of colors and the comfort estimation, both averaged over the 25 subjects, was shown. The abscissa means the averaged number of categorical colors of an image and the ordinate the averaged comfort estimation. There are 36 data point plotted in the figure corresponding to the images used in the experiment. There found a negative correlation between the
number of colors and the comfort estimation as shown by the linear regression in the figure. This means that the larger the number of categorical colors contained in an image, the less comfortable the image is felt.

3. Optimum percent chroma.

Another experiment was carried out where we intended to obtain an optimum percent chroma for a whole image by asking subjects to continuously adjust the chroma of all the pixels in the image at the same time relatively from zero (achromatic image) to 100% (original chroma) while the other colorimetric quantities, hue and brightness, were kept constant and to set it at the most comfortable point along the chroma axis. The correlation between the optimum percent chroma and the comfort estimation was investigated for the same set of the 36 colored images.

Figure 2 shows the results. The abscissa is the optimum percent chroma averaged over the 25 subjects and the ordinate the averaged comfort estimation. It is clearly shown that there exists a fairly good positive correlation between the comfort estimation data and the optimum percent chroma. This means that the less comfortable image is apt to be seen in a reduced chroma near an achromatic image while the comfortable image can be seen in nearly original chroma without any change.

4. Summary.

The two experimental findings above mentioned suggested that the visual comfort of a colored image could be reasonably evaluated by the number of categorical colors contained in an image and the relative amount of chroma of a whole image but not of a particular part of an image.

References:

The Aesthetics of Recognition
- An Important Aspect of a Colour Harmony Theory

Most people working with choosing colours know that colour is a very complex field and that it contains unlimited possibilities. Some, especially artists, spend all their life experimenting with colours. For people working with environmental design, colour is however only one of many aspects to consider, and the active work with colour normally occurs in short periods at long intervals. What kind of knowledge is available for these professionals who want to develop their confidence in handling colours? Is this knowledge relevant to their work with colour?

Available knowledge about colour in environmental design. Very little research about colour in environmental design has been carried out, and there are few books with any analytical ambition on this subject. The knowledge the architects and designers normally meet can be found within the following three categories:

The experiences of art painters about colours and the interaction of colours. Most of those who teach colour in architecture and design schools are art painters and thus their knowledge and experiences is a considerable part of what is taught about colour. This knowledge is mainly based on the most frequent pigments on an artist's palette, how they act in mixtures and what effects they have in a painting. Many artists have published their experiences and theories about colour, e.g. Albers, Lorenz and Kandinsky.

The connotations of single colours. In almost every book and article dealing with the use of colour, there is a list of colours or colour categories and their psychological meanings. Often it is an unstructured mix of statements about symbolism, associations and different kinds of psychological influence on man. Beside these popular and superficial lists there are more serious literature on research in this field (e.g. Lars Sivik's reports on colour connotations), but they are on the other hand often too complicated to reach the practitioners.

Colour combination theories based on colour order systems. Many creators and users of colour order systems, especially those illustrated by systematically selected colour samples, have been fascinated by the sequences of colours that can be achieved along lines or on sections in the colour space illustrating the system. These systematic similarities and relations are often used as a means in colour design and colour education. In connection to some colour order systems, e.g. Ostwald's colour system, there are complete colour harmony theories, with rules how to combine colours in different ways.

Anders Hied and Lars Sivik have developed a descriptive, non-evaluating model for colour combinations. With its three main dimensions with three subdimensions each it is an interesting model for further research, but far to abstract to be useful for an architect or designer.

To choose colours in environmental design, I have myself used similarities and relations in accordance to the colour order system NCS as means in colour combination exercises in my colour courses. My experiences as an architect and colour consultant however have gradually made me realise that the kind of knowledge described above often has little or no relevance when choosing colours in environmental design.

Colour design seldom is a free artistic creation or a systematic combining of colours as such. The colour is achieved by a material and it belongs to an object with certain form and function. The colour shall contribute in expressing a wished character and shall interplay in a suitable way with the surroundings. Normally there are so many different aspects to take into consideration that the rules and advice built on the theories mentioned above, often are far too rough or sometimes misleading.

To obtain knowledge about colour in environmental design, one must study colours mainly in its real context with all the complexity this implies. As I am both teaching colour and practically working with colour design, I have had reason to be very observant of colours around me. I have tried to find out if there is any general pattern in when we experience colours to fit or misfit in an environment and how the colours influence if we find an environment beautiful or ugly, natural or full of contradictions etc. No theory will ever
give definite answers to these questions, but by illuminating different relevant aspects, one can reach a deeper understanding of colour in the environment. Here are some aspects, that all have something to do with recognition. In my discourse I will exemplify them with slides.

The natural relation of lightness. The theory of the natural relation of lightness implies that a composition of colours within a limited range, e.g. colours with the hue between yellow and red, will appear more natural, harmonic and often more beautiful if the colours with a hue closer to yellow are lighter and the colours with a hue closer to red are darker, in accordance to the relation in lightness between the pure chromatic colours with the same hues. If the relation is reversed with light pink colours combined with yellowish browns, the composition will appear unusual, disharmonic and often ugly. This theory I have not invented myself, but when the Swiss professor Werner Spillman presented it to me many years ago, I experienced it as an explanation of something I already recognized, both from nature and from environments created by man. Since then Karin Fridell Anter has confirmed the validity of the theory in her investigation Nature's Colour Palette (presented as poster).

The colours of nature as a reference and prototype. The colours of nature is an important reference in common to mankind. I am thinking partly of the untouched nature with colours of animals, vegetation and minerals and partly of the "natural" colours of the materials we take from nature and use in e.g. textiles, furniture and buildings. For many of those working with colour, nature serves as prototype and source of inspiration. In colour design of products and environments there has always been a considerable element of more or less consciously imitating colours and colour combinations of nature.

Common pigments give us typical colour scales. The supply of cheap and resistant pigments has in all ages and in all cultures characterized the colours in human environment. Right up to a few decades ago the normal way of choosing colour of objects or buildings was to select an appropriate pigment and than tint it with more or less white. Adjusting the colour with other chromatic pigments was an exception in traditional colour design. This can be confirmed by the fact that colours typical for the most common pigments so frequently can be recognized in our environment. These colours and colour scales therefore have got a special meaning for us and we often associate them with certain objects or contexts where they are normally seen.

Even if the way of choosing colours has been changed by the introduction of extensive colour atlases as means for colour design, many of these typical colours or colour scales still are alive and will survive. One reason is that the same pigments or dyes still are the best, another is that these colours have got so intimately associated with certain materials or objects that we experience them as more or less unified. A few examples:

- The typical blue colour of denim (blue-jeans).
- The black colour of iron forgings.
- The yellow colour scale of plaster facades, typical for Stockholm and many other old cities.
- The red, mat paint on wooden facades which colour is so characteristic for the Swedish countryside.

(See poster Colour Scales of Traditional Pigments for External Painting!)

The aesthetics of recognition. In my opinion one runs a great risk of coming astray, if one isolates colour from its context in studies of the meaning of colour in reality. Colours are always seen in a context and always get meanings beyond the colours as such, meanings that may vary in different contexts. We can choose colours that cooperate with or contradict the material and the object. The important thing is that we are aware that the interrelation between colour, material, object and context gives us information that influences the interpretation and evaluation of what we see. The recognition, that could be more or less conscious, is a fundamental part of our perception and an important aspect of aesthetics.
COLOUR AND THE EXPERIMENTAL REPRESENTATION OF STRESS AND COMFORT.

1. Experimental setting, procedures and results.

For five years we have been performing experiments with adults who are asked to remember stressful or comfortable situations they have been in and to represent them in drawings (Biasi & Bonaiuto, 1991, 1992; Bonaiuto, Biasi, Bonaiuto & Bartoli, 1993). In the obtained drawings, characteristics of colour (e.g. consisting of presence or absence, scarcity or abundance, distribution, tonality, saturation, etc.) play a meaningful role. It is possible to study the relationships of colour with other psychological variables.

According to the experimental setting, the subject sits at a table with light pieces of drawing cardboard (32x24 cm.), a black pencil, an eraser, a black pen, 36 coloured pastels, and 36 coloured pens. Subjects (19-39 years of age) are treated individually and include equal numbers of each gender. Each person is asked to represent their own individual stressful or relaxing real-life experiences. Each drawing session lasts 20 minutes.

In the first case (stress) the instructions, given orally to the subject, are as follows: "Now try to imagine and focus on a personal, particularly stressful, anxiety arousing, troubling and unpleasant situation. It can be a past experience or a present one, that you have felt in this way. Try to represent this experience with the materials here at your disposal. Do it freely, as you are able to, using whatever you wish...".

In the opposite treatment, another subject is asked to recall "... a personal, particularly relaxing, comfortable, pleasant and enjoyable situation ...". The remaining instructions are as above.

In either case, if there is enough time, the subject is asked to imagine and represent another situation of the same type.

The psychological effects of these drawing procedures are quite remarkable, considering two orders of consequences.

a) This non-intrusive procedure of drawing recollections of personal events induces very effective short term (reversible) states of stress or, respectively, comfort. Achievement of the programmed emotional states and the intensity of the main activated emotions, motivations, and impressions, are checked through the use of pre-post treatment self-appraisal scales. Influences upon cognitive and decisional processes are very similar to those we observed with classical, more demanding and invasive techniques of stress or relaxation (Bonaiuto, Giannini & Bonaiuto, 1989, 1990; Bonaiuto, Biasi, Giannini, Bonaiuto & Bartoli, 1992).

b) The graphic (non-verbal) languages, and especially the colour language, used on average in the two contrasting types of drawing appear clearly opposite, when independent examiners systematically evaluate their properties.

Recollecting stressful situations, subjects use on average a large quantity of black contours, and black and white representations (without colours). When chromatic colours are present, preference is given to cold colours, extreme contrasts and conflicting colours, dull colours, alarming colours, fragmented and less extended coloured areas. Together with a large number of straight lines, angular surfaces, simplification and executive hurry, colour inhibition or its selection and use appear expressive of conflict. These qualities also express negative emotions, aggression, defenses, avoidance of feelings.

On the other hand when recollecting comfort situations, subjects mainly use coloured contours, bright and warm colours, gradations, playful colours, uniform...
and more extended coloured areas, together with curved and continuous lines, circular surfaces, rich details, and executive accuracy. The types of colours selected and used, express attempts to solve and avoid conflict. Also they express positive emotions, well accepted needs, pleasure and prolonged contact with inner feelings.

2. Relations among colour, meaning and psychodynamic mechanisms.

The expression of meanings appropriate to the contrasting concepts of stress or comfort, through the use of colours in drawing stressful or relaxing situations, appears based on the concurrence of different principles and mechanisms.

a) One is the tendency to reach a similarity between the attributes of colour and the attributes of the phenomenal ego affected by the typical emotional states of stress or comfort. This principle is related to the general principle of expression through isomorphism (Arneheim, 1949). For this reason, e.g., dissonant colours are preferred to express conflict. Moreover, there are rules generally quite well known and accepted in communication based on colour: because of the above mentioned principle and those rules it is almost automatic that the use of alarming colours, such as violet, black, olive green, streakings of grey, yellow, and red, indicates stress. On the other hand playful colours, such as pink, light green, yellow, orange, light blue, white, indicate comfort. It is possible to check these relations by examining colours in cartoons and illustrated narratives, in fashion clothing, theatrical, film and other costumes, or colours in tests of expressive sensitivity, and colours in specific experiments on perceptual defense or facilitation (Bonaiuto, 1978; Bonaiuto, Gianinni, Biasi, Miceu Romano & Bonaiuto, 1996).

b) We also take into consideration a general principle of avoidance-approaching with respect to unpleasant or pleasant emotional states, as it is also confirmed by literature on Rorschach (1921) and other projective tests.

References
EFFECTS OF THREE COLOR SCHEMES ON OFFICE WORKER PERFORMANCE AND MOOD

The study assessed the effects of three color schemes on mood and worker performance in an office environment during a four day work week. The three color schemes studied were monochromatic white, predominantly bright red, and predominantly light blue-green color scheme. Since white is the standard color scheme for NASA's mock up habitation module, white was chosen to inform NASA of its effects on worker productivity and mood over an extended period of time in a confined space. The color bright red was chosen because past studies have suggested that vivid, warm colors like red produce environments that are perceived as confined, intrusive, and less conductive to productivity. Red has been associated with such negative effects. A light blue-green color scheme was chosen to permit a comparison of a predominantly cool color scheme blue-green) with that of a predominantly warm color scheme (red). Light blue-green is the compliment or contrasting color to the red color scheme. Also, workers in past studies have reported that they would prefer a light blue-green office environment in which to work.

With respect to how individual differences may impact workers' experience of a given color scheme in terms of productivity and mood, past studies on performance and mood have suggested that the ability to screen irrelevant environmental stimuli may play an important moderating role. Thus, the study examined how workers' experience of an interior color scheme may be influenced by his or her stimulus screening ability.

It was predicted that workers in the red office color scheme would be more adversely affected in terms of their productivity and mood than the workers in the blue-green office color scheme who would experience a more positive effect on productivity and mood. Second, it was hypothesized that individuals with low stimulus screening ability would be more adversely affected in the red office color scheme in terms of their productivity and mood than individuals who can more easily ignore environmental stimuli.

Workers were first assessed to establish the participant's ability to screen out environmental stimuli. They were categorized as screeners or non-screeners. Subjects, matched on relevant variables, were assigned to one of the three office color schemes. The sample consisted of 90 office workers with 67 females and 23 males. Workers performed office tasks that simulated actual working conditions. The workers were asked to type a manuscript, perform catalogue pricing, file index cards, and proofread text and zip code data during the course of a single day. Workers were also administered standardized measures of productivity and mood dispersed among their daily duties.
These tasks varied in the order in which they were conducted from day to day for the four days. Mood was measured by a paper-and-pencil questionnaire administered in the am and p.m. of each day. A test of speed and accuracy of proofreading was administered on the first day and again on the fourth and final workday. Each day started at 9:00 am and continued until 5:00 p.m. Each office worker was given two 15 minute breaks and a one hour lunch period during the day.

Preplanned comparisons were used to examine differences among color schemes on productivity and mood. Stimulus screening ability was treated as a covariate.

For productivity, workers who scored low on the stimulus screening measure (non-screeners) scored low on proofreading names in the red office, while the converse was true for the workers in the blue-green office. The reverse was true for those workers who scored high on the stimulus screening measure (screeners).

For mood, on average, higher scores for Confusion and Tension were reported by workers in the red office than in the blue-green office, while higher scores for Vigor were reported in the blue-green office than in the red office. Individuals who scored low on the stimulus screening measure (non-screeners) scored higher on Depression in the white office than individuals who scored high on stimulus screening (screeners).

In examining the effects of the three different color schemes on productivity, the results suggest that color schemes alone have no impact on productivity. Only when individual differences in the ability to screen out irrelevant environmental stimuli are taken into account did the color scheme have an effect on productivity. These findings are discussed as an extension of the Yerkes-Dodson principle. The findings on mood definitely suggest that color scheme alone may impact mood states in accordance with previous results. Furthermore, individual stimulus screening ability may act as a moderating variable influencing how people experience a particular interior color scheme.

The study was developed under a grant sponsored by the Institute of Business Designers Foundation (IBDF) and funded by BASF Corporation and Interface Flooring Systems, Inc.
EMOTIONAL STATE OF PEOPLE WHO EXPERIENCED THE KOBE EARTHQUAKE
- IN TERMS OF COLOUR PERCEPTION -

1. Introduction
On January 17, 1995 Japan experienced one of the most disastrous events in its history, the southern Hyogo earthquake. This earthquake was epicentral and directly attacked not only the central city area of Kobe but also the outskirts of the city. The estimated seismic intensity was more than the 7th degree, which had overwhelming power to completely destroy the huge area of the peaceful town. Furthermore, this fearful incident had resulted in destruction of houses (more than 400,000) and numerous death (approximately 6,000). Needless to say, both researchers of this study had experienced the earthquake and their institution also has been suffering damage more than one year. To take this situation into consideration, it is beneficial to put factual and perceptual data on record, such as people's emotional state, degree of housing destruction, degree of damage on the lifeline (electricity, water, gas, and telephone), and color image of shaking as an individual experience.

2. Purpose of the study
Concerning other earthquake studies, many people have included the diverse topics in relation to the lifeline problems, the building problems, the escaping behavior and the living circumstances, the emergency behavior in human, and so on. Most of those investigations have focused on either the structural problems of the buildings or the psychological problems of adjustment, such as the post traumatic stress disorder (PTSD).

First, this study concentrated on the relations between the color image perception and the emotional state when people were in the midst of quake. In fact, such a study is seldom found in the past literature. Additionally, a second aim of the study would be to look at the perceptual change in color image after the earthquake. Thirdly, it is important to clarify the connection color image in the fearful experience and people's color preference.

3. Method
Subjects were students sample from several universities and colleges, where were located in the disastrous areas hit by the earthquake. The researchers constructed self-administered questionnaires.

Questionnaires included ratings, yes-no questions, and brief descriptive items on various dimensions of the earthquake experiences. And we delivered questionnaires to the participants and got 600 responses.

Moreover, the shorter version of the questionnaires was administered, which more directly focused on the color image and the emotional state of the earthquake experience. We have got 90 replies so far.
4. Results and discussion

Our investigation was guided by three general expectations. First, because of a great deal of fear and shock by the earthquake, it was hypothesized that the victims would indicate dark color, such as black and gray, as the color image of the quake. Second, it was expected, as the time would have gone by, that the victims would show the change of the psychological state, like gradual transformation from great fear right after the quake, by way of anxiety, to relief. Finally, because of the emotional changes in victims with the lapse of time, we hypothesized that the color image of each psychological experience would also change.

Overall, our hypotheses were supported. In questionnaires, the emotional state was inquired at seven different phases of time when/after the quake occurred: 1) the emotional state when the quake just occurred, 2) the emotional state during the quake, 3) the emotional state when the quake just stopped, 4) the emotional state a week after the quake, 5) the emotional state 3 months after the quake, 6) the emotional state 6 months after the quake, and 7) the emotional state one year after the quake. Most people reported that they experienced great fear when the quake occurred and while the quake continued. Additionally at the same phase of the quake occurrence, many people reported that the color image of great fear was gray, black, and white.

As time has passed by, the victims' emotional state has gradually changed. At the immediate occurrence of the quake, they felt fear; however, both after the end of the quake, people reported that they mainly felt anxiety, confusion, surprise, and uneasiness. One week after the event, anxiety and uneasiness became more central concern for the victims. Then, 3 months after the event, people reported that their emotional state became more stable, by expressing the words like peace, relief, release. However, some victims still expressed the emotional tense such as anxiety and uneasiness. The same results were found at the phase of 6 months after the quake.

The immediate experience of the actual quake gave the dark-color image to the people. Then, anxiety feeling which was seen after the quake stopped gave the people the same kind of color image, gray, black, and white. It is very interesting to see "white" as fear or anxiety color for us. On the other hand, if positive feelings such as relief and peace emerged, the people reported that the color image would be green, white, yellow, blue.

It is believed that the perception of color is influenced by cultural context. Our investigation also has shown the environmental and experiential effects on color image. In this study, the experiential dimension was the actual quake. The environmental dimension was the seasonal change (the victims went through 4 seasons after the quake) and the tangible circumstances (for example, reconstructing buildings, heavy traffic, and different view of neighbourhood). More importantly, the change of the psychological state at each phase of recovery from the disaster will bring about the change of color image in people.
CAN COLOUR ACT AS AN AID IN THE ENVIRONMENT FOR PATIENTS WITH DEMENTIA?

Background
Since a couple of years I am interested in the design of the environment of demented patients. At several occasions at my work with patients with Alzheimer’s disease I have noticed how colour can work as a code of recognition and thereby have a calming effect on the disorientated patient. Characteristic of the demented patient is a regression in cognitive capacity in combination with increasing sensitivity to stress which early in the disease causes problems to orient oneself in both new and well-known environments. This is due to memory dysfunction especially for new information and memory loading. These patients also suffers from visuospatial dysfunctions resulting in problems of room perception. In addition to this several study’s report problems in the visual function of the Alzheimer patient specially in the aspects of contrast sensitivity, visual acuity and visual field. The dysfunction in perception of the environment causes patients with Alzheimer’s disease much discomfort and can lead to feelings of panic, anger and despair. One way to deal with this is to create an environment that instil a feeling of maximum security and safety for the patient. Criteria for such a department is that it should be the home for only a few residents with approximately 5-6 rooms, with a plain design that is easy to understand. Some international studies reports positive findings where colour as “coding and cueing” has been tried in demented patients environment.

Hypothesis
The colour perception of patients with Alzheimer’s disease is comparatively intact. Therefore it is possible for colour to act as an aid in orientation during memory dysfunction.

The aim of the study is to investigate the colour perception of Alzheimer patients in comparison with healthy young and elderly subjects. Method. The author together with docent Lars Sivik developed a method to investigate colour perception in the aspects of colour identification, colour preference, discriminations of colour
shades, colour as a code and a colour - symbol test.

Population

Elderly patients with Alzheimer’s disease, healthy young and elderly subjects.

Results

A pilot study with twelve patients suffering from Alzheimer’s disease in comparison with a matched control group of twelve healthy persons could not evaluate any significant differences among the two groups. In addition the patients with Alzheimer’s disease gained substantial help from colour cues in remembering symbols. Making the same tests with young healthy subjects (n=16) revealed interesting differences in aspects of colour preference and colour as a code. The author is now involved in a Nordic comparative study of functional ageing investigating the colour perception of about 230 elderly men and women of eighty years of age. At the same time institutionalised patients with Alzheimer’s disease are tested with the same methods.

Importance

If the colour perception of patients with Alzheimer’s disease is relative intact it points out the possibility for colour to act as an aid in their environment in order to make it clear and easy to understand and thereby increase the feeling of comfort.
How coloured materials will appear in spatial situations is the kind of knowledge architects, designers and others working professionally with colours are forced to gain through experience. Obviously, individual experience is invaluable, but learning through “trial and error” is usually too expensive and the risks are too great. The possibilities of working consciously with colours are limited by our knowledge about how coloured materials will appear and how the colour will affect the spatial perception.

The Department of Building Design is carrying out a research project with the purposes to achieve more knowledge about this, and develop methods for studying colours in built environment. The main aim of this paper is to discuss the observations made in some of our studies of spatial colour phenomena.

This paper presents some studies of colours in rooms, studies that showed possibilities for continued studying of colours in our built environment. The purpose of these studies was to map out for further investigations, on the one hand some phenomena of colour appearance in rooms, and on the other hand the methodological problems of defining the perceived colours in varied situations. Some studies were done in public buildings, some in smaller models and the main and latter part of the studies were done in three rooms built in the experimental hall at Chalmers. In the existing buildings, the rooms were described. In models and experimental rooms we had the possibility to try different colour combinations and different illuminations suggested by the findings in the existing buildings. Of specific interest for these studies were the effects of reflections and simultaneous contrast for the perception of the colours in a room, and the effect of different illuminations both on the perceived colour and the shape of the room. I will briefly mention some of our observations that will be further presented in the paper. Before doing this some of the concepts used need to be defined.

Colour changeability, the varied appearances of the same coloured material in different situations, is one side of the complexity of colour perception. Another is our different ways of identifying colours. What I perceive in a situation depends, among other things, of my attention and apprehensions. With a reflective attitude, an attentive perception, we may concentrate on one point of the visual field, while with an unreflective attention, like in living perception, we are usually experiencing the world around us as a whole and not taking it apart. It is difficult to focus on both colour perception and spatial perception at the same time, because the colours in a room painted with the same bucket of paint can be perceived in different ways. On the one hand, all the variations due to differences in light distribution can be perceived. On the other, a uniformly coloured room can be
perceived. In the former case we take the room apart and focus on colour spots. In the latter case, we experience form. The perceived colour which we consider as a property of an object or the room itself, is what we call the identity colour.

In all cases we could compare the identity colour with the variations, we noted that the identity colour was stronger in chromaticness than the variations. The identity colour was only sometimes recognised in the variations and then it was, though hard to locate precisely, found in the middle of a medium light area.

We had two rooms painted with the same blue-grey colour. One was illuminated with bulbs and one with fluorescent light. The identity colours of the rooms were perceived as distinctly different.

When the “fluorescent room” was painted to obtain the identity colour of the “bulb room”. The room illuminated with bulbs were perceived as more distinct in shape than the room illuminated with fluorescent light. The variations were more different in hue in the “bulb room” – the corners were reddish blue-grey even if the identity colour of the blue walls were greenish blue-grey – while the variations of the “fluorescent room” had the same hue. This imply that not only lightness, but also hue has influence on our spatial perception. Thus, different light sources affect the perception of space, not only due to light distribution and strength, but also because of the colour rendering capacity1 of the specific light source.

A grey yellow-green box was placed in the middle of each room. The boxes appeared surprisingly alike in colour and no yellowness was perceived in the green. The effect of reflections from the walls thus seemed to mean more than the impact of the different light sources on the perceived colour. When the boxes were painted yellow with more chromaticness, the influence of the light source seemed to increase – the boxes where perceived as more different in colours in comparison between the rooms.

In our rooms it were obvious how much reflections from surrouned colours meant for the perception of the single colour. Simultaneous contrast was only perceived when two colours met “on the same surface”.

The methodological problems of these studies were how to define the perceived colours and how to be able to compare two differently illuminated situations. Descriptions in words have limited possibilities in precision. We needed a reference situation for colours samples, and tried a box with one “standard” illumination to compare the samples to the perceived colours in the room. The paper treats the problems and possibilities with this method.

All the factors that affect colour appearance and the different ways of perceiving are parts of the problem when studying colours in spatial situations. The phenomena noted here are specifically spatial and the situation where they appear are hard to reduce further. Methods need to be developed that allow the complexity of a spatial situation to be a condition and not an obstacle to achieve understanding for the perception of colours in our environment.

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COLOR EXPERIENCE AND ARCHITECTURAL DESIGN

"The experience of colour and light is important for the architecture as a whole and cannot be subordinated form. Volume, function, form, colour, light, material, structure and human movement are all important elements. Colour can be apprehended as difficult to handle in three-dimensional spatial design and hard to predict, but within this changeable complexity comes also the witty and exciting dimension. It is a challenge for architects forming the built environments to be sensitive for the changes of light in the interplay between form and colour in the spatial experience.

In my paper I intend to discuss the following questions:

A common opinion is that colour experience is related to feelings and the so called "intuition".

What "is" intuition, a word we often use when we speak about (artistic) colour experience? The definition according to a dictionary is; "immediate, unreflected apprehension". Is the intuition dependent on experience and the time and culture we live in? Or is it a primordial and divine force outside all influence? Even though, we carry the imagination that much of the creative work take place spontaneously (and intuitive?), the interpretation of the context is very important for the design process. Is it possible to train the seeing and increase the capacity to understand and experience colour in space? Can the intuitive possibilities be developed during the analysis to find out what is spatial going on with colour in an architectural composition?

The seeing is basis for our experiences of colour, but not universally prevailing. For the whole intellectual process to interpret and be conscious of the experience, there is a need of a language for communication. Most of the competence the practising architect has or should have, for colour design, is hard to point out. It is composed by several different kinds of knowledge combined specially for the design problem with artistic standpoints for finding an optimal solution in the actual situation. The architect must choose among knowledge in the large interdisci-
plinary chromatics. It is possible to study examples in our built environment and discuss colour contrasts, reflections and light effects that influence how people read form and space. For architects and other designers there is a need to develop the concepts to clarify the complexity about spatial colour problems. Even though practising architects communicate on the first hand visually with drawings, photos, sketches and three-dimensional models, there is a need for supplements and explanations with concepts. For researchers dealing with spatial colour problems in experimental situations (or as for me personally, trying to discuss what “is” the “competence” for architects to use colour in architectural design), there is an absolute need to develop concepts and ask what is relevant here and now, in the actual issue.

The seeing is basis for our experiences of colour, but not universally prevailing. For the whole intellectual process to interpret and be conscious of the experience, there is a need of a language for communication. Most of the competence the practis-
The Elemental Aspects of Colour in Spatial Design.

In spatial design the use of colour has very special characteristics in that any colour employed within a space that you can enter into has the aspect of wrapping itself around you. In effect you are inside the colour or colours. However these colours, like the spaces themselves remain essentially physically static, but constantly change experientially. Any small particle of colour specifically analysed in a constant situation at a specified time can easily be isolated and quantified. However, in reality, nothing exists in isolation. Wherever we are, the way in which we experience things and the time in which they occur can completely change our perceptions, both from external and internal points of view.

Apart from the fact that we all see colours differently, and that our reactions to them differ in terms of emotional responses, the colours themselves also alter with changes in the conditions that we are able to see them in. These can be explained as the elemental aspects of colour.

Fire = Light/Lighting

Without light we cannot see. All light comes from burning energy, whether this is natural light from the sun, or artificial light from any source. Light defines the space that we can visually perceive. The quantity of the light and its own inherent colour qualities ultimately manipulates the way that we are able to see any solid colour within that space. All colours will be seen as black in the total absence of light.

The intensity and nature of natural light varies in many ways: in different parts of the world, at different times of the day and year, and in different weather conditions. With artificial light we are able to create any variant that we desire and consequently alter the appearance of any colour.

Earth = Solidity/Form/Structure/Texture

This expresses the constant physical aspects of a space and creates size and scale. When we are in an interior the amount of a colour that we see effects the way in which we experience it. Also the way in which colours are juxtaposed with each other can alter the way in which we perceive them.

When light illuminates and gives definition to the physical characteristics of a space it creates shadows. Shadows themselves also have inherent colour qualities in terms of intensity, darkness and temperature which dramatically effect the way that we can see those areas of a colour obscured by them.

The positioning of solids and voids - windows, walls, doors, floors and ceilings all effect the direction, quantity and nature of light and consequent creation of shadows. Depending upon which surfaces the same solid colour is applied to will effect the actual colour that we are able to perceive. The same solid colour painted
onto different walls, or a floor, or a ceiling will not necessarily appear the same.

Texture also modulates the amount of light and shadow across the surface of a colour and as a result creates any number of colours and variants.

WATER = TRANSPARENCY/REFLECTION

Not all colours and spaces are solid. If colours are transparent then they take on characteristics that they transmit from what lies beyond. If colours are reflective then they take on characteristics that they mirror from what lies in front. A light shining through a red shade will illuminate the surrounding white walls as pink. A highly shiny black floor will reflect all the other colours in the room around it.

Therefore the transparency and matt/gloss qualities of any colour can radically alter the way and range of colours that we actually perceive.

Combinations of transparencies and reflections build up a myriad of colour effects.

AIR = SPACE/TIME

Air fills any contained space. It is the atmosphere. It is all around and creates the ways in which we can sense and experience - smell, hear, see, touch and feel. No sense is independent of the others and therefore all modify/enhance/challenge the ways in which we perceive the colours that we see. Our emotive response and mental condition can also change our vision.

The atmosphere within a space also contains the further elements of time. Over periods of time colours weather and change with wear and tear. The constant inter-reaction of people with surfaces and objects polishes/mellows/bleaches/dirties the original colours.

It is the combination of all these elemental aspects of colour that have to be considered when employing the use of colour in spatial design. Colours cannot be arbitrarily picked from a chart and utilised in a global fashion. If colours are expected to have poignancy and meaning then they must be selected within a meaningful context.

The consideration and analysis of the elemental aspects of colour in spatial design can help achieve more exhilarating/interesting/relevant/contextual/people and purpose orientated spaces in which to live, work and play.
The colour of a house does not always look like the chosen colour sample - this is an experience faced by most people working with colours on buildings. But how does the colour of the finished facade differ from the colour of the sample, and why did not the result turn out as it was meant?

These questions are the background of the research project Inherent and Perceived Colours in Exterior Architecture. The project is carried out at the Dept. of Architectural Forms, School of Architecture and Town Planning, Royal Inst. of Technology, Stockholm. It is funded by the Swedish Colour Science Foundation and Stiftelsen Svensk Färgr- och Lackforskning.

Concepts

Colour here means colour percept, and it is understood that one and the same colour element (e.g. facade) can have different colours under different viewing conditions (light, distance, angle etc.).

One of these colours is the inherent colour. In simple terms, the inherent colour of a newly painted surface is equal to the colour code of the paint used. More strictly, the inherent colour is here defined as the colour that the surface would have if it was seen under the standardized viewing conditions of the NCS system. Naturally it is impossible to see any facade under these strictly controlled conditions. Thus in practice the inherent colour of a facade is assessed through comparison with NCS samples placed directly on the surface.

The perceived colour of a facade is the colour that an observer can see in the actual situation. It changes all the time and is affected by factors such as viewing distance, light conditions, colours of surrounding houses and vegetation etc.

Questions

The research project deals with the following questions:

- How does the perceived colour of a specific facade vary when the viewing conditions change: Season, time of the day, distance etc.?
- How does the perceived colour vary between facades with the same inherent colour but different materials, different colours of surrounding houses etc.?
- How does the perceived colour in different situations differ from the inherent colour?

Previous studies of perceived colour

Swedish colour researchers, above all Anders Hård and Lars Sivik, have carried out a number of studies of perceived colour under varying viewing conditions. The most important of these are presented by Åke Svedmyr in Upplivelse av färg och färgrätt miljö (Swedish Building Research Council, T5:1995). Most of these studies, however, are pilot studies that give no scientifically verified results but can give starting points and hypotheses for further research.

The pilot studies suggest that viewing distance has little effect on colour perception, as long as the distance is shorter than 300 meters. Longer distances give, for the green colours of vegetation, a gradual hue
shift from yellowish green (near) to blue (far away). At the same time the chromaticness diminishes when distance grows. Preliminary long distance studies of other colours than green have not given so clear results.

Contrary to the hypothesis indicated by practical experience, Lars Sivik has shown that the size of the colour element does not affect the perception of chromaticness. This of course does not make experience invalid - it only forces us to find other explanations to the observed phenomena.

One of the pilot studies involve big material samples in natural environment (dry grass), viewed and assessed from a distance of 80 meters. The result is very clear: The big samples are, in this situation, assessed to have less blackness and often also more cromaticness, compared to their inherent colours. According to the previously referred studies this difference should not be the effect of distance or size. One hypothesis is, that it is caused by simultaneous contrast, as the method of assessment included comparison with small samples on white paper.

Light and colour perception has been studied in a more thorough study, which shows that colours change surprisingly little with varying light, as long as the light source gives a continuous spectrum (which is always the case with daylight).

Methods
The first part of the research work aims mainly at finding methods for determining the perceived colour of a facade. A number of observation series are done. Subjects in these are a few trained observers as well as groups of students from different schools. All observations are done from a approximately constant distance (about 50 m), and the light conditions etc. are carefully noted.

To date the following methods have been tested:

- Comparison with the samples of the NCS atlas, sorted hue-wise on white background.
- Comparison with larger NCS samples, seen individually with the facade as background.
- Notation of perceived colour in the NCS symbols (hue circle and nuance triangle) without comparison with reference samples.
- Spontaneous verbal description of the colour of the house.
- Estimation of the colour of the house in relationship to given colour words.
- Pairwise comparisons between colour samples, where the subjects for each pair are to tell which one is more similar to the colour of the house.

Results
The project has started recently, and data are not yet analysed. I hope, however, to be able to present preliminary results on the meeting in June 1996.

Presentation
The oral presentation will include slides illustrating the problems and the different methods of investigation. I also hope for a constructive discussion on the basis of my preliminary results.
INDIVIDUAL AND CONTEXTUAL FACTORS
IN URBAN COLOUR PERCEPTION

Within the field of architecture, colour constitutes an important means of expression and most architects are aware of the significance of colour design. A successful colouration may improve an otherwise poor design, and vice versa. It is often assumed that colourations cannot be subjected to systematic study but have to be based on natural talent and practical experience. However, rather often the designer may become surprised by objections to proposed colourations from users and from the general public. Discrepancies between experts and laymen in the environmental evaluation may also obstruct the agreement in issues of colouration.

In a recently completed study amongst design experts and design students on the knowledge of and attitudes towards colour research, poor results were reported (Janssens, 1995). More than half of the subjects interviewed could not relate any modern colour research achievements. Shortcomings in educational curricula was one explanation, the poor reading habits of the experts another. Many misbeliefs and erroneous interpretations of the research results were expressed. Reliable and well-illustrated knowledge on exterior colouration was in great demand.

Most of the applied colour research so far has dealt with interior space, often using colour samples under strictly standardised conditions. In contrast to most indoor rooms, the urban space has to please far more tastes and demands. The impact of large coloured surfaces may also be larger. These surfaces often have a long life span and may change substantially, affected as they are by UV-radiation, moist, dirt or damage. Weather conditions, seasonal variations and time of day will add to this change, as will looking distance and angle of view. Thus, many interfering variables have to be accounted for.

One of the few systematic studies of exterior colouration was reported by Sivik (1974b). He explored the perception of facade colours both under field conditions and by means of manipulated pictures. The results indicated that laymen’s statements about exterior colours could be described in three dimensions: emotional evaluation, social evaluation and enclosedness. When the colours were presented as samples, Sivik found warm colours to be preferred to cold ones (1974a). In the field, however, preferences could change, and even blue buildings could be appreciated. Social evaluation and enclosedness were shown to be dependent on the colour’s blackness, the former even on the strength or saturation of the colour. Sivik concluded that there exists a difference between the perception of the colour as such and as applied to objects, such as building exteriors.

Previous comparisons of architects’ and laymen’s assessments of the built environment show a more distinctive and clear-cut preference pattern for the experts (Janssens, 1984). Architects prefer simple, unitary and functional designs, whereas laymen prefer more ornamental and varied environments. In the present study, the hypothesis was that experts would prefer integrated colourations, whereas laymen would appreciate complexity. It may also be reasonable to expect higher preference ratings for exteriors in direct sunlight as compared to overcast or rainy weather conditions. Another assumption is that some colours may be preferred during the warm season, others during the cold season.

Old and well-kept environments are generally perceived as more pleasant than modern buildings. Genuine handicraft in the local building tradition is always appreciated and contributes to the environment’s affective value. One hypothesis here is that traditional colourations will be assessed in more positive terms even on new buildings. On the other hand, old buildings with diverging colours may be less preferred. Social status is not only a matter of economic value, but also of uphold and care. Damage in the coloured surfaces might thus affect preference in a negative
way. It may however be assumed that traditional paint and materials would benefit by a higher acceptance level for age and wear. The object of the present study was to examine the perception of exterior colouration in its context, both in the field and in visual computer simulations. A number of relevant examples of urban colouration were studied and documented in both perceptual and aesthetic terms. One purpose was to investigate possible discrepancies between experts and laymen in the assessment of exterior colours. Another issue concerned the impact of the more casual factors on exterior colour perception, such as surface material, weather and lighting conditions. The results will be reported as an illustrated collection of commented colourations of urban spaces.

Twelve urban streets have been chosen to represent environments of different scale, age, architectural style, function and surface materials (also Küller, 1996). In each of these environments, one building was chosen as the prime object of study. Both the single buildings and the whole streets have been thoroughly documented, especially their colouration. The perception of these environments has been assessed in the field on different occasions by experimental subjects, both laymen and experts. Assessments were gathered by means of interviews and assessment forms. The questions included not only perceptual experiences, but also the range of acceptable colours as well as technical and functional aspects. The subjective experience of the environments was assessed by means of 36 semantic rating scales, describing the perception of the building exteriors in eight dimensions: pleasantness, complexity, unity, enclosedness, potency, social status, affection and originality (Küller, 1991). The results of these assessments will be presented as graphs for each of the environments and may help explain the variations between different subject groups and different external conditions.

Analyses of the subjects' environmental assessments revealed two main dimensions: one overall aesthetic evaluative factor related to preference and the environments' coherence and age; and one more technical/functional factor related to maintenance, material and paint quality. The results showed strong differences for all eight dimensions of the semantic descriptions of the various urban settings.

The experimental subjects' assessments clearly indicated higher preferences for the older environments both among laymen and experts. Male subjects generally perceived the environments as significantly more colourful than female subjects. Comparisons between winter and summer evaluations gave only minor differences. Further documentation was gathered of the environments' architectural and stylistic qualities, as well as of each setting's acceptancy level for different colourations.

These descriptions will form the basis for further investigations about the impact of specific colourations of urban settings. In another experiment, visual display pictures of the environments will be manipulated systematically with regard to their colouration. These changes, made by digital picture processing, will be used to test different proposed preference hypotheses. Again experimental subjects will be asked to assess the simulated environments in various respects. Preferences for exterior colours will also be related to a number of individual background variables.

References


Man leads his life in continuous interaction with his environment and uses all his means to improve this environment to preserve and heighten his spiritual, and physical health. For this reason architects and designers try to create healthy livable spaces to respond to these physiological, biological and psychological needs. This phenomenon being valid for the world we live today will still continue to be valid in the following century in settlements that are expected to be created under sea or in space.

In the creation of an architectural space several elements and principals of design are used. Colour is a basic element of design that take place in such an arrangement. The aim of this research is to determine the colour preferences of male and female students for the wall surface of a studio in an architectural building they are in constant interaction with and to evaluate these data with semantic and arithmetic mean methods.

The determination of the colour preferences of the students that come from different regions of the country and of different cultural origins for the walls of the studio they constantly occupy will enable arrangements to be made for these students so that they may sustain their education in a healthier environment. It is a fact that in an environment that has been designed with a correct choice of colour and properly illuminated more interest, better performance, higher level of productivity, good morals, more activity, least chance of making mistakes and as result of these factors as a more chance for success is expected from the students occupying that environment.

Experimental order
A studio that was regularly used by the same students was chosen as the environment for the experiment and all the walls and ceiling of this studio was painted a neutral colour (white). Only the opposite wall which was directly in the field of perception of the students was painted a different colour every week and the different effects of every colour on the students and the preference of the students for the different colours were noted on lists. The colour of the blackboard that was located on this wall was originally green (NCS 6030 BB 00 G) and this colour wasn’t changed throughout the experiment (Figure 1).

The experiment was carried out in usual educational conditions without any extra arrangements under normal day-light and fluorescent light sources of min. 250 lx and max. 500 lx are accepted to be ideal illumination levels.

Colours used in the experiment
In the preliminary experiment that was carried out in the beginning of the research 4 basic colours (Yellow, Blue, Green, Red) and 4 intermediate ones (Yellow-Green, Green-Blue, Blue-Red, Red-Yellow) chosen from the colour circle of NCS Colour System were used (Figure 2). This experiment was carried out with 10 colours when white and grey were added to those chosen above.

In the second part of the experiment the most and least saturated, and the pale and dark values of the same colours used in the first experiment (4 different values of a single colour) together with 2 grey tones newly added, making up 36 different colours will be used (Figure 3).

Determination of the colours used in the experiment
The 36 different colours used in the experiment were determined as plastic wall paint from a system called "The Colour Spring" of a paint producing firm (DYC) with the combinations derived from the colour systems involved (NCS) in this program.
Ceiling painted white

Daylight

Artificial light

Wall surface painted a different colour every week

Blackboard originally painted green, NCS 6030-B 60 G

Wall painted white

Studio Section Scale 1/100

Studio Plan Scale 1/100

Fig. 1
COLOR MEANING AND CONTEXT

Extensive psychological research has been conducted to determine people’s preferences for and associations to colors. Although this research should be highly relevant in many fields such as design, marketing, etc., it has been criticized for having produced little impact outside the scientific world (Whitfield & Slatter, 1991). One of the principal reasons for this failure derives from the fact that color preference and color meaning research has been carried out using stimulus materials consisting almost exclusively of small color chips, rather than contextualized colors. Thus, that color is nearly always associated with objects/settings has largely been neglected (e.g., Norman & Scott, 1952; Wise & Wise, 1969; Davidoff, 1991). This poses obvious problems concerning the generality of color preference and meaning findings. In fact, researchers have often explicitly cautioned against generalizing their results beyond the specific experimental context (e.g., Guilford & Smith, 1959; Taft & Sivik, 1992). In light of this, it is not surprising if color professionals are perhaps unclear about where, or if, it is possible to apply these research results in practical design situations.

Can preferences and meanings relating to color chips be considered representative of those relating to applied colors? The answer, emerging from the few empirical studies that have explored this question, appears to be “it depends”. It depends on, among other things, the type of appraisal made, the object/setting appraised and the color in question. For example, color descriptive appraisals (e.g., warm, strong, etc.) have been found to be largely unaffected by the context that colors appear in, while color preferences and aesthetic evaluations (e.g., like, appealing, positive, etc.) are especially sensitive to context effects (Osgood et al., 1957; Sivik, 1974; Hogg et al., 1979). However, when other contexts have been studied good agreement with preferences/evaluations of chips has been indicated (Saito, 1983; Holmes & Buchanan, 1984; Walsh et al., 1990). Appraisals of certain colors (pastels) also appear to be less influenced by context than highly saturated colors (Osgood et al., 1957). Color-to-object appropriateness, shaped by cultural norms or convention, has been suggested as a possible explanation for variation in color preferences and meanings as a function of context (Osgood et al., 1957; Sivik, 1974; Slatter & Whitfield, 1977; Whitfield & Slatter, 1978, 1979).

In the above studies correlations were generally computed between chip and object appraisals (e.g., Hogg et al., 1979; Sivik, 1974). A drawback to this type of analysis is that it may conceal important similarities or differences existing in the data. For example, behind a high positive correlation may hide object ratings that are consistently inflated or deflated with respect to chip ratings. In contrast, a low correlation may result from large differences between chips and objects on comparatively few colors.

This paper reports the results of a study comparing semantic ratings of color chips with those of the same colors applied to a variety of familiar objects. The overall aim of the study was to examine whether significant differences exist between preferences/meanings of color chips and the same colors applied to objects and, if so, in relation to which types of objects, colors and appraisals variation is greatest/least. To study the effect of color-to-object appropriateness in determining appraisals, objects were chosen that ranged in the number of colors that they conventionally appear in (from a computer at the low end to a bicycle at the high end). Colors represented a fairly even coverage of the outer perimeter of the NCS hue circle and as well as some colors of low or zero chromaticness. Semantic scales reflected factors commonly extracted in previous research.

Subjects rated a set of 13 color chips and 6 digital photographs of objects, each appearing in the same 13 colors as the chips,
against 5 semantic differential scales. Chips and objects were displayed one at a time on a computer screen. The same chip/object in 13 colors was presented as a series. Both series and colors within series were randomized. Analyses performed on the data were principally sets of analyses of variance (ANOVA) and post hoc mean comparisons between ratings of chips and objects of the same color.

The results of the study indicate, with some qualification, that there is generally good correspondence between semantic ratings of chip and object colors. Of a total of 390 comparisons between ratings of color chips and objects, in only 16 cases (4%) was the color on the chip judged qualitatively different from the same color on an object, e.g., beautiful on the chip but ugly on the object. Such differences were primarily restricted to 2 of the 13 objects (computer [9] and antique chair [5]), on principally 3 of the 13 colors (red, green and purple) and in respect to 3 of the 5 scales (beautiful-ugly, discreet-loaded and elegant-vulgar). Significant degree differences, e.g., more beautiful on the chip than on the object, were also revealed. Most such differences (10/14) were also in relation to the computer and antique chair. Furthermore, where differences existed, colors on chips were invariably judged more beautiful, elegant, discreet, feminine and warm than the same colors on objects.

Although these findings generally support earlier research results especially with regard to the stability of rating against descriptive scales, they also indicate that the reported poor correspondence between chips and objects on evaluative scales may be exaggerated. For the most part, our results show that colors that are liked are also liked when appearing on an object and those that are disliked are disliked on an object as well. Differences arise when the color does not customarily appear on an object and only when it is of high chromaticness. This has implications regarding the generality of previous chip-based research findings, as well as for the use of color chips in color planning and design.

References


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Preferences for Colours in Urban Places

Background. Colours may influence the arousal level of the human brain and the autonomic nervous system (Küller & Mikellides, 1993). They may promote emotions of pleasure or depression, and influence the perception of the architectural space (Acking & Küller, 1972; Aksungur, 1977; Küller, 1980; Srivastava & Peel, 1968). Colours can load environments with specific symbolic values (Sivik, 1969). They can be applied as signals in order to warn or inform about various environmental hazards (Glass et al., 1983; Küller et al., 1993). Colours may also provide identity and cultural validity to certain environments (Hesselgren, 1987; Porter & Mikellides, 1978). Still, the lack of research and applicable knowledge about exterior colouration may lead to uncertainty amongst urban designers, who will have to rely on their personal taste and experience. The purpose of the present study is to examine the perception of urban colouration in context, both in the field and by means of computer simulations. The prime aim is the testing and comparison of four different theories of colour preferences. Other aims are to investigate possible discrepancies between experts and laymen in their colour assessments, and the impact of contextual factors, such as surface materials and weather and lighting conditions.

Four theories of colour preferences. The existence of several conflicting theories of colour preferences has led to the formulation of a number of precise hypotheses concerning urban spaces. One of our hypotheses proposes that exterior colours will follow a general preference order. In the beginning of this century, a large number of colour preference studies were carried out. In 1941, Eysenck made a summary of these studies, which showed that the blue colour was the most preferred, followed by red, green, violet, orange and yellow. This result was mostly based on assessments of small coloured slips of paper, often with the colours being poorly defined. More sophisticated preference studies were reported by Sivik, who summarised his findings in so called isosemantic maps (Sivik, 1974 a & b). In addition to coloured slips, Sivik explored the perception of colours both on real buildings under field conditions and by means of manipulated pictures. The results indicated the existence of systematic differences between the perception of the colour as such and as applied to building exteriors. Sivik’s isosemantic maps form a detailed basis for the prediction of a hierarchy of colour preferences.

An alternative hypothesis, proposed by Berridge (1971), assumes that preferences for all kinds of stimulation, including colours, are determined by their arousal potential. Involving various reward and aversion systems in the brain, this theory is summarised in a famous graph, where the hedonic value of a stimulus is related to the arousal potential of the stimulation. The graph shows what can be expected to happen as the arousal potential increases from zero. First, there will be no reaction at all. Then, as the arousal potential increases, the stimulus becomes more and more pleasant, with positive hedonic value reaching a peak when the arousal potential is at a moderately high point. Further increase causes a decline in positive hedonic value towards indifference, and then the stimulus becomes increasingly unpleasant.

A modified version of this hypothesis is the idea that the preference of an environment may be related to perceptual qualities such as complexity and coherence. Many years of research at the Environmental Psychology Unit at the Lund Institute of Technology has shown that the perception of an environment may be described in at least eight semantic dimensions, amongst others pleasantness, complexity and unity (coherence)(Küller, 1981). These dimensions were used to demonstrate, amongst others, how the colouration of interior walls and decoration will influence the perception of the room as a whole (Acking & Küller, 1972). Based on these studies, Küller has suggested that preferences in general may be dependent on the balance between complexity and unity (Küller, 1980).

A fourth hypothesis proposes that people’s expectations, as based on previous experience, will be decisive for colour preferences in real environments. Whitfield & Slater (1979) claim that the aesthetic value of everyday objects
depends on their "prototypicality", that is, each object's resemblance to a certain category or type, for buildings and furniture, their style and function. These considerations may have important implications for the study of exterior coloration, because certain colors may be associated with certain prototypes. This assumption was supported by Inui (1969), who found certain room functions to be connected with specific colour choices. Finally, some scholars assume that arousal potential and prototypicality will co-operate in the process of aesthetic evaluation (Tversky, 1977).

Methods and procedure. Twelve urban streets have been chosen to represent environments of different scale, age, architectural style, function and surface materials (also Janssens, 1995). In each of these environments, one building was chosen as the prime object of study. Both the single buildings and the whole streets have been thoroughly documented, especially their coloration. The perception of these environments has been assessed in the field on different occasions by experimental subjects, including laymen and experts. Assessments were gathered by means of interviews and assessment forms. The questions included not only perceptual experiences, but also the range of acceptable colours, as well as certain technical and functional aspects. The subjective experience of the environments was assessed by means of semantic ratings, describing the perception of the building exteriors in eight dimensions: pleasantness, complexity, unity, enclosedness, potency, social status, affection and originality (Küller, 1991).

In another experiment, visual display pictures of the environments were manipulated systematically with regard to their coloration. These manipulated environments will be used to test the hypotheses proposed above. Again experimental subjects will be asked to assess the environments in different respects. Here the focus will be on preferences. In addition to preference ratings, assessments will be made of both arousal potential, prototypicality, and of the perceived pleasantness, complexity and unity. The preferences of the various colorations will also be related to individual characteristics as assessed by personality tests.

Selected references


INDIVIDUAL COLOUR PREFERENCES -
WHAT DO THEY REALLY TELL ABOUT A PERSON?

Investigations on the subject of colour preferences (preferred and disliked colours) fall into the 2 following categories: a) Studies of general (universal) colour preferences; b) Studies of differential (individual) colour preferences.

a) Investigations on general colour preferences deal with whether there are inter-individually - possibly cross-culturally - preferred and disliked colours. These investigations show a generally very positive evaluation of the colour blue, and a general preference for white rather than black [1,2]. Furthermore, cross-cultural comparative studies show a remarkably stable order of preference. Supporters of the objective approach within colour preference research studies assume this is due to a general factor - possibly of biological cause - of aesthetic appreciation.

b) Investigations on differential colour preferences bring into focus individual differences as regards choice of preferred and disliked colours. These studies ascertain that there are in general distinct differences in people's preferences. According to Halder-Sim [3], "There is indeed evidence that an inter-individual order of preference is significant, but by comparison, a much higher proportion of variations, however, may be accounted for by individual reactions. This implies that the use of colour stimuli for purposes of diagnosing personality is justified. The question arises, however, as to how far these individual colour preferences may in fact be related to personality traits.

In this context, Lüscher's famous colour preference test [4,5], for example, claims to be able to diagnose characteristic personality differences by means of the 8 colour cards provided. The value of this personality diagnosis, however, is highly doubtful.

Halder-Sim refers to the fact that colour preferences are determined by more than one factor, namely (a) by an aesthetic factor of biological nature, and (b) by social and cultural influences, and (c) by individual, personality-specific features and current state of well-being.

The question of the significance of these factors forms the basis of several investigations which we carried out in Germany and Austria. Within the framework of studies conducted in Germany on group-specific value and taste orientation by the Institut für Zielgruppenmarketing und Kommunikation [6,7] we ascertained the ranking of colours in order of preference of 200 people, aged 20 to 64. The interviewees chose their favourite and least liked colours from altogether 27 pages of the NCS Atlas (including the achromatic colours), put them in order of preference and gave reasons for their choice.

Results

* People differentiate (as we already observed in a study carried out in Austria in 1994 [8]) between simply aesthetic colours, of intrinsic beauty, and colours intended for a specific, practical use.

Favourite and least liked colours, which are non-normatively and aesthetically intended, are perceived inwardly, independant of real objects. These colours could possibly throw some light on specific personality traits or phylogenic experiences. Colours chosen in the context of their material use, on the other hand, are a public statement to society and are subject to social and cultural influences. These colours are not chosen primarily for their intrinsic beauty, but because they have a certain, socially recognised significance.

* When people can choose from many colours, they choose in many different ways. A simple mathematical addition of the frequency of choice - without taking any order of preference into consideration - of preferred colours (the sum total, sex, age, and milieu-specific) thus proved to be of little value, but nevertheless confirmed a general preference for highly chromatic colours. By putting the most frequently chosen colours into colour groups, a
general preference for blue, red, purple, yellow, turquoise, green and black can be observed. Furthermore it is noticeable that women also choose the colour groups pink, mint and dark blue.

- A visual (qualitative) comparison of the order of colour preferences - when colours are grouped into colour categories - confirms clearly that blue is well in the lead (given list to third place), followed by red, then yellow, orange, green, purple, turquoise, brown and black.

- An important assumption of our investigations was, that colour preferences can be interpreted against the background of group-specific value orientation, life-styles and taste [9]. At a first glance, this does not necessarily seems to be the case: people of comparable life- and living styles (Soziales Milieu), nevertheless make very different choices. On closer inspection, however, we notice that the different groups do indeed collectively show a marked difference in their colour sensitivity, susceptibility to trends and general use of colour. Those who demonstrate a "good taste in style", for example, distinguish themselves by choosing an elaborate, aesthetically attractive yet unconventional order of preference, usually also a feature of their own homes, incidentally. "Trend-conscious" people appear indeed to be susceptible to current colour styles, whereas "status-oriented" people choose increasingly dark, prestigious colours.

- Furthermore, from our observations we discern that the more striking of trend colours (compare our studies on the cyclic recurrence of collective colour preferences [10,11]) do, in some way, affect also groups of people whose attitudes and values are more traditional. For example, purple, which is usually considered as an unpopular colour, appears remarkably often as one of the preferred colours of this group. Whereas people who are sensitive to trends very often consciously adapt their order of preference to the current fashion, people with traditional attitudes react instead unconsciously, with delayed reaction, to the more striking trend colours, by eventually including them, long term, among their preferred colours. It is a fact that, when confronted with a stimulus often enough, people become familiarised to it and eventually accept it.

We hope to be giving more evidence on the extent to which the above-mentioned factors influence different groups of people's choice of colour (the different social milieus).

However, quite independently of this, our observations clearly reveal that the order of preference of colours alone is in no way sufficient to classify people, diagnosing their personality or "labelling" them sociologically. Basically, colour preferences appear to relate closely to people's everyday aesthetic behaviour. A meaningful interpretation of colour preference seems to be more promising within the framework of research on everyday life-styles than personality diagnosis.

References:

Releasing Colour Effects
from Traditional Psychological Valuation

In his chapter about the "Sinnlich-sittliche Wirkung der Farben" (The Sensory-Pure Effect of Colours) Goethe gave every main colour a psychological valuation. His concept has proved to be consistent for a long time. Some painters, especially Kandinsky and some psychologists readily accepted Goethe’s characterisation of colours.

Are Goethe’s views, analysis and interpretations still applicable to our present needs? Have experiences with colours remained constant? In the meantime what has changed, what has been forgotten or dismissed, what has been added?

Let us take as an example of a "pure phenomenon", a clear bright red. We learned that several languages have adopted the name of red from the name of blood. But do you still see the reference of the colour red to the colour of real blood? In public today the sight of serious bloodshed is avoided or hidden as far as possible, only abattoir workers, recue workers and doctors are obliged to observe bloody events. Compared to other individuals who can decide for themselves if they wish to see in the media, news, war or criminal films, tinted film blood which in any case has been modified by the screen. Nobody can however walk in the street and insulate himself from the assortment of red vehicles, publicity hoardings and constructions demanding attention. And travelling near an agricultural flower nursery area you may come across vast fields of red tulips near to blue hyacinths. You can likewise be surprised to find red painted walls in the exhibition area of a recently constructed museum.

In contrast to former times when natural surroundings were not the target of aesthetic intention and manipulation today’s environment is controlled by provocative strong colours. That overpowering is urged on by the hard fight to gain public attention using constantly increasing assistance of new technical possibilities, colouring matters and applications. The decisive factor in this competition is the fleeting moment when a colour signal pene-
trates and does something in the brain. Colours which are so inserted as signals appear as subservient devices, they function in a peculiar way to achieve each time an intended effect. The psychologist is interested primarily in the question of what colour can do to the human spirit, above all in the subconscious, what reactions colours can trigger on individuals: the common emotions.

The unbridled colourfulness misplaces our present-day situation which an artistic or cultural environment has difficulty following when looked at with critical detachment. Then the task is to give voluntary consideration to a clash of various colour objects. Admittedly the Pop-Art of the 60's reacted rather directly to modern products that were especially intrusive with their colour. That the colour culture à la Matisse lost its way following this path was, for example, hinted at by Tom Wesselmann.

Alongside the direct influence of the omnipresent publicity objects there are remarkable efforts being made by some painters to obtain creative, fresh qualities in colour - in dialogue with colour only. They are seeking to disconnect every formerly-met known meaning, material or real derivations and corresponding associations, as well as conventional classifications or connotations. The most important is what in colour is perceptible, is recognisable, what it possesses, what it contains. It concerns its "objective" side: the character of colour. How does a colour give itself precedence, how does it represent itself, growing with time, using itself, aging and renewing itself, rejuvenating?

In the artistic process especially, colour is respected as an intimate friend, as another person, who is curiously and carefully confronted and not too hastily used again.

The example of paintings stretches from the spectral expansion of colourfulness to the exclusive work with black.
This presentation will explore particular visual relationships of colour used within paintings created by the author and others which express illusions of form and space within abstract painting. Illusions of form and space within visual art and design are strongly dependent upon the appropriate manipulation of relative colour contrasts. The visual impressions created by particular contrasts of colour can create illusions of three-dimensional form and space within the two-dimensional format. The process of creating these images and the relative forces of colour which are generated within that process will be presented orally and with accompanying slide examples.

The artist, within his or her particular medium, has the power to visually manipulate the viewer's perceptions. The large acrylic paintings on canvas which will be presented and discussed within this presentation represent this artist's interest in creating illusions and/or impressions of abstract shapes and forms which, as perceived by the viewer, seem to exist in their own space. The particular colour contrasts which are applied to these images are manipulated in such a manner as to generate psychological references to our natural visual world. Our manner of reading these two-dimensional images is related to our everyday occurrence of reading "actual space" and it is the illusionistic organization of these particular colour contrasts by the painter which "recreates" this common experience.

The presentation will demonstrate two different modes of color organization used by this artist within the creation of the illusionistic paintings:

Color and Light: Sculptural Form. (See color reproduction and slides 8-14 provided.)

The group of paintings which utilize color and light as an organizational basis refer to actual sculptural models which are created in the studio. The sculptural models are colourless when completed and are highlighted under dramatic lighting and photographed. The photographic images are used as a compositional basis for the paintings in which colour relationships are invented relative to the following colour contrasts:

Light Intensity.
Relative quantities of light used to indicate light source, define dimensional form and suggest dimensional space.

Chroma/Saturation.
Contrasts of higher chromatic hues against lower chromatic hues used to emphasize light contrasts and form definition.
Temperature (Warm/Cool).
Contrasts of psychological temperature relationships (hue variances) to emphasis and elaborate impressions and illusions of light.

Spatial Illusion: Abstract Shapes (See slide examples 1-7 provided.)

This group of paintings creates the illusion of suspended shapes on the picture plane surface and layers of atmospheric colour. They are totally abstract in nature and are derived from controlled layerings of transparent colour on the canvas surface in addition to geometric shapes which are illusionistically suspended within the painting's two-dimensional surface. The following colour contrasts will be addressed:

Transparency.
Actual layerings of transparent/translucent colour which form a visual tension against geometric shapes and create an illusionistic "push/pull" into the picture plane surface.

Light Shadows.
Air-brushed colour shadows of mixed hues which aid in the illusionistic impression of "real space."

Geometric Shapes.
Geometric shapes mechanically drafted into picture plane used as another element of contrast to the organic layerings of liquid colour.

Hue, Value, Chroma and Temperature Contrasts.
Relative contrasts of colour which are organized and exist concurrently with the above elements to create a holistic illusion of pictorial space.

The paintings which will be discussed within this presentation represent a number of years of developing and refining organizational strategies which best express this artist's interest in colour as an illusionistic device. The progression of this exploration will be demonstrated as the paintings were created over a time span of a number of years. It is the intention that this presentation will provide insight not only into the illusionistic colour systems developed by this artist, but also into the creative process which reflects levels of intuitive and psychological responses.
METHODS FOR DETERMINING PERCEPTUAL EQUAL BRIGHTNESS RATIOS AND THEIR EFFECT ON PERCEIVED VELOCITY

This study evaluates a number of established methods used in psychophysical experimentation for determining equal-brightness ratios. It is now an accepted idea that chromatic and luminance information is primarily processed in different cortical areas along physically separate neurological pathways i.e. magnocellular and parvocellular pathways. The two main cell types (magnocellular and parvocellular) show widely different characteristics, and by using stimuli which are directed to only one cell type, impairment of higher-order psychophysical tasks has been noticed. Most debated is the notion that magnocellular cells are entirely responsible for perception of luminance and provides input to the motion-perception system while parvocellular cells are entirely responsible for chromatic perception.

CIE formally defined luminance as the integrated radian of a source weighted by the spectral luminosity of the CIE standard observer. The definition implies that spectral luminosity is additive. Although the psychophysiology of the human visual system suggests that additive and stable luminous efficiency functions are improbable, a number of methods do exist which are capable of yielding linear additive measures. Most critical in the discussion concerning different methods are spatio-temporal factors and the effects of adaptation. The most commonly used methods today involve flicker fusion, although in the past minimal distinct border has also been a popular additive method. Other direct brightness matching methods such as magnitude estimation are not considered practical as they are unable to supply additive spectral sensitivity functions.

In the first part of the experiment proposed in this study, equal brightness ratios are determined for the methods: minimal distinct border, magnitude estimation, flicker fusion, and objective photoptical measurement. The results are expected to demonstrate the essential differences or similarities between the methods. In the second part of the experiment different brightness contrasts will be calculated from the methods used in order to generate red-green and red-blue sinusoidally modulated gratings. The perceived velocities of these gratings are then estimated. It is expected that perceived motion will be underestimated where no luminance contrast is prevalent. The degree of this underestimation should, however, be dependent on the subjects' discriminative ability in the first experiment and the physiological differences in the human visual system.

Six subjects aged between 25 and 35 participated in the experiment. Test stimuli were generated by specially designed software based on Macintosh hardware and a special test environment was constructed. In the magnitude estimation method subjects were required to estimate stimulus brightness in accordance with the previously estimated stimulus. The second method, minimal distinct border involves identifying the least distinct border between differently colored outer and inner-circles. For the flicker fusion method two stimuli colors at a time
were alternated until subjects achieved minimum flicker by adjusting the relative colour/brightness ratio. In the fourth method phototical measurements of luminance were recorded at different intervals of relative monitor output. In the second part of the experiment grating stimuli were presented. Brightness contrasts, including equal brightness, were calculated from the results of the first part of the experiment. The gratings were sinusiodally modulated 180 degrees out-of-phase and drifted at three different temporal frequencies. Subjects were asked to estimate the perceived velocity.

Linear regression equations (untransformed) provided the best fit for the subjective methods when plotted against relative monitor output. Proportions of predictable variance favoured the flicker fusion method. The objective method of phototical measurement also showed a linear relationship between relative monitor output and Candels (m2) following logarithmic transformation. Using the regression equations, red-green and red-blue equal-brightness ratios could be calculated for each method. In the red-green condition, highly correspondent line-plots emerged with the exception of magnitude estimation. Similar trends were found for the red-blue condition.

ANOVA's examining the effect of luminance on perceived velocity for the different methods showed significance in each case in the red-green condition. Similar results were found in the red-blue condition with a few exceptions. ANOVA's examining the effect of actual velocity and method on perceived velocity at different brightness contrasts in the red-green condition showed a significant difference between the methods and significant interaction between method and actual velocity at equal-brightness contrast. Similar, although less convincing, results were again found in the red-blue condition. ANOVA's examining the effect of actual velocity and colour combination on perceived velocity at each brightness contrast showed significant differences for the different methods and the effect of colour combination on perceived velocity at equal-brightness contrast.

The results from the first part of the experiment concerning proportions of predictable total variance for linear regression equations indicate that flicker fusion produces the most consistent results, while magnitude estimation is least reliable. Similarly, the second part of this experiment shows that flicker fusion tends to provide the greatest effect on perceived velocity around the point of equal brightness. Other methods also proved to be valid although they were unable to produce the same degree of effect on perceived velocity in this experiment. The fact that the flicker fusion method is superior despite the similarity of several of the equal brightness functions can be explained by the accuracy of the method in pinpointing equal brightness ratios and may also be due to the fact that flicker fusion and the motion perception system tap into the same or similar post-receptoral temporal frequency channels.

The less impressive results from the red-blue condition are most probably associated with the physiological differences associated with the short-wavelength-sensitive cones and their much debated contribution to the achromatic channel. Results showed qualitative differences in the effect of colour combination (i.e. red-green or red-blue) on perceived velocity at equal brightness.

In Conclusion it can be said that different methods of determining spectral sensitivity bring about different results for different reasons. The most likely explanation for such differences can be attributed to changes in chromatic adaption, differences in the post-receptoral mechanisms tapped by different tasks, and the varying contributions made to luminance by the chromatic and achromatic systems.
A COLOR CONSTANCY PHENOMENON RELATED TO PERCEIVED 3-D SHAPE

Flat, rectangular displays consisting of 2, 3, 4, or 6 vertical grey stripes, every other one being light and dark grey (NCS 3500 and NCS 6000, respectively) were presented one at a time illuminated by two identical projectors. One projector illuminated the upper half of the display through a yellowish colour filter (Strand "Golden Amber"), and the other one illuminated the lower half through a blueish colour filter (Kodak Wratten 80 A).

The display now appeared ambiguous, periodically and spontaneously shifting between two distinct 3-D shape percepts, A and B:

A: The display appeared vertically folded along the reflectance edges ("shape from shading" where the dark fields appeared to be attached shadows). The colours were quite saturated yellow and blue surface colours. There was no colour constancy.

B: The display appeared horizontally folded along the illumination edge like a roof ("shape from shading", where one of the illuminations appeared to be an attached shadow). The display now appeared very desaturated, even achromatic, but in a "warm" illumination. The colour constancy was almost complete.

The phenomenon will be demonstrated (slide) and some psychophysical data on the colour desaturation and on the frequency of shifts between the two percepts are reported as well as some observations on combinations of illuminant colours other than yellow and blue.

The reported colour constancy phenomenon is discussed in relation to an earlier presented model for the perception of illumination, colour, and depth (1,2,3,4).

References:


SHEDDING LIGHT ON COLOR TRANSPARENCY
IN ARCHITECTURAL FORM

Three dimensional design is created with three essential elements: light, color and form. Therefore these fundamentals have to be at the core of any serious design experience. Presently, however, the design process places the emphasis on creating form. Light and color, if mentioned at all, are only referred to in passing. The designs that result from this process are often quite limited and devoid of the sensory stimulation that our 'being' needs to be a 'well' being. To illustrate how using aspects of sensory stimulation in design can significantly enhance the perceptual experience of architecture this paper will deal with an intellectually and visually intriguing characteristic of color: literal and phenomenal transparency.

Transparency has existed in architecture since mankind allowed daylight to enter its first shelter. Daylight was needed to perform certain tasks indoors and modulating this light (and heat) through the use of screens, glass, shutters, curtains, curtain walls or other devices was a necessity that soon became an opportunity. Architecturally the idea of layering that is the creation of a series of successive but separate walls with overlapping openings (what John Raskin in Stones of Venice calls wall veils) became well accepted and connected to the early explorations of perspective. Both transparency created by truly transparent materials and the use of successive layers or screens was thoroughly explored by architects and designers of the Bauhaus and more recently those exhibited in the exhibition "Light Construction" at the Museum of Modern Art in New York in 1995. Surprisingly, in spite of the very sophisticated visual literacy taught at institutions like the Bauhaus, architectural dictionaries do not carry the terms transparency or transparent. The concept is either too obvious or too esoteric.

Transparent means being able to transmit light relatively unobstructedly making forms and shapes at the other side fully visible. In that context literal transparency refers to literally having the ability to transmit light like, for instance, glass. This characteristic, i.e. the ability to see the inside from the outside and vice versa, is one of the hallmarks of the architecture of the Modern Movement and the teachings of the Bauhaus.

Phenomenal transparency on the other hand is illusionary. It is the visual suggestion of three dimensional space without any space actually existing. Two seminal articles by Colin Rowe and Robert Slutzky written in 1955 and 1956 and published respectively in 1964 and 1971 define literal and phenomenal transparency and their use in three dimensional design. In their words: "...transparency may be an inherent quality of substance - as in a wire mesh or glass curtain wall, or it may be an inherent quality of organization as both Kepes and to a lesser degree Moholy-Nagy suggests it to be..." The authors are referring to Gyorgy Kepes' "Language of Vision" and Moholy-Nagy's essay "Vision in Motion", both Hungarian artists who were at one time affiliated with the Bauhaus. Kepes defined the two-dimensional aspect of transparency as the ability of figures to interpenetrate each other without destroying one or the other optically. Rowe and Slutzky identified evidence of phenomenal transparency in the work of other Cubist and post-Cubist painters. It is Josef Albers in his work Interaction of Color who describes and explores the notion of a phenomenal transparency specifically using color: "...when color is read as appearing above or below another in transparency (sic) studies, a third deception is recognized...space illusion".

Terence Riley re-introduced the concept of literal transparency in his introductory essay in the catalogue for the exhibition "Light Construction". Although he takes issue with some of Rowe and Slutzky's observations about literal and phenomenal transparency he does identify the presence of the phenomena in the work of several contemporary architects. Veils, screens and other physical separations are
used in the work of these architects to create space or volume. Riley sees the origins for this fascination in the early renaissance and the discovery of perspective. Although he does not specifically mention the 'camera obscura', this black box used at the time to study perspective and to convert a three dimensional representation into a two dimensional image comes to mind. The interiors by the 17th century Dutch painter Vermeer are good examples of the use of the camera obscura and the exploration of literal transparency in a two-dimensional medium. Another example of the widespread intuitive understanding of the concept of transparency, which is also not mentioned by Riley, is John Ruskin's use of the word 'well' in Stones of Venice. In the chapter of that title does he describe the character of walls and their construction.

Riley acknowledges a significant shift in thinking as witnessed by his reference to a less "formal" architecture. This architecture is one that less driven by the "formality" or in other words the constraints of the form and with more interest in the perceptual and therefore sensory aspects of design. In his mind the shimmering quality of the skin of Renzo Piano's Osaka Terminal is an example of how a surface quality (without mentioning color!) can shift attention away from the otherwise distinctive form.

In all these discussions the word or even the concept of color is glaringly absent. All examples deal only with the perception of space created by the use of veiling and screening devices. Using color to suggest transparency is not included. The subject of this paper is to take the idea of less "formal" architecture one step further and to reintroduce light and color once again as integral design tools.

The types of transparencies described above all involve the three basic design elements of light, color and form, without any of which neither literal nor phenomenal transparency can occur. While light, color and form are common to both two-dimensional and three-dimensional art and architecture, a further shift in intellectual and visual perception is necessary to translate relationships seen on a two-dimensional plane like a painting to effects perceived in three-dimensional or cubic space. Again in the words of Rowe and Slutzky: "... while painting can only imply the third dimension, architecture can not suppress it. Provided with the reality rather than the counterfeit of three dimensions, in architecture, literal transparency can become a physical fact; but more difficult to achieve - and is indeed, so difficult to discuss that generally critics have been entirely willing to associate transparency in architecture exclusively with a transparency of materials." If phenomenal transparency is that difficult to discuss it is not surprising that it remains outside of the architects' training as is its parent...color.

While literal transparency was explored by the architects of the Bauhaus and phenomenal transparency by the artists of that time, they appear to have remained completely segregated. The fact that the articles of Rowe and Slutzky did not appear until years after they were written (apparently an initial version was rejected for publication by Architectural Review) is an indication of the lack of understanding and how far and deep the segregation extended.

The exploration of literal transparency has given us a functional and rational architecture epitomized by the glass and metal curtain walls of the 1950's and 1960's. This architecture maximizes transparency literally and, while functionally correct, is totally devoid of the type of experiences that are necessary for an environment to be truly sensory stimulating or supportive to human behavior. It seems that the architects stayed architects and that the painters remained painters and the two never really "talked".

My explorations of literal and phenomenal transparency in three dimensional work has as its goal to integrate the three basic design elements, i.e. light, color and form. By using these elements simultaneously and alternatively in three dimensional space (or to suggest three dimensional space) a richness, warmth and stimulus has been explored that will enrich our built environment.

It is critical that the integration between architect and painter occurs so that the techniques of phenomenal transparency can be used to enhance our three dimensional environment. Light and color are primary tools for the painter; let us add them to the form giving tools of the architect and thereby enrich our spaces and consequently our lives.
THE SERIAL REPRODUCTION OF PARADOXICAL COLOURS

1. Introduction

Paradoxical colours occur when a well-known object is coloured with a tonality dissonant with respect to the norm. This situation is also known as "colour incongruity", and its occurrence and psychological consequences depend upon observation conditions.

When a paradoxical colour is observed in ambiguous perceptual conditions - i.e. tachistoscopically - processes of perceptual defense take place. For example, delays in recognition, highest perceptual thresholds, compromise solutions, assimilation to the memory colours (Bruner & Postman, 1949).

The exhibition of paradoxical colours is in non-ambiguous perceptual conditions (i.e. in free vision of a near and well-enlighted chromatically incongruous object, such as the drawing of a blue hand), gives rise to a typical enhancement of the anomaly (a more saturated blue colour). This phenomenon has been studied by our research group (Bonaiuto, Miceu Romano & Bonaiuto, 1990; Bonaiuto, Giannini, Miceu Romano, Biati & Bonaiuto, 1994).

2. Serial reproduction: procedures and previous studies.

Serial reproduction is a technique by which, starting from a given model, a series of subjects sequentially copy one from the other, until, for example, ten or more reproductions have been made.

It may involve simple pencil drawings or sophisticated computer graphics. Also it may involve verbal narratives; either written, like the works of medieval copyists, or merely oral, like the spread of rumors. Again it may involve body movements, as in the sequentially imitation of gymnastic, yoga or dance paradigms.

Bartlett (1953) used serial reproduction of a black dot that initially appeared slightly out of center, inside a vertical white rectangular paper. This demonstration showed the surprising progressive migration of that point toward the nearest corner, through successive reproductions each made by a different person. Stadler, Richter, Pfaff & Kruse (1991) developed this demonstration to support the hypothesis of complex psycho-physical and psycho-physiological dynamics due to the presence and action of "attractors" at the corners of the rectangular field. Bonaiuto (1991a, 1991b) outlined a different hypothesis: serial reproduction may progressively emphasize a slight anomaly because of automatic comparisons leading to contrast effects during the exploration of the model, and because of the general tendency to exaggerate the anomaly as relevant information during the act of copying. He was able to demonstrate that the serial reproduction of a human facial profile with a slightly prominent nose, progressively leads, after sequentially copying by 25 subjects, to a nose four times as long as the original.

Recently, Bonaiuto, Giannini, Biati & Bonaiuto (1996) replicated this experiment and found support for this finding in different cultures.


When pastels on paper are used, they showed the concurrence of different phenomena: emphasis and normalization. The copying procedure significantly emphasizes colour saturation of each model, as a main effect. According to our hypotheses and explanations, the dynamics of this phenomenon may include: a) a simultaneous contrast effect between the coloured model (in the role of "induced" element) and the corresponding empty contour to be coloured (in the role of "inducer"); b) a successive contrast effect bet-
ween the coloured model ("inducer") and the corresponding mental schema with normal and plausible coloration when the model exhibits paradoxical colour ("inducer"); c) a general tendency to signal a focused colour as relevant information in copying; and d) a tendency to exaggerate colour saturation of the paradoxical colour as a crucial piece of information in copying.

The second phenomenon, normalization, happens when serial reproduction of paradoxical colour tends to regularize some very disturbing small coloured details, activating defensive behaviors. These normalization dynamics cooperate with the main emfahization dynamics leading to dramatic transformations after a series of reproductions starting from a given model.

Of course, when colour is homogeneously added using computer graphics, only the emphasis dynamics are shown. Nevertheless, the last procedure exhibits some advantages in terms of speed and completeness in colouring by subjects, as well as reproduction, control and exact evaluation of objective colour parameters by examiners. For these reasons we adopted both experimental techniques, the traditional pencil and paper and the more sophisticated computer graphics.

4. New experiments.

Replicating our previous studies and developing new experiments, subjects were asked to colour the inside of configurations visible within a black linear contour on white background, using: a) coloured pastels on paper; or b) a computer with a colour monitor (Power Macintosh 7100/80 with Adobe Photoshop 3.0 software). Subjects were adults equally distributed by gender, aged 19-39 yrs. and individually examined. Each person was tested only once and only with one technique. Each series included 15 sequential coping tasks. Different patterns of the same light blue colour served as models (hue: Cyan; saturation: 20%). Models include: object outlines with light blue as normal or acceptable surface colour (bluebells, lamp-shade, amoeboid shape, etc.) or incongruous colour (human head, human hand, set of teeth, etc.).

The serial reproduction task significantly emphasized the colour saturation of each different model, but intensified the paradoxical colour almost twice as much as the congruous ones.

These results confirm the concurrence of more dynamic factors in enhancing paradoxical colours than with regard to the congruous ones.

References


SEMIOTICS AND CECIA:  
THE MEANINGS OF THE SPATIAL DISTRIBUTION OF LIGHT

This paper poses the problem of how to organize the different aspects of cemia from the semiotic analysis. Defining cemia as a perceptual phenomenon, what we see from the different spatial distributions of light—the same aspect that others have designated as “geometric attributes of appearance” (Hunter 1975) or “quality of surfaces” (Geeen-Emynytage 1992, 1993)—, the task is to consider the previous research in this field (Caivano 1991, 1994, 1996) from the point of view of the semiotic processes, i.e., the processes by which something signifies some other thing for someone. In our case, this kind of visual signs—cemia— are taken as the representation and interpretation that our visual system makes of the different modalities of spatial distribution of light.

On one hand we have a physical phenomenon: visible radiation and the way it interacts physically with the objects, producing diffuse or regular, transmitted or reflected light, and their combinations. On the other hand we have a perceptual phenomenon: a visual sensation produced by that physical stimulus and a cognitive inference that generates the perception of translucency, transparency, matte opacity and specular gloss, with all their intermediate degrees. Both aspects, the physical and the perceptual ones, separately produce semiosis in their respective levels: in the first case within the scope of physiogenesis (among physical events), in the second one within the sphere of cognitive semiosis (among sensorial representations and knowledge). We could place the connection between the physical and the perceptual aspects within the study of biosemiosis, concerned with how a particular biological device, such as the vision system, decodes certain physical events obtaining useful information for the survival or the interplay with the environment of the animal to which this vision system belongs.

In relation to this last aspect, even if collaterally, it would be interesting to see how different animal species build up signs of cemia. Research has been made on color vision in species other than the hu-
man one, that is, with respect to the sensations produced by the spectral distribution of light. We know that some animals sense light beyond the range visible for the human being (for instance in the ultraviolet), that some do have trichromatic vision while others do not, etc. In the same way, the subject of how different animals sense the different spatial distributions of light could also be approached.

References:


THE SHAPING PROPERTIES OF COLOURS

This paper will present a research project which takes its point of departure in some pragmatic and phenomenological notions concerning practical knowledge and our bodily handling of the world as shaping our becoming way-of-being.

One basic assumption is that the culture sets certain material conditions for our development of capacities as well as needs. Some of our dispositions - or what Drew Leder (1990) calls “vectors” - are shaped in our everyday handling of architecture. Architecture is, in a lot of respects, a culturally homogeneous phenomena which shows almost negligible variations, and may from this point of view be seen as practically involved in our development of normal capacities and needs.

Another assumption is that our normal way of practically handling something is revealed when the conditions it depends on are manipulated. Practical manipulation with material conditions is thus seen as a method to investigate our dependence on certain conditions. This study is particularly directed towards architecturally related visual capacities and needs, that is, our way of seeing and its dependence on certain architecturally given material conditions.

Some of the questions which will be guiding to this project is: to what extent is it possible - and interesting - to practically investigate the architectural conditions for certain behaviour-like usages? What would be illuminated by practically experimenting with (or “manipulating”) those basic architectural conditions which we normally never perceive that we handle at all? What is, for instance, accomplished by the “illusions” of the Fun House, when regarded as such revealing experiments?

Contrary to the specialist’s practical knowledge, our practical knowledge of how to handle architecture does not seem remarkable in any way. However, some of this “routinized behaviour” may be unveiled, for instance in the “distorted” rooms of Fun Houses in amusement parks. Studies of specialist practices show that knowing how something ought to be, is dependent on a “feeling” - a sort of bodily recognition of how something is, when it is right. When this kind of judgement is extrapolated to everyday living, it concerns how things are - normally. The distorted architecture of a Fun House reveals properties we are trained to handle as permanent and uniform.

The illusions of Fun Houses all play on our practiced skill to handle architecture “as it is” - normally. Our “feel” for spatial direction becomes distorted. The concrete material properties we are trained to handle are absent, and our handling of the room as if it was familiar turns into a sort of bodily mis-reading. The properties manipulated in Fun Houses, are those which according to our routinized architectural behaviour are essential to recognize.

Most spatial “distortions” of Fun Houses manipulates our habitual recognition of floors and walls as horizontal, vertical and right angled. This habit may also be decisive to the effect of a lot of perspective “illusions” (used, for instance, as architectural or scenic effects). Trompe-
Trompe-l'œil may also, partly take support from this habit, but here other regularities in our perceiving are more decisive. Trompe-l'œil manipulates with our habitual recognition of differences between varying colour patterns, which allows us to distinguish three significant features: the light situation, the identity colours{1}, and the object shapes. Usually trompe-l'œil represents attempts to paint a flat surface in such a way that it seems to “stand out”. It thus captures, but does not further manipulate spatial qualities. What I call a “reversed trompe-l’œil” instead manipulates our habitual recognition of the light situation, identity colours of objects, and object shapes of actually protruding volumes. The “distortions” accomplished in reversed trompe-l’œil let other sorts of illusions appear, where our normal ways of perceiving light, colour and shape becomes contradictory and reveal some of its regularities.

The use of reversed trompe-l’œil gives us concrete situations to study. So far I have been working with geometric reliefs where the pattern of the painted variations{2} is repeated in a way which lets the effect of the manipulation appear clearly. The phenomena appearing in these reversed trompe-l’œils is comparable with Monica Billger’s findings in her studies of colour appearance in room. The comparability may depend on the repetitive reliefs capacity to create a “room” of its own – where we can accept certain lighting conditions which may deviate radically from that of the surrounding room.

The reversed trompe-l’œil reliefs which make up some of the starting material for this project let some interesting phenomena appear which are even more interesting to analyze in comparison with the observations made by Monica Billger. I will briefly describe this relief material here:

* “chameleon-star” allows the identity colour to change when the direction of the light is changed. Still, the appearance colour differences then seem less significant than when five identical reliefs are put in different angles in relation to the same light. This phenomena is quite independent of viewing angle (that is, under the condition that most of the painted side of the relief is seen at all).

* “shape-distinctiveness” has been manipulated by painting different patterns of light-and-shade variations. The “shaping” is enhanced or weakened by variations in, for instance hue, chromaticness or brightness. Some patterns of variations let the shape appear in a surrealist clear way, while others make it almost hard to perceive distinctly. This phenomena too is quite independent of viewing angle. In both cases the distinctiveness is not experienced as painted, still it is neither experienced as depending on the light. The difference in distinctiveness is obvious, but very hard to give a name.

* “blue-tinted contradiction” appears in a grey-scale relief when the painted variation seems to come in conflict with the actual light-and-shape: those sides which ought to appear lighter seems to be lit by a blue light. Also this phenomena is quite independent of viewing angle.

* “breaking up painting” may under certain circumstances result in a shift of meaning of the perceived colour variations: what is actually a light and shade variation appears as differences in identity colour of the painted elements (this phenomena presupposes that the relief is seen from an angle where the painted shape does not seem to contradict the actual shape).

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1 Monica Billger, unpublished manuscript.
2 Monica Billger, unpublished manuscript.
ILLUSIONS IN ARCHITECTURE, WITH COLOUR

Illusions have been experienced in historical and modern architecture for many purposes at various scales and with different means, the lightest and the cheapest of which is perhaps the colour. The aim of this paper is to make a systematic inventory, illustrated with specific historical and modern examples, of the main categories of illusions in architecture realized with the help of colour.

A first category of illusions in architecture is represented by the imitation with colour of real building materials, architectural elements and other artificial and natural objects. The imitation with painting of real building materials is motivated by economic and sometimes by more complex cultural reasons and can be found in interior and outside walls, in floors and ceilings. The most common materials imitated with painting are granite, marble, stone, brick, terracotta, wood, iron, bronze, but also gold, glass, wall paper and other less common materials have been imitated with colour, sometimes at the urban scale. These «painted illusions» can be reproduced directly on flat walls or on the materials or elements to be enriched and dignified by colour. The imitation in trompe-l'oeil of architectural details is made usually at the scale of the single element (sockets, basements, corner stones, cornices, windows, doors, shutters, iron bars, railings and so on), with or without the identification of the texture peculiar to the material with which the element is supposed to be made. The illusion can also be extended to an entire building or to the whole city conceived as a living theatre, as it happened in Genoa (Genoa Picta) and in Turin (Theatrum Sabaudiae) and can be found both in historical and modern architecture. To the same category belongs also the imitation of «architectural ruins» of which can be found amusing historical (Baroque architecture) and modern (S.I.T.E. Group) examples. Sometimes, the architectural environments imitated in trompe-l'oeil can also include imitations of human, animal and naturals elements like sky, water, snow, earth, trees, flowers etc., added to give a more concrete sense of illusion.

A second category of illusions in architecture with colour is constituted by the creation with painting of special optical effects. To this category belongs the illusion of perspective, obtained for instance with the use of dégradé, a technique employed in the original decoration of the Tour Eiffel in Paris or in on alternative decoration project of the London Crystal Palace; the illusion of lightness, reached through the use of particular colours; the illusion of light and dark, obtained with various tricks; the illusion of transparency and that of vacuity, reached in classic architecture with the use of different colours like blue, red and black; the camouflage in military architecture, obtained with the use of mimetic colours applied to military buildings during the war, but also obtained with the imitation of natural or built environments painted directly on military structures, a strategy applied with some adaptations also to civil buildings, to improve the quality of the built environment.

A third category of illusions in architecture still obtained with the help of colour is represented by the illusion of freshness, hygiene, tranquillity, excitement, richness, nobility, individualism, ethnicity etc., experimented by different cultures in various historical periods in particular environments. Some of
these illusions, based on precise psychological rules, have been included sometimes in the Nineteenth Century building codes in Italy.

Illusions in architecture can be realized at various scales and by different meanings. The aim of this paper is an attempt to make a systematic inventory, illustrated with specific examples, of the main categories of illusions in architecture realized with the help of colour.

Illusions in architecture with colour

The main categories of illusions in architecture with colour identified until now are the following:

1. Illusions created by means of the imitation, with painting, of real building materials, constructive elements and other natural objects:
   1. imitation of real building materials in interiors and outside walls, floors and ceilings (fake granites, marbles, stones, bricks, woods, iron, bronze, gold, glass, wall papers etc.);
   2. imitation in trompe-l’oeil of single architectural details (sockets, basements, corners stones, cornices, windows, doors, shutters, iron bars, railings and so on);
   3. imitation of entire buildings (historical and modern trompe-l’oeil);
   4. imitation of ruins (historical and modern examples);
   5. imitation of human, animal, vegetal elements and environmental elements (sky, water, snow, earth etc.);

2. Creation, with painting, of special optical effects
   1. Illusion of perspective obtained with dégradé;
   2. Illusion of lightness;

3. Illusion of vacuity in classic architecture;
4. Illusion of déjà vu;
5. Camouflage

6. Other illusions in architecture with colour:
   1. illusion of freshness, hygiene, tranquility, excitement etc.;
   2. colour used with functional and symbolic means in industrial and commercial buildings, (security, corporate identity etc.), hospitals etc.
   3. colour used with erotic and occultist intentions.

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Earlier studies (Feallcock et al., 1966; Chaparras & Overbay, 1971; Drefeldt et al., 1984) have shown that 10 to 15 colours is not an upper perceptual limit for absolute identification of colours. With careful selection and training, as many as 20 to 30 colours can be identified. Even more colours can be absolutely identified with extended practice (Hanes & Rhoads, 1959). In dealing with color-naming data, internal consistency is usually good while between-subject differences are great (Halsey, 1959; Chaparras, 1965). This tendency could also be seen in the data by Chaparras and Overbay (1971). On the first trial not a single color was correctly identified by all the subjects. Smallman and Boynton (1993) have showed that color codes made up of eleven personally generated nonbasic colors segregated equally well in displays as color codes made up by eleven basic colors. However, when subjects were asked to search for nonbasic colors with names determined by a different subject a slight increase in response time was observed. The authors suggest that this loss of performance was due to less practice with the idiosyncratic color codes made up by other subjects.

The internal consistency and between-subject differences in color-naming data can be discussed in terms of recent neuropsychological findings on the brain systems for color. Damasio and Damasio (1992) suggest that the brain systems for color involve a three-part organization: (a) the concepts of the colors depend on the functioning of one system, (b) the words for the colors depend on another system, and (c) the connections between words and concepts depend on a third system mediating between the two. Patients with lesions in the third system suffer from a peculiar defect called color anomia, which affects neither color concepts nor the utterance of color words. These patients continue to experience color normally; they can match different hues, correctly rank hues of different saturation and easily put the correct colored paint chip next to objects in a black-and-white photograph. But their ability to put names to color is dismally impaired... The defect goes both ways: given a color name, the patient will point to the wrong color.* (Damasio & Damasio, 1992, p. 65).

Purpose of this study

From the language-concept connection it might be suggested that color concept retrieval may be enhanced by free color naming manifesting already established individual associations between color concepts and color words. Color cognition would be more easily accessed by free color naming without training compared to when standardized color names have to be learned. The purpose of this study was to test absolute identification of colors by free color naming.

Procedure

Selection of colors. A color selection tool (Hedin & Drefeldt, 1990) was used for the selection and adjustment of the colors. The transformation from CIE 1931 XYZ tristimulus values into CIELUV space was made using standard formulae (CIE, 1986) and the transformation to NCS notations (Hedin & Drefeldt, 1990) was based on modified versions of computer programs developed by Tornquist and Celander (Celander, 1973; Celander & Tornquist, 1972).

35 color stimuli consisting of two sets of colors were selected to be used in a window-oriented Graphical User Interface (GUI). One set, safety colors, consisted of 5 luminous colors of high chroma, and the other set, window colors, consisted of 30 surface colors. To meet requirements for three-dimensional design in the GUI, three levels of lightness (L*) were selected for each window color where the highest level of lightness was used for the window color proper and the two lower levels for the window background colors contributing to the 3-D effects.

Safety and window colors have qualitatively different functions: The primary functions of safety colors are to warn and inform operators and make them prepared to act. Safety colors
are often bright basic colors since bright colors tend to attract attention and basic colors are less confusing and more easily remembered than non-basic colors (Uchikawa & Boynton, 1987; Boynton, 1989; Smallman & Boynton, 1993). Window colors must also be easy to identify but they should not attract or divert the operators attention from the task at hand. Each window color must segregate well and harmonize with every other window color and with the background.

Using a color selection tool (Hedin & Deredfeldt, 1990), the colors were selected and adjusted through an iterative process: First five basic colors with high chroma were selected as safety colors. The thirteenth window colors were selected in successive steps, beginning with the NCS elementary colors. Colors from intermediate regions of the hue NCS circle were then added one at a time, and tested and adjusted until each color appeared as perceptually different as possible from every other color of the set and it was possible to separate and name each color. The background color was a neutral color.

Experimental session

Color-naming procedure. Each subject was told that he/she was to be asked to name each of 30 window colors. The subject was instructed to choose names of the window colors that had strong associations (personal experiences, memories) to the colors at hand. They were also given examples of color names.

Identification session. During the identification session, the subject was seated as during the color naming procedure. Each color was presented as a filled circle with a radius of 25 mm in the center of the screen. The background color was the same as in the color naming condition. Each color was presented for 3 sec with 15 sec between each exposure during which the background color was shown and the subject had to give his/her response. The task of the subject was to identify the presented color using the color names given during the color-naming procedure.

References


THE MEANINGS OF COLOR IN ARGENTINA

This paper presents the results of applying in Argentina an international survey initiated by Lars Sivik (1974, 1974a) and Charles Taft (1989). The survey employs 27 color samples taken from the Atlas of the Natural Color System, and 26 semantic scales limited by two opposite concepts. The inquiry has been made in Sweden and Greece in 1968, and in Sweden and the United States in 1988. This allowed for the comparison of cultural differences in the meanings of color (Sweden-Greece and Sweden-USA) and the stability or variability of the meanings within a span of 20 years in the same culture (Sweden 1968-1988). Thereafter, the study was carried out in Russia and Croatia, and now it is made in Argentina.

The questionnaire is administered individually, and includes data allowing comparisons by sex, age ranges, and profession. In principle, it is made over 100 subjects (50 males and 50 females) with ages going from 16 to 65. They are divided into five categories (16 to 25, 26 to 35, 36 to 45, 46 to 55, and 56 to 65 years). The same quantity of subjects is covered for each age group (10 males and 10 females). With respect to the professions, we also look for an even distribution, excluding only from the survey those professions directly concerned with color, such as interior design, fine arts, architecture, etc. (this is the same criteria employed in Sweden).

The results of this research could be useful, from the theoretical point of view, for semantic and linguistic studies. In addition, they will certainly serve to practitioners in different modalities of design (interior, industrial, graphic design, architecture, etc.), and for the marketing of products.

References


A CROSS-CULTURAL STUDY ON COLOR PREFERENCE
IN JAPAN, CHINA AND INDONESIA,
WITH EMPHASIS ON THE PREFERENCE FOR WHITE

To determine and compare the main color preference tendencies in Japan, China and Indonesia, 490 subjects (175 Japanese, 158 Chinese and 157 Indonesian) were asked to choose from a color chart with 77 colored chips the three colors they liked most and the three they liked least, and to state the reasons for their choices. In most of the cases, the questions were asked orally either individually or in small groups of two or three people. The color chart was observed under either fluorescent light or daylight from northern windows.

Analysis of the results by correspondence analysis showed that each area has unique color preference tendencies and that there are statistically significant differences in the frequency of selection of colors of certain hues and tones. However, a high preference for white was common to all areas, along with preferences for some other colors. The successive studies done by the author have demonstrated a common strong preference for white in other Asian areas as well. The reasons given for the choices suggested that associative images based on environmental and cultural aspects may be an important factor influencing color preference.

To sum up, the following results were mainly obtained in the present study: (1) A strong preference for white was observed not only in Japan but also, to an even greater degree, in all Asian areas where the survey has been carried out so far. One of the reasons for this common preference in these neighboring areas was believed to be geographical and cultural proximity. The psychological and anthropological reasons for the common preference for white in Asian areas should be studied more extensively in other Asian areas to clarify the components of color preference.

Cross-cultural agreements were found in regard to some colors beside white. Vivid blue, light green and vivid red were com-
monly ranked among the top ten preferred colors in all three areas. Meanwhile, gold and dark red purple were commonly unpopular.

(2) Unique tendencies in color preference were found for each area when the results were analyzed by correspondence analysis; while the Japanese people were characterized by their preference for BG, metallic and pale tone colors and non-preference for YR, light grayish and dull tone colors, Chinese subjects were distinctive for their preference for vivid tones and non-preference for achromatic and dark tone. On the other hand, the people in Indonesia had a preference for achromatic colors and non-preference for vivid tone (especially vivid yellow), pale tone, metallic and bluish colors.

(3) The results of the present series of studies suggested that the associative images of colors were responsible for color preference. These associative images mostly reflected the subjects' mental images towards colors themselves. This also suggested that the psychological affective value of colors should be investigated by presenting colors without any association with or influence from particular objects, although contrasting views may propose that the affective value of color cannot be studied separately from other variables such as form and texture. The fact that subjects can associate and evaluate color images more freely by observing single color chips is probably the main reason why many past studies have carried out the investigation of the affective value of color not in combination with other variables, but free from their influence.

Moreover, in the present study, the associative images of colors sometimes reflected cultural and environmental aspects in each area surveyed. Therefore, one could conclude that beside the individual factors of sex and age, environmental factors such as geographical and cultural aspects are important in regulating color preference.
Colour as Idiom

Just as language is determined by the way in which society sets up systems of values, things, and ideas, so our chromatic perception is determined by language ....... the names of colours, taken in themselves, have no precise chromatic content: they must be viewed within the general context of many interacting semiotic systems (Umberto Eco).

The names of the principle colours frequently appear in written and spoken language in the context of idioms, figures of speech and similar forms of commonly-used phrases. Sometimes the reference to a colour is obviously descriptive as in the green shoots of recovery for the initial visible signs of growth, or to be in the red for an account which is in debt, or a bolt from the blue for a sudden and unexpected event.

Other occurences can be less obviously descriptive but the connection with the colour concerned can be traced back to show that it has indeed originated from a descriptive reference but that the source has long ceased to be immediately apparent as, for example in red tape for 'excessive bureaucracy', or the yellow press for 'sensational journalism', or a blue stocking for 'a female intellectual'. While idioms which are descriptive or literal in origin do not in themselves directly reveal a great deal about the psychological associations of colour, the sum effect of repeated usage may of itself condition our responses to colours, particularly where certain states of feeling and emotion are evident. For example, to paint the town red (to have a really good time), a red letter day (a particularly memorable occasion), to see red (to get very angry), a red rag to a bull (to do something guaranteed to make someone angry), and red-hot (sexy, passionate) are all evocative of lively, excited and even angry emotions.

But there is also a third form in which the names of colours are used in idiomatic language. This is where the use of the colour is not descriptive in any sense, for example to tell a white lie for a relatively minor untruth, or to be green with envy for being very jealous, or to cry blue murder for an extravagant outcry. Where do these associations of colour with feelings, emotions and other qualities originate from? And more importantly, what does the use of colour in idiomatic language tell us about the ways in which colours are associated with certain feelings and emotions, the so-called psychological associations or meanings of colour? By identifying the idioms involving each of the principle colours - red, blue, green, yellow, purple, orange, black, white, gold and silver - the author asks which qualities are consistently associated with each colour. Do these therefore provide a basis for conclusions about links between colours and emotions which transcend the descriptive and the symbolic?
As part of this enquiry, the paper will also examine the occurrence of colour names as idioms in numerous other languages. Do examples exist where there is a consistent association between colour and emotion across several or even many languages which might reveal a more deeply rooted link between chromatic sensation and emotional feelings? Conversely, where there is no consistency between different languages, can we conclude that the association is merely arbitrary or 'culture-specific'? Why, for example, is a book or film of a pornographic nature considered to be blue in English (as in a blue movie) while in French, to tell a rude story is associated with the colour green as in en raconter des vertes?

A comparison of idiomatic usage of green in European languages gives an indication of the variety of associations which can be found. In French un vieillard encore vert is a 'dirty old man' while in German a grüne Witwe is 'a lonely suburban housewife' but die beiden sind sich gar nicht grün translates as 'there's no love lost between them'. To an Italian ridursi a verde means 'to loose all one's money' but in Spain poner verde a alguien is 'to give somebody a dressing down' and in Portugal jogar verde para colher maduro is 'to ask leading questions'. The Dutch say het werd hem groen en geel voor de ogen meaning 'his head began to swim' but in Denmark søve pa sit gronne ore translates as 'to be fast asleep'. Norwegians say komme pa den gronne gren meaning 'to do well for oneself' but they also say han egret seg gul og grønn which translates as 'it irritated him beyond annoyance'. Green for a Hungarian can mean either 'to get on, to reach one's goal' - zold agra vergodik - or it can mean 'to talk garbage, to talk nonsense' as in zoldosket beszel while for the Finns penna vihen veran alle is 'to sweep under the carpet'.

The research for this paper consists of a series of interviews with - and questionnaires completed by - native speakers of a broad range of European and non-European languages. Reference will also be made to various dictionaries, thesauruses, etc. particularly dictionaries of idioms, etc. such as the Oxford Dictionary of Current Idiomatic English.
ALL COLOURS ARE NOT CREATED EQUAL:
THE PSYCHOLOGY OF CATEGORICAL COLOUR NAMING

Colour space metrics have long been a popular field for visual research. Such work has led to the development of such constructs as colour difference metrics, uniform colour spaces and other theories related to the development of psychophysical differences between colours. However, although many metrics exist, as yet there is no explicit metric or space to describe colour naming, and similar categorical colour differences, nor the nature of best examples of named colours ('prototypical' or 'Focal' colours). Such a metric, if derived would shed light on the nature of colour cognition, and would also aid in practical issues such as the generation of nameable, discriminable colours for computer work.

The work described here seeks to quantify categorical colour perception and thus build a categorical colour perception space analogous to the psychologically uniform colour spaces such as CIELUV. This work is centred around responses to colours on a computer display (CRT).

Method. Three luminance slices through the CIE 1976 UCS were taken, sampling colours every 0.02 UCS units along the u' and v' axes within the gamut of the monitor (a 21-inch NEC 6FGp). This provided three palettes of equally luminous colour stimuli-137 stimuli at 7.6cdm⁻², 132 at 16.6cdm⁻² and 79 at 27.4cdm⁻², a total of 348 different colours. Three different background luminances were also provided at 2.7, 7.6 and 16.6cdm⁻².

The stimulus array consisted of a semi-complex display layout, with a reference white border (D65 at 65cdm⁻²), background area, central 2 degree of visual angle stimulus square and eight landmark colours of various hues, luminances and sizes.

Ten subjects viewed all nine possible stimulus colour set-background combinations. Name responses to stimuli were unconstrained (i.e. were not forced to be monolexemic). During viewing subjects encountered each colour thrice. Each subject thus provided a grand total of 3132 observations.

Response latencies to name colours were measured. Additionally subjects provided confidence ratings along a five point scale for each given colour name. This rating was based on how likely the subjects felt it would be that they would call the colour so named by the same name if they saw it again at a later time.

Results. The consistency of a subject for the three name responses given to each particular stimulus colour-background combination (a 'response triad') was derived. The measure quantified the linguistic similarity of names used for the particular response triad.

For each stimulus colour within the three palettes, against each of three different backgrounds, mean response latencies, confidence ratings and consistency values were obtained. These mean data were entered into a principal components analysis to obtain a nameability value for each of the colours. The nameability values for colours correlated highly with a previous index of ease of free naming: Simpson & Tarrant (1992) codability index. When these nameability values were plotted along u' and v' axes, nameability surfaces for colours against each of the backgrounds were derived. These surfaces possessed a distinct and remarkable structure. This structure consisted of, firstly, a general trend of increasing nameability with increasing saturation. More interestingly, however, were two ortho-
nal 'valleys' of low nameability, crossing at the white point, and interrupting the simple saturation-nameability link.

Structure of Naming Space. Distinct divisions in colour space were evident between Basic and Non-Basic name types, as has been found by previous researchers (e.g. Boynton & Olson, 1987). Valleys in nameability space, lying approximately parallel to u' and v' axes strongly defined regions of predominately non-Basic name types, cutting the colour space into quadrants. These non-Basic regions between quadrants seemed to occur in transitional zones, where the opponent chromatic channels defined in Hunts' colour appearance model (Hunt, 1987) were swapping polarity of output. Belief in this type of physiological link has predominated since Ratliff (1974). As well as the primary quadrant based division, there also exist colour name boundaries within quadrants, and a Grey named region in the centre of colour space. The quadrants subdivide into name groups of:

(i) Green,
(ii) Blue,
(iii) Pink and Purple,
(iv) Red, Orange, Brown and Yellow.

The categorical boundaries present within quadrants (for example between Pink and Purple regions) do not show large nameability changes and are not associated with any distinct non-Basic names. For example between the Blue and Green regions there is a distinct Turquoise name group which has a corresponding large decrease in nameability. That is there is a Turquoise region, but it is comprised of relatively hard to name colours. Conversely between Pink and Purple regions there is neither a noticeable dip in nameability nor a transitional, non-Basic subregion. The distinction between name boundaries within and between quadrants is also reflected in the degree of overlap in names used at each stimulus location. For instance the Blue-Green boundary is very distinct; very few colours in the Blue region are frequently named Green. Yet the Pink-Purple region boundary is indistinct; many colours in the Purple region are called Pink frequently. Additionally the polarity of output in Hunts' opponent channel expressions does not change within these quadrants, unlike across the major quadrant boundaries. This may be linked to why the within-quadrant boundaries are different, although the precise reason remains uncertain.

Focality. The best examples of colours for name regions ('Focal colours') were also considered and their roles in the colour naming space investigated. These Focals were operationally defined as the stimulus colours with a given modal name, on the background under consideration, with the highest nameability value.

The quadrants with only a single dominant name within the region (i.e. Blue and Green quadrants) always possessed the best Focals. Indeed, in rank order many Blue and Green colours were better named than even the Focal example of any other colours. This effect was found against all three backgrounds. However there was no clear distinction in Focal 'quality' between the names within the other quadrants.

Conclusions. This work does seem to lend support to a physiological distinction between certain Basic colours, and different types of colour name boundary. Certainly Blue and Green colours seem remarkable in their unsharing 'capture' of regions of colour space. However the distinction does not seem to extend to 'landmark' Basic colours (Müller & Johnson-Laird, 1974) versus other Basic. There may also be two types of categorical perception process present. It appears that (for example) a Purple-Pink boundary and a Blue-Green boundary are quantitatively and hence perhaps qualitatively different. Unfortunately since a computer monitor can only show a (large) subset of colours which exist in reality, the certainty of this distinction across all visible stimuli must remain clouded; at least until display technology improves to allow full sampling of colour space.
A comparative study of the domain of color space between foci of red, blue, white and black (hereafter called violet-domain) was based on experimental data and linguistic material; as well the subject matter of folklore and historical background was studied.

Colour perceptions of violet-domain are ones in which there appears some uncertainty in the designation by colour words. In English the commonly accepted basic colour term is "purple" although the "violet" is in general use too. Still the English "purple" is translated by the violet-stem words into a number of languages, French, German, and Russian among others. In Estonian there are at least three monolexemic colour-naming for violet-domain: LILLA, VIOLETNE, PURPURNE. All three are loan words from the 19th century.

The purpose of current research was to examine two questions: to get a synchronic model of categorization of the violet-domain in nowadays Estonian and to compare result with a historical background, so getting the diachronic dimension. The aim was not so much to find out the basic colour term for the space, but the differences between the given colour categories.

In order to get the model of categorization of the violet domain two experiments were made. In Experiment I, the subjects were asked to name the samples of the violet-domain. The use of words were free. In Experiment II the subjects were asked to show the best sample (focus) and all samples by the given monolexemic colour-words.

The samples used as stimulus materials in the experiment had NCS notation. As there exists no adequate Euclidean model of perceptual color space, therefore: (1) from the available samples of that domain of colour space a suitable and most uniform set was chosen;

(2) in order to calculate the volumes of the color domain the correction has been maid using the data of OSA-UCS.
LILLA ("lilac") is the most possible basic colour term. It is the oldest loan word from the beginning of 19th century. Hypothetically it is possible to claim that VIOLETNE ("violet") reached into Estonian through the physics schoolbooks (first of them written by the J. G. Schwartz in 1855) and through the public education literature. So the word is a late echo of the Newtonian color circle and categorization. In the everyday use violet still designates first of all the spectral hue having a taxiommetrical value, for the less saturated and lighter colours the lilac is used. PURPURNE ("purple") came into use through translations of the Bible having so a certain Christian and appreciative connotation.

A final task of the research was the comparison across languages using the published data of different experiments concerning basic colour terms.
COLOUR TERMINOLOGY

COLLOCATIONS AND THE WORD ASSOCIATION RESPONSES

The main target of this paper is to analyse colour names in the framework of the word association theory.

Our experiment includes 50 informants and it suggests that there are strong habitual associations with colour terms probably due to cultural and linguistic reasons, e.g.

<table>
<thead>
<tr>
<th>stimulus word</th>
<th>the most frequent response</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLACK.........</td>
<td>WHITE, CAT, SAD, DEATH....</td>
</tr>
<tr>
<td>WHITE..........</td>
<td>BLACK, SNOW, CHRISTMAS...</td>
</tr>
</tbody>
</table>

We have compared the results of the word association responses relevant for English, Croatian and Japanese language. Besides stable cultural associations specific for one language only, these three languages share some common features leading to some kind of patterned behaviour in the choice of word association responses. In order to support our research with additional information we have analysed a limited number of fixed phrases (200) dealing with colours because of the possibility their influence on the word association responses.

The results of the analysis show that colour terms have natural and conventional associations. They usually refer to human behaviour, objects, etc. Cross-cultural analysis of collocations and word association responses gives us an insight into linguistic and cultural differences and similarities.

Finally, we can conclude that the members of different cultures live in the same world but they categorise it differently using different colour terms for the same experience. Similarities are probably due to the constraints of the human perception, similar cultural background and language universal influences.
This talk will discuss the use of colour in literature with reference to Beckett's written work and in particular the Trilogy (Molloy, Malone Dies and The Unnamable).

The evolution of his "linguistic colour palette" will be examined in the context of various theories of colour by earlier writers like Proust and in the light of his involvement with painters such as the Van Velde brothers.

Though they appear relatively infrequently (only 167 terms in the 160 pages of Molloy), the colours play a determining role, both structurally and symbolically. And in this writing where the boundaries between the three novels of the Trilogy and indeed between earlier and later works are fuzzy and indistinct, repetition is an important factor in creating unity. Appearances of colour connect the different contexts in which they appear (like the grey hens and parrots who turn up in different novels), and invite review and comparison.

Colour also has the further advantage of stressing the importance of sensory as well as to adding to the battle between the Senses and the Intellect. The sense of sight, underlined, as it is here by the many mentions of lamps, torches, glasses and light, and indeed, frequent enigmatic mentions of the word "colour", culminates in the painful image of the enormous unprotected eye, forced to gaze unceasingly on a blank white wall.

Each colour shows a governing attitude or theme. Grey seems to be the colour most characteristic of Beckett's work, followed by its components, black and white.

Colours, whether reflecting the Irish moors of his childhood or derived from religious symbolism, mythology or just popular expressions, like "green with envy" give meaning and depth to Beckett's work. Like salt in the soup.
COLOUR - FORM PREFERENCE IN ART AND ART TEACHING

This presentation will examine the implications arising out of a proposed or presumed polarity between preference for form and preference for colour, with particular reference to application of colour in art and design.

Why one artist should favour form in their visual work, while another emphasizes colour, is open to question. So-called 'colouring books' commonly introduce children to the notion of colour as an optional extra to drawing; that is, a non-structural element employed primarily to 'fill in' outlines. Alternatively, in approaches to picture-making advocated by Rudolph Steiner, for instance, it is form which is encouraged to emerge out of the manipulation of colour.

Preference tests have been devised which attempt to identify and assess degrees of so-called 'colour-dominant' versus 'form-dominant' tendencies in individuals. In undertaking such tests, a candidate may be required to match a variety of coloured objects set against a predetermined standard. For example, one set of objects of the same shape differs in colour, while another set exhibits the same colour but differs in shape. Colour dominance is indicated, as a rule, by an individual for whom differences of colour have greater appeal than differences of shape or form.

In examining differences between identifiable colour-form bias, evidence of preference testing (Sharpe, 1974) suggests that significant swings occur during the first ten years of childhood, commonly with a peak of colour dominance occurring before the age of five years old. While the great majority of children stabilize as form-dominant by age nine, evidence suggests that this is not so for all children. The minority (perhaps five to ten per cent) who apparently prolong colour-dominance into teenage, or even into adulthood, may exhibit indications of greater creativity or innovation in their artwork. It is possible that presence or absence of such preference swings in childhood might determine colour-form bias in their mature work as adults.

It is proposed that the initial four stages which permit the visual system to interpret formal clues in the visible world, such as division between figure and ground, can be summarized as occurring in the following (rapid) sequence: an awareness that 'something' is there followed by examination of its visual features (such as colour, contour and texture); then a recognition (almost always) of what is seen is followed by the naming of what is seen. It is possible that steps one and two, inasmuch as they can be isolated, are associated with the sensation of colour, whereas steps three and four are associated with the perception of form.

Numerous art teachers through many decades have admitted difficulty in effectively teaching colour theory in the classroom or studio. Whereas teaching the
principles of chiaroscuro, linear perspective and proportion have long since been relatively straightforward, establishing teachable principles about the application of colour has remained more elusive. In this talk, it is proposed that a useful teaching strategy, which might encourage art students to shift to a colour-dominant bias, might consist in devising and tackling exercises which somehow sustain perceptual awareness and examination while simultaneously blocking recognition and naming. This may involve confronting problems which, in one way or another, encourage the 'form-dominant' learner to see through 'colour-dominant' eyes (at least for the duration of the colour class).

What seems often to accompany the recognition and naming of objects and visual features is the logical preconception of what shape or form an object would look like if seen from its most characteristic point of view — usually its elevation — and what colour it would appear if illuminated uniformly by daylight. In consequence, when responding to differences of colour, brightness and texture, art students must be taught to be aware of and, importantly, how to discount, preconceptions which might cause them to employ colours or proportions inappropriate to the creation of convincing pictorial illusions. The problem is not recent, since Joshua Reynolds observed, in the mid-eighteenth century: 'The error I mean is, that the Students never draw exactly from the living models which they have before them.... They make a drawing rather of what they think the figure ought to be, than of what it appears.' The memory and expectation of what is assessed to be unchanging about the form and/or colour of an object — known as its constancy — while serving the non-artist well in everyday experience, invariably represents a major obstacle when teaching art.

A simple method for countering constancy effects was suggested by Ruskin (1857). When wishing to match colours accurately in a landscape, for example, he directs the student to take a piece of cardboard, cut out a hole in it, and then view each colour in turn through the hole in the card, held at arm's length. The part of the object seen through the hole is so small that it allows examination the object without necessarily recognizing its identity. This, in turn, discourages colour matching to be influenced by the colour the student thinks that object ought to appear — what artists usually refer to as its local or unmodulated colour.

Other, more sophisticated teaching strategies might involve the prolonging of viewing time during which the artist or viewer scans a picture or design. The purpose of this might be to encourage greater emphasis on the examination of the colours of the picture, rather than merely the recognition of its forms. Pictorial or compositional devices employed for this purpose — all of which will tend to undermine unambiguous readings of figure-ground segregation — might include the following: uniform brightness, which will tend to diminish or eradicate chiaroscuro; experimentation with transparency, in comparison to opacity or chiaroscuro; the repetition of regular pictorial occlusion; the repetition of regular pictorial occlusion; the repetition of regular pictorial occlusion; the repetition of regular pictorial occlusion; the repetition of regular pictorial occlusion; the repetition of regular pictorial occlusion;
COLOR IN TRADITIONAL TURKISH HOUSE AND FOLKLORE

Cultural synthesis of Turkey is formed as a combination of Turkish and Islamic cultures and the culture of Anatolia, which has been a cradle to numerous civilizations during her past history. Traditional Turkish houses appear in Anatolia as a result of this combination, too.

Turkey is divided into seven geographical regions, most of which are characterized by traditional Turkish houses based on layout, approaching to façade and functioning of the room as an independent unit. However, traditional Mesopotamian and Hittite houses surrounded by stone walls are seen in some regions according to the regional geography and climatic conditions. Despite monochromy dominating on the outer surfaces of traditional houses, polychromy is widely applied to indoor decorating and clothes.

Examining the architectural properties of the traditional houses in the recent years only on the basis of lay-out, façade, materials and colors leads to interpreting thereof with missing data. I do believe that folkloric aspects of this architecture should be too considered. It would be inappropriate to examine these structures, which have been formed depending on the beliefs and traditions of the people and their attitudes against natural events, feasts, rituals, weddings and births, without knowing the folkloric features of the Anatolian people. Therefore, it is my suggestion that colors in architectural structures and folklore do complement each other in an inseparable manner. Purpose of this paper is to quote some of the highlights of the study titled "Changes in color sections of traditional Turkish houses and folklore by regions" which I have recently begun to work on.
Background

In the late spring of 1994 the project ELEMENTS OF DESIGN was organized to prepare a proposal for a 13-part television series that addresses separately each of the components required to create the most rewarding personal environments. In other word, what do you need to know to put together excellent interior spaces? Color schemes, tables, chairs, lighting, etc., are required, of course. But, much more than that, this series explores the theories and the people that are state-of-the-art in each component: Light; Space; Color; Color Psychology; History; Technology; Universal Design; Design Periods; Style; Antiques and Furnishings; Trend Setters; and, the subject of this presentation, Design and Children.

In the course of filming the pilot episode of Design and Children, over 40 children were asked about their color preferences, the objects they most treasured and what they most wished for in their room. Before the interviews, the children were asked to prepare a drawing of their room, either real or imagined. The children interviewed were both boys and girls, kindergartners and first graders. The interviews took place at the Lowell School in Washington, DC over a two day period. The student body of the Lowell School is comprised of pre-primary through third grade and is representative of the many ethnic and socio-economic populations of the District of Columbia.

Introduction

"DESIGN BY CHILDREN - And Other Great Ideas" is a presentation of a selection of the drawings and color preferences prepared by a group of the Lowell students. The children were open and charming in every way and very wise. The renderings are divided into four groups:

1. Hue preference. The choices were very sophisticated and comprehensive. Each child was thoughtful and very serious about the colors in their room.

2. Some of the interviews were extremely thorough about objects and accessories they either had or wanted, especially stating desires for TV's, stereos, musical instruments, pets, such as gerbils or fish, and clocks.

3. Lighting was always mentioned, either that there was too much or not enough, as well as, a keen interest in patterns.

4. Post Occupancy Evaluation is the final group of renderings. We explored with the children how they felt in their rooms!
Discussion

Bruno Bettelheim in "The Uses of Enchantment" tells us that "Unfortunately, too many parents want their children's mind to function as their own do—as if mature understanding of ourselves and the world, and our ideas about the meaning of life, did not have to develop as slowly as our bodies and minds. We all tend to assess the future merits of an activity on the basis of what it offers now. But this is especially true for the child, who, much more than the adult, lives in the present and although he has anxieties about his future, has only the vaguest notions of what it may require or be like."

Freud defined the child as a developing human being with unique needs and not as just a small adult on the way to the work force.

Bettelheim and Freud give us the key word ... "developing". Carrying this concept a step further, the designer must appreciate and treat the child not only as a developing human being, but as a client, albeit, one that is physically growing and emotionally changing. In working with a child the designer has a client that is usually without experience or inhibition; requires immediate and close sensual gratification, needs images to stimulate admiration and imagination; and, most importantly, have feelings of security and the joy and confidence that result from empowered decision making.

Research tells us that a room's color and furnishings most certainly can have positive and beneficial effects on the health and development of a child.

As a result of the interest in this current research, interior design and educational color schemes for children have in recent years become a very big market. Every shopping mall features a store with furnishings that "can grow" with the child and every book store features the latest color theories on child development. I most definitely encourage the field of designing with child customers in mind, however, I fear that there exists only one design principle title "Design FOR Children". One scheme or plan does not fit all or solve all problems, any more than it does for adults. As designers, color consultants, and indeed world citizens, we must invest in, honor and listen to each child.

Without exception, the children interviewed in this study, said the most important furnishing in their room was their bed; most did not care for the colors that had been selected for them; and, again, without exception, their favorite object was something that was old or had belonged to a family member!

Really listening to the child / client can provide the designer with unexpected and valuable information that well may contradict the contemporary theories and assumptions about children's preferences and taste. Exciting things can happen when it is truly design BY children.
COLOUR CULTURE – THEORY AND PRACTICE IN INDIA

Colour, apart from being the most prominent visual elements, is both very ancient and yet very modern. Ancient, because right from the beginning man has looked at colours in nature with wonderment, has tried to use them for self expression and constructed cultural symbols with them. He did not quite know why green gave the feeling of tranquility or that the bulls were colour blind and the red scarf meant nothing to them really. And yet so much has been expressed through colour and so many wars have been fought for colour. Modern because, so much is being revealed every day through modern sciences about the physiological and psychological effects of colour to make colour decisions more logical and scientific. On the other hand, the colour is used exactly the way in which nature has used colour, i.e. for propagation (identity code) and protection and survival (camouflage). In this connection it is interesting to note how code aspect and the visual aspect of colour have merged in the colour design decisions. In course of time such practices have become, rituals, customs, traditions and culture of sorts. It is interesting to note here that there are tribes of many kind, some are not so ancient. I am talking about Desmond’s tribes. Even designers in India can be considered as a tribe for that matter, which has sub tribes. Even these tribes have evolved rituals and customs through their own codes or sets of codes. And here also one can find its roots in survival and propagation.

Next we come to the classical. In the west I have often been assaulted by statements that there is no colour theory in India. I wonder, in a country where there is such a rich tradition of art and craft, where there are towns that are colour coded, where there is a festiival of colours and where people sing songs of colours, how there can not be a colour theory! Indian treatises on colour are based on the symbolic and emotional aspects. Most thinking parallels between the symbolism of colour and emotions is found in jain philosophy. Different emotions that bind the soul to the cycle of life and death as visualised as colours. For better under-
standing of the symbolic value of colour it may be necessary to divide them one can take cue from kandinsky's work which is by no means authoritative, but is systematic and comes very close to the symbolism of colour in India. It is said that Kandinsky was very much influenced by Indian philosophical and religious ideas and was familiar with the Theosophical translations of India religious texts. Kandinsky did many paintings to experiment with the effect of colour on the viewer. Unlike Kandinsky there is no clear cut Indian theory of colours. But the relationship between colour, form and the five elements of nature as mentioned in the tantrik and yoga texts forms a working base from which the colour symbolism can be interpreted. The icon of Vishnu, the lord of universal balance and harmony is itself a beautiful symbolisation of colours of the five elements. The relationship between colour and the icon of the deity is further elaborated in the Tantras. The idea is that a deity should take on the colour to suit the psychological and emotional need of the worshipper. The shapes and colours of the five elements is also a part of the yogic concept of the subtle body and the six centres of psychic energy.

Another more ancient and dynamic symbolism of colour is seen in the concept of the three qualities or the nature or personality. The complete symbolism of colour is expressed in the Shri Yantra. This yantra is the diagramic plan of the universe. And so on. So much for the theory and philosophy, but when it comes to using the colours things are not so nice. For the sake of understanding the use of colour in present context, one can divide the users into two parts. The traditional rural and tribal and the urban modern. Among the first group the use of colour is very culture and tradition bound and is often based on symbolic considerations. Rituals, textile, handicrafts, village and town houses are all existing examples of this trend. The modern Indian society is largely educated in and exposed to western ways. Here the choice and use of colour is some what mixed, confused and devoid of traditional bearings.

Modern designers, architects are all educated in the western system and they look at colour in that manner through the eyes of Itten, Birren, Munshell et al. The colour shade cards for paints do not have a single Indian name. In this confused situation one sees an interesting ray of hope, that is in the contemporary Indian fashion trends. Here one sees a light of awareness towards the Indian qualities of colour with respect to the material, environment and light. But designers are also a tribe and I look at them in comparison to the traditional tribes to see what are their psychological responses to colour, are they logical and analytical or emerging out of their own taboos, traditions and culture.
CONSTRUCTS OF COLOR EVIDENCE: THE PSYCHOLOGICAL ORDERING OF COLOR RELATIONSHIPS IN THE TEACHING OF COLOUR THEORY

Perhaps there is no clearer juncture where psychology and the physics of perceiving color connect than in a creation of a system for ordering colors. The problem of ordering empirical color evidence raises questions that lie directly at the heart of a psycholgocal study of color.

This paper focuses on the construction of individual color ordering systems by students of color theory at Hunter College over the past few years. The presented problem intends for each student to create a two-dimensional system for ordering colors that shows particular color relationships beyond hue, value and saturation.

In working toward a solution, each student is encouraged to combine their knowledge of existent color ordering systems with emergent or discovered interactions, perceived harmonies, or particular phenomena. Each ordering is designed to highlight their concern and to be a construct of maximum usefulness toward the creation of their own work. Their models thus demonstrate a bridge between observations of color appearance and the potential usefulness of an ordering system. As students decide on the range of allowable variables to include they may also question the boundaries of what are considered accepted ordering relationships.

Their solutions often isolate problems for further inquiry or demonstrate new and particular color effects. Further, their constructs set up a foundation for continued individual empirical research into color.

The paper presents verbally and visually the results of this assignment, describes the psychological issues that must take place in transforming the real world of color to the world of paint color, and focuses on the educational potential of such an assigned problem in the ordering color evidence.
A TIME FOR COLOUR

The expression of colour in artists, as well as creative psychotics, only represents an often tiny part of the artistic production of a creative activity considered as a whole in any one individual. To account for the many-faceted nature of this activity, and escape from the exclusive vogue for images and the simplistic pre-eminence of colour, importance must be restored to various rhythms behind non-linguistic creation, to the writing, sketches and black-and-white drawings which precede and accompany colour, or are used alternatively with it. A number of studies have stressed the extreme variability of this expression as well as its complexity which develops in a particular climate of vehemence through which some of these works seem to tend towards a universal field of expression, and through this, towards the timeless conquest of the absolute, or eternity. The activity from which these works have emerged can therefore tolerate no limits, no time unused, as if the interest which these creators show for their work becomes one with their lives themselves and with the construction of their identity which goes well beyond the simple demand for well-executed work.

Too often, all that remains of these vast wholes is colour, to attract the spectator’s attention and create the discomfort of aesthetic language, which is always remote and powerless. There is a time for colour, preceded by periods of preparation; colour arrives when the time is ripe, sometimes late in a creator’s life. The artist who most effectively confronts us with this idea of a time for colour, which ultimately becomes vital, is Odilon Redon, who was born in 1840 and died in 1916. His work of charcoal drawings and black-and-white lithographs took up most of his life, since he only gave up charcoal drawing from 1890-1900, and then concentrated on pastels and oils. From his lonely childhood in the Mèdoc region near Bordeaux to his successful career in Paris, Odilon Redon’s artistic life took an atypical course:

He was a musician and could have had a career as a violinist. The composer Chausson would accompany him on the piano at Parisian parties.

He could have been a writer, if he had followed his friends’ advice. He wrote a sort of autobiographical diary curiously entitled: To Oneself\textsuperscript{1}.

He could have studied as an architect.

Odilon Redon won recognition for charcoal as a noble material; until then it had been considered as little more than a tool for students of art schools. He was influenced by a little-known engraver, Rodolphe Bresdin, and by a botanist, Ar-

\textsuperscript{1} A soi-même
mand Clavaud, who was a kind of mentor for him.

Thanks to R. Bresdin he followed the tradition of Dürer, Rembrandt and Goya in his lithographs, and in his exploration of colour, he followed Delacroix.

The change from charcoal to pastels, water-colours and oil, which had become definitive by 1900, corresponds to a series of events in Odilon Redon’s life and to the conjunction of several factors which we will describe as we show the charcoals and lithographs of his first black-and-white period. We will then move on to consider the meaning of colour for Odilon Redon, as part of the same personal quest he had pursued since his youth.

After this typical example in which colour arrived after expression in black and white in a famous artist, we will present – in a purely descriptive fashion – a few observations.

In this way we will attempt to establish how difficult it is for colour to emerge, to show the hidden conditions which colour has to satisfy, and show how colour is unable to serve the expression of a precise theme such as for example the representation of woman, or the couple, symbolising love. Finally we will study the disappearance of colour, which is however sometimes only temporary, as in some cases it re-appears later.

The time for colour is never indifferent. It deserves attention, for its simple appearance raises a number of questions.
COLOUR AND PSYCHOLOGY

CONTROVERSIAL ISSUES DURING THE EARLY SOVIET ERA

Mikhail Matiushin's colour theory "The Laws Governing the Variability of Colour Combinations. A Reference Book on Colour" (Zakonomennost' izmenjaemosti tsvetovykh sochetaniii. Spravochnik po tsvetu.), was published in Moscow and Leningrad 1932, and was one of the last manifestos from the Russian Avant-garde.

The colour theory of Matiushin (1866-1934) was stored away in archives and forgotten as a result of political circumstances. Hitherto unknown within the science of colour it aims, amongst other things, to present a method for colouration of architecture. It's target group was professionals working with colour; colour-industry; polygraphy, architects, art-schools, etc.

Matiushin's colour theory consists of a 32 page text and a "Reference Book on Colour" with 30 different colour combinations. It was hand-painted by a group of Matiushin's assistant students and issued in 400 copies.

The first part of the text is a foreword by Matiushin's assistant, Maria Ender. The tone is polemical and she takes up a discussion with the colour theorist Wilhelm Ostwald and the so-called "realists". The second and third parts, written by Matiushin himself, concentrate on the experiments and colour education at the GINKhUK (State Institute of Artistic Culture) in Leningrad during the 1920s. The last part is a somewhat fragmented explanation on what the colour combinations are meant to be.

The 1920s debate in Soviet Russia concerning aesthetic subjects like art and literature, was focussed on the conflict between "realists" and "formalists". According to the marxist doctrine, the realists considered art to be a "mirror" of reality. The formalists, on the other hand, thought of art to be an end in itself. The realists eventually developed their doctrine into "Socialist Realism", which became the norm from 1932, the very same year that Matiushin's colour theory miraculously passed censorship and was published. The realists thought of Matiushin as a formalist, which made it difficult for him to make his voice heard.

The GINKhUK institute, where Matiushin was the leader of the "Research Department of Organic Culture", worked towards a union between art, science and practical life. The main project was to compile a grammar, where the results from the different departments were to be gathered (it was never realized). Kazimir Malevich (who painted the famous "Black Square", was the headmaster of the institute,
and conducted research on form and architecture. "Evolution" not only in art, but also in man, was to be shown, which would lead to a means of "curing the illness" of "bad" art, and achieving "absolute" and "objective" methods of judgment and consequently improvement of the arts. The experiments were carried out in "laboratories" (a few streets away from Pavlov's experiments with the dogs).

Inspired by thoughts on synesthesia - a union of the senses, Matiushin worked towards the goal of "conceiving the world as one whole single organism through methods in four different directions: sight, hearing, feeling and thinking, to create and develop the artist and his new physical possibilities of perception". The Matiushin-group conducted experiments on interaction between different colours, colour and form, colour and movement, colour and music.

The method used for the perceptual experiments, called "expanded field vision", involved a visual angle up to a 360 ° which, according to Matiushin, was possible to achieve through training. Matiushin believed in the possibilities within man to develop his mind and his sight into this "expanded field vision". This expansion of the inner possibilities of man was one of the main goals in the Matiushin colour theory.

The concept of a "new man" was a prevalent thought in the Soviet union from the 1930s, as were the ideas of French biologist Lamarck who believed that one could ascend to higher evolutionary stages, that bodily organs could be improved by repeated use and that skills could also be inherited genetically; ("Lysenkoism" dominated Soviet genetics until the 1960s). According to a materialistic behaviourism, psychology of man can only be a "manifestation of his concrete historical conditions, in class society primarily generated by the class to which he belongs".

Research on colour was controversial during Stalin's totalitarian dictatorship. Because colour is something existing not only in the "real" - external, physical world, but also physiologically and psychologically, research on colour was thought of as too closely linked with the subconscious and consequently Matiushin did not fit in with the Soviet official doctrine as regards both physiology and psychology.

Matiushin's view on colour as belonging to a spiritual level, recalls concepts of the Bauhaus in Germany, where Kandinsky, Itten and Albers were active, although Matiushin's concepts in many ways are unique.
There have been many bitter disputes in the history of colour theory but the proposition that complementary colours must be harmonious does not seem to have met any opposition more serious than indifference. It has become an article of faith to be passed from one generation of students to the next even where teachers have only the most rudimentary idea of what the words really mean. That faith may well turn out to be justified but the proposition is at least 200 years overdue for a thorough examination.

Harmony is usually understood to mean some kind of measurable relationship that people find satisfying. So the adjective 'harmonious' can be descriptive and evaluative at the same time. Philosophers might argue about the possibility or impossibility of any link between description and evaluation. But for most people, to say that a flag is blue and yellow is description, while to say that it is beautiful is evaluation. And they would probably be reluctant to accept the claim that because it is blue and yellow it must be beautiful, or the claim that because it is beautiful it must be blue and yellow. Yet that seems to be the kind of thing that people mean when they talk about colour harmony, especially in connection with complementary colours.

In this situation there are two ways to establish a link between description and evaluation. One can start from description by testing various kinds of colour relationship to see which are judged most beautiful, or one can start from evaluation by collecting colour pairs that are widely accepted as beautiful and then looking to see what kinds of measurable relationships there are between the colours in each pair. Only if there turns out to be some clear pattern would one be justified in claiming the existence of a link.

The word 'complementary' itself should be a descriptive term since it means "completing" and that implies the possibility of measurement. There seems to be an assumption that if something is complete it must be beautiful, but such an assumption should surely be tested. Furthermore how can it be established whether or not two colours together are complete? Several methods have been proposed, but the colour pairs established by those methods are not the same. For example the complementary of blue is shown to be yellow by one method and orange by another. This could be taken as undermining the proposition altogether; at least it raises the further question about which of the various methods for establishing complementary relationships is the correct one.

In English the word 'complementary' is often confused with the word 'complimentary'. The latter means "praising" and that means that there has been some kind of evaluation. By pushing the meaning a bit further it could be said that complimentary colours are those that show each other off to best advantage. This could only be established by the consensus of those making the judgements. If the term were adopted, complimentary colours would be those established by subjective means, while complementary colours would be those established by objective means, by measurement or by some consistently repeatable process. The question to be answered is whether complimentary colours are also complimentary and vice versa.
Alberti, in 15th century Italy, seems to have been the first to draw attention to a special relationship between colours of the kind that we are dealing with here. He claimed that "There is a kind of sympathy among colours whereby their grace and beauty is increased when they are placed side by side". (1). He gives red and green as an example. Leonardo also suggested that certain colour pairs enhance one another: "The colours that go well together are green with red ... and yellow with blue". (2). Since red "praised" green and vice versa we could say that they are complimentary. But there is nothing objective or measurable here, only the admittedly authoritative opinions of two great artists.

The first to have used the term "complementary colours" seems to have been Count Rumford who presented his studies of coloured shadows in 1794 (3). While claiming that the colours of the light and shadow completed one another he went further and suggested that here might be a guide for artists in the "magic of colouring". He had made the connection between an objective relationship - description - with subjective judgement - evaluation. Goethe made the same connection but was more emphatic: "In this resides the fundamental law of all harmony of colours ...." (4). And Chevreul followed suit except that, as a scientist, he felt obliged to add: "I do not pretend to establish rules based on scientific principles, but to enunciate general propositions which express my own peculiar ideas". (5).

Goethe and Chevreul proposed colour circles in which their complementary colours were opposite to one another and they recommended the use of their circles as guides for colour composition. Their opinions and suggestions have been readily accepted by succeeding generations of artists and designers, and the fact that different ways of establishing complementary relationships result in different colour circles has either not been noticed or it has been ignored. So there is work to be done.

This paper will review the history of complementary (and complimentary) colours. The different ways of establishing complementary relationships will be demonstrated and the subtly different colour circles that correspond will be shown. Results from preliminary investigations of people's preferences will also be presented. Expectations are that there will be no clear consensus to support any one way of establishing complementary relationships and, therefore, no single "correct" colour circle. But it is expected that there will be a general preference for colour pairs that are more or less opposite on a colour circle; people's preferences may well provide broad support for the theories of Goethe and Chevreul. In a situation where the colour circle itself is no longer fixed, designers may feel confident to use traditional theories as a starting point and then feel free to use their own judgments in the process of refinement.

REFERENCES:


When the basic colour words, e.g. "grön" (green), "blå" (blue) are not sufficient for describing colour nuances, new words can be created by making compounds of basic colour words and other words, e.g. "papegojgrön" (parrot green), "solgul" (sun yellow).

These compounds show different semantic processes, both processes that are general for meaning extension, such as simile "olivgrön" (olive green) and metaphor "knallgul" (bang yellow), and processes that are specific for colour term compounds, such as optical modification "ljusröd" (light red) and source "koschenillröd" (cochineal red).

In the present study 300 Swedish colour compounds, excerpted from the Swedish reverse order dictionary, have been analysed in detail and classified according to kind of simile, metaphor etc. A smaller study on English colour terms excerpted from the Brown corpus was also done.

The results show what categories seem to be important for comparison, e.g. plants, animals, metals, parts of the body. Also, the frequencies of modifications of basic colour words are in accordance with the results of Berlin and Kay (1969). The analysis also results in the "Linguistic Colour Circle" which shows e.g. that black, white, brown and grey are linguistically as basic as e.g. red and blue. It also shows that yellow and blue are closely related, and the same for red and green.
LE JEU DES SEPT COULEURS
PSYCHOLOGICAL EXPERIMENTS ON COLOUR GROUPS

Esthetic, semantic, psychological and sociological notions have been developed for many years in ENSAD (Ecole Nationale Supérieure des Arts Décoratifs de Paris), based on an experimental approach.

It has been possible to establish some essential rules on collective judgments:

1 - PREFERENTIAL CHOICES:
We had asked our students to choose their 3 most "pleasant" and "unpleasant" colours. Afterwards there was a vote on these individual choices. Year after year the results have revealed a constant preference for graded instead of primary colours.

Later these same colours were employed in different compositions. The following paradox has resulted: The most "pleasant" colours became too uniform to be easily distinguished. On the other hand, "unpleasant" colours resulted in the most lively, different and legible compositions.

2 - ESTHETICS:
Some exercises showed that it was possible to draw up a typology following 3 main esthetic categories:

- COLOURS
- VALUES
- NUANCES.

These 3 categories are equally valid and liberates colour harmony from its subjective character. So it is possible to demonstrate that the irreducible esthetic categories of the past are in fact partial visions of the problem.

There are no "beautiful" or "ugly" colour compositions, only appropriate or inappropriate colours according to their functions.

3 - DIFFERENCES:
To go beyond this analysis, it has been demonstrated that colour groups do not vary to indefinitely, as we could frequently suppose. But after 22 fundamental colour groups have been defined they all become confused and impossible to distinguish from one another.

This work to determine the 22 most distinguishable colour groups is really difficult, and it requires a constant struggle against one's own reflexes. But it is also very important, because it allows the student to enlarge his palette and take more distance with his tastes of the moment.

4 - TRANSCRIPTIONS:
This exercise consists in transposing a text into colours, following the student's own preconceived code. This has been very instructive, because it shows that all
attempts at subtlety which are not perceived by the viewer have a random effect.

In other words beyond the 22 fundamental colour groups, everything looks similar and loses meaning, because there are no dominant colours and consequently no perceptible intent.

5 - COMMUNICATION:

A comparative work was made with students on colour transcriptions of themes like "the ages of life" that communicate information well, but in an unconscious manner. It is as if a recognizable, but unwritten colour code exists at all levels of society.

Thus "baby" or "childhood", and "old age" elicit very similar answers, because they are distant and abstract. On the other hand "adolescence" produces divergent responses on students, because this period is very close to them and could represent very different life experiences.

6 - ABSTRACT CONCEPTS:

Experience shows that colours have the capacity to transmit very subtle information. Divergences do not come from different appreciations of the colours themselves, but from different social and cultural contexts.

So the idea of "the 18th Century" has diverged in two exclusive directions: one is the "little marquis" of this very brilliant royalist period, and the other is "the French Revolution" so important for the working classes.

Similarly students from more distant countries produce colour combinations which the European viewer will find difficult or even impossible to understand.

7 - THE IMAGE:

Some fruitful collaboration has also taken place with the print shop, consisting in changing the colours of the image, in order to change its meaning.

Certain images can radically change in meaning: the elements can change from liquid to solid, to gas, to fire, and so on. The psychological climates can be inverted. We can also put the accent on any detail which then becomes essential.

8 - EVERYDAY OBJECTS:

Experiments with unusually coloured objects have allowed us to realize how extremely conventional the employment of colours can be in our society and how these colour could be more freely used in a more liberal society.

Wishing to carry our analysis further, we asked our students to propose some colours for various subjects, from individual to collective ones. The result was a desire for more and more intense colours as they left the individual context and approached a less personal, collective environment.

CONCLUSION:

All these experiments show that colour groups constitute an excellent starting point for investigations into the future and an unavoidable passage between art and science.
How do ordinary people decide on colours in their homes?

That was the main question in a research project initiated and performed by Lena Anderson, architect SIR and Kerstin Berg, architect SAR. Both in their daily work making proposals and deciding on colours and materials in public spaces and work environment - decisions affecting ordinary people’s everyday life.

The purpose of the project has been to find out what these same persons prefer, like and choose when they make their own decisions particularly regarding colours.

An opinion poll was performed by the leading Swedish market research institute SIPO AB using the SIPO Consumer Monitor where value judgements are added to demographics and market data. The Consumer Monitor is based on systematic classifications of individuals by the basics values they hold. A questionnaire was sent to more than 2300 representative persons in the age group 15+. 2155 replies were accepted. The questions involved finding out actual colours, materials and patterns of ceilings, walls and floors in all rooms of their homes - finding out who had decided on the colours used, the degree of satisfaction with the choice of colours etc. It was also asked what inspired people of their choice of colours, whether they liked colours, whether they thought they knew enough about colours or wanted to learn more and so on.

The research project has been financed by the Swedish Colour Science Foundation and by Alcro Beckers and Nordsjö, the Swedish paint manufacturers.

The project started in the spring of 1994 and the results are now being evaluated. A final report is under preparation.
THE PLEASANTNESS OF GREEN-BLUE COMBINATIONS IN INDIAN ADULTS

Many factors affect colour combination harmony, and the list of works studying this problem is rather long. Moreover, it is quite difficult to compare the relevance of the different factors enumerated until now; the task of ranking them in order of importance has not yet been performed. The main obstacle is certainly due to the extremely large number of colour combinations which should be tested to prove any quite general hypothesis, and this makes all theories about colour harmony somewhat limited. Nevertheless, a useful working distinction can be made between chromatic and non-chromatic factors, and further in the field of chromatic factors, between purely perceptual factors and others of higher level, like symbolism.

It is commonly accepted that colour in itself is a relational phenomenon, and therefore perceptual theories which try to formalise the rules for colour harmony (although the term harmony sounds too resonant) are proposing essential relationships between the most relevant colour dimensions.

Theories about colour combinations can be developed inside two main different frameworks, which can be simplified as the perceptual tri-chromacy and esa-chromacy. In one case, the main colour dimensions are hue, chroma, and value (or some others very similar), as proposed by Munsell; in the second case, the dimensions are identified in the resemblance of a colour with the six unique colours: white, black, yellow, red, blue, green, as proposed by Hering. In this latter instance, the hue dimension can be identified in the resemblance of a particular colour to one, or maximum two adjacent, unique hues (yellow red blue green); the two other dimensions are identified in the similarity of the given colour to white and to black, respectively (these dimensions are then named whiteness and blackness).

On the one hand, a theory, independently proposed by Abbot and Müller, dealing with bi-colour combinations of two different hues, states that two colours are pleasantly combined if the colour belonging to the naturally lighter hue is also the lighter in the bi-colour combination (i.e. its value is higher than the value of the other colour). On the other hand, forced by some inconsistent observations faced following that theory, W. Spillmann proposed a basic development of it suggesting that the matter should have been treated inside a different colour paradigm, i.e. inside the natural colour system as proposed by Hering. Accordingly, there are not only two possible kinds of colour combination, i.e. those in which the relationship between the lightnesses of the two colour corresponds to the natural lightness of their hues and those in which such relationship is reversed, but three kinds of relationships should be relevant, and they would be defined inside the natural colour system. Therefore the original theory by Abbot and Müller is refer-
mulated by W. Spillmann in the following way: correspondent bi-colour combinations of different hue are made of two colours one of which, belonging to the naturally lighter hue, appears more whitish and less blackish than the other; in the distinct inverted combinations such relationship is reversed; a third kind of combination (called vague inverted) is given when one colour is more whitish but also more blackish than the other. This combination would be generally considered unpleasant, while the inverted combinations could be sometime considered quite pleasant by some peculiar people.

A number of experimental works has been performed which support Spillmann's theory. Nevertheless one, among others, aspect remains open: are these relationships culture-dependent or are they active also in different cultures? The present research was aimed at answering this question, and consequently we repeated in India an experiment already performed in Italy, with the idea that Indian culture can be considered basically different from the European one. Moreover we wanted also to study whether a non-chromatic aspect of colour combinations, i.e. the figure/background relationship, can affect the preference of observers for bi-colour combinations. Two series of six stimulus cards were prepared: in the first series, the background of a two colour card (10.5 x 14.8 cm) was constant (10 70 B10G) and the figure (a 5 x 10 cm rectangle in the middle) could have one of the following G30Y colour nuances: 30 20, 20 40 (making two vague inverted combinations with the background), 10 50, 10 60, 00 80 (making three correspondent combinations), 30 50 (making one distinct inverted combination); the second series of six stimulus cards was prepared by using the same colours and inverting the figure/background relationships. 20 Indian adults performed the observations using a comparison method procedure and judging which member of each couple they liked more. All the 15 possible pairs of the first, and of the second series as well, were randomly presented and evaluated. The results are interesting under two main aspects: first of all they perfectly agree with Spillmann's theory as correspondent combinations are always better evaluated than vague inverted combinations: this result also agree with the results obtained in a similar previous research performed in Italy (G. Fabrizi & G. Vignocco), indicating that a structural, more than a cultural basis is underlying colour combination pleasantness. Moreover the distinct inverted combination is much better evaluated by Indian subjects than by Italians, for whom it occupies the last scale position: in India, when it plays the role of figure, it comes at the very first place, while it comes at the third place when playing the role of background. Thirdly, the most chromatic correspondent combination is judged quite less pleasant (fourth place) by Indian than by Italian subjects (first place). Colour combination pleasantness seems therefore to depend on some basic, structural factors identified in the mentioned colour relationships, and in some other factors (mainly affecting the preference for the distinct inverted combinations) which can be traced in personality traits, cultural determinants, and maybe others, like age difference (but not sex, for instance), in agreement with other analogue research works.
RESEARCH ON TRADITIONAL CHINESE CONSTRUCTION CHARACTER

China is one of the ancient civilised countries in the world. It is with a vast territory and has 56 nations. In such a big nation family, the form of construction varies according to climate feature, geographic position and environmental resources, grass house to cloth house. The use of construction character is also different with the difference of form and material the following is the main introduction of several areas:

I. Ancient city of Beijing.

The whole picture of the ancient city of Beijing is that large area of grey folk-living architectural complex set off small area of gorgeous red and yellow palace architectural complex.

Among the large area of grey architectural complex, there is a few bright and colourful royal garden construction, which not only adds colour but also make the centre palace architectural complex avoids its isolation and stiffness of standing in the centre of the city.

The whole ancient city of Beijing is like a chapter of a colourful music. The grey habitation building is the low violoncello music; the gorgeous royal garden among the green habitation building is like the tune of gradually appearing trumpet; the bright and colourful palace building is the strong symphony; the white stone stage in the palace like the gradually recovering violoncello music, which sings together with grey habitation building and slowly disappears. In the whole colourful construction music, green colour is like natural and harmonious meter linking the low and strong music as a inseparable chapter.

II. Folk building of Wanna in central China

The construction form of "Horse Head Wall" is the symbol of Wanna folk building. The use of white wall and dark tile is the main character. In the luxuriantly green, richly-endowed and beautiful central China, the use of this kind of construction colour brings harmonious and stable atmosphere to the surrounding environment.

"Ancestral temple" is the centre of the architectural complex. It is sumptuously decorated, highlighting the centre of religious meeting.

III. Post-Tibetan Construction in Tibet

White, red and dark are the main colour used in the post-Tibetan construction.
The post-Tibetan construction uses white as the main colour, while daughter wall of palace and temple are mud red, symbolising its dignity. On the tall mud daughter wall is endowed golden Buddha, while the roof is also golden, which cannot be in folk building.

With the case of folk building, only two red and dark rings can be decorated on the middle of daughter wall. These two simple colour rings connect folk building with palace and temple, linking the relation of architectural complex clear.

Besides, the common character of building, palace and temple of post-Tibetan building is that there is a black bridge on the door and window, that there is gorgeous picture under the roof, and that the window curtain unifies the construction character of the whole city.

IV. Xinjiang Wei Ethnic Construction

Besides the yellow mud wall on the outside, the Xinjiang Wei ethnic construction tends to use blue green and yellow to decorate.

As there exist much yellow sand and yellow soil in Xinjiang, and the tile made from Xinjiang special soil turns to be used for decoration. Thus the two colour complements each other and make the whole more beautiful.

V. Guangxi Tong Ethnic Folk Building

Guangxi Tong ethnic folk building uses the natural colour of fir and black grey as the main colour of construction. Regarding the simple natural colour as beautiful, varies kinds of fir wall and black roof use in both community construction and folk building. Yet community construction is identified from folk building for its white decoration under the roof, and some of the community construction are decorated whit wood flowers in the natural colour of red, mid-yellow or mid-green.

VI. Li Ethnic Boat room in Hainan

The cogongrass and sunflower leaf peculiar in Hainan are one of the main construction materials. The little willow tree at about ten centimetres is the best construction material.

Among the straight, tall and luxuriantly green coconut trees, cogongrass and sunflower leaf turns light yellow and deep green, forming a patch of boat-like cogongrass roof. Willow tree are the wall and roof beam, with mud outside, and thus form an ancient simple natural life area.

The above mentioned construction in different area spread in China's north, central mainland, south, Southwest and Southeast, from which we can see Chinese traditional construction character. It has strict level system and strong culture meaning, fully reflecting its special construction art and topping in the forest of world nations.
CHROMATIC CHART AND PUBLIC SPACES IN URBAN DEVELOPMENT
CONCEPT FOR THREE PROJECTS

Menton.

Goals:
Chromatic chart as a support for a material, light and colour support for aspects treatments.
This chart will be used to precise a concept, or provide information to Architects, Landscapers, Contractors, Decision makers for new settlement or maintenance of Urban Public spaces.

* Chromatic Memory, for what use?
* Site analysis on Light - Chromatic & Texture aspects.
* Diagnostic of site: lights, materials, colours and schedule & rhythm of time.

Concepts:
* General or specific Chromatic ranges are applied on "micro-sites".
* Location of architectural events or specific urban spaces as sea-front, Heritage part on the rocks, landscaped area...

* Will also be introduced as criterion:
  - Corporate image of the city of Menton,
  - function, activity as sea-front entertainment,
  - geographical aspect,
  - architectural mood,

* Use of the NCS vocabulary for colour identification and to name the colour appearance.

Follow up:
* How to manage Chromatic moods in maintenance and for new development policy?
This phase is a middle long term part, and needs efficient designer to provide information.

* For each town, the process level will depends, from the administration policy.

Hong Kong, Social Housing Estate

The developer program is 40 000 flats a year, with the same standard Architectural design, so it means new works and maintenance.

Goals:
Those are not really similar to Menton treatment
Major local "variations" have to be introduced.
* Architecture concerns 32 floors towers
* Lights and atmosphere look different
* Way of life and cultural aspects are different.

* Architecture and sites appear specific.
* Way of building, material and cost are different.

In that study, NCS vocabulary to name colour and to "explain it", was really helpful, and was also applied to coating, ceramic, glass tile manufacturers. For those they have suggested the colour range that they can provide on "micro-sites".

For the presently provided follow up, the use of vocabulary simplify colours translation.

This project cover all the line process: the analysis, the concept, the materials, the follow up.
State of AIN CAUE Chromatic exhibition

(Architectural-Urban-Environmental Administration Consultancy)

Presentation of an exhibition designed by state of AIN CAUE, in France to be used in villages & cities town halls.

Based on various studies, worked by Atelier Cler, on small towns, villages, the exhibition had to explain pedagogically and in a simple manner that colours, textures, plants, minerals, skies, daylight and nightlights are parts of the environment day life rhythm, with a past and a future.

Titles of panels:
1- Lights, materials, colours.
2 - Genius Loçi
3 - Coloured aspect
4 - Urban mood
5 - Colours and maps
6 - Urban spaces
7 - A renovated mood
8 - Contemporary "inputs"
9 - Follow up practice
10-13 traditional and contemporary material samples.
Osvaldo da Pos  
Dept. General Psychology  
University of Padova  
Italy

THE PLEASANTNESS OF BI-COLOUR COMBINATIONS OF THE FOUR UNIQUE HUES IN INDIAN ADULTS

The role of some relationships between relevant colour dimensions in determining the pleasantness of bicolour combinations has been rather extensively studied by da Pos in an experimental research, in which correspondent, vague inverted and distinct inverted combinations of the four unique hues have been evaluated by a large number of Italian subjects. In that work it resulted that Spillmann's hypothesis can adequately describe the chromatic conditions for obtaining bicolour combinations of different hue which can on the average be evaluated as pleasant / unpleasant. Spillmann's hypothesis core is that colours in pleasant combinations should keep the same whiteness / blackness relationships as those dictated by their natural lightness. This means that the colour whose hue is naturally lighter (for instance yellow as compared with red) must be more whitish and less blackish than the other colour. There may be two kinds of deviations from this relationship: either both the whiteness and blackness are reversed (distinct reversal, in Spillmann's terminology: the particular yellow will be less whitish and more blackish) or only one of the two is reversed (vague reversal: the particular yellow will be either more whitish and more blackish, or less whitish and less blackish). The vague inverted colour combinations are describable only in the frame of the natural colour system (or others analogous) and are on the average considered always unpleasant. The distinct inverted combinations show a rather odd appearance, and therefore they can be appreciated by particular persons only. In the quoted research the results were in very good agreement with Spillmann's hypothesis, except for two cases: the vague inverted red-blue, and red-green as well, combinations were quite well appreciated. As regard to the first case, the red-blue combinations cannot be strictly considered either correspondent or inverted, and this for chromatic reasons: the two hues are naturally of almost the same lightness (although red is slightly darker than blue). Therefore the exception is very weak. In the second case, it seems that the vague inverted red-green combination corresponded to the colours of a very famous Italian team: this is not a chromatic factor, and therefore it should not be considered by the theory, which is only applicable 'coeteris paribus', i.e. all other conditions remaining the same. Following this argumentation, cultural determinants should also be excluded from studies on colour perception: nevertheless the theory is useful just because it allows a distinction between what is common in different culture, and therefore could be ascribed to structural / innate characteristics of colour perception, and what is different and therefore pointing to acquired capabilities. The problem of the personality traits in
colour perception is still different and little examined nowadays.

In this research we wanted to verify first whether also in the Indian culture correspondent and vague inverted combinations of the four unique hues are evaluated as in Italy; secondly, how distinct inverted combinations are there appreciated; and lastly whether the order of preference for the different hue combinations is similar to what we found in Italy. The same 18 stimulus cards were used as in the previous research: all 6 possible bi-hue combinations of the four unique hues have been used, with an example of correspondent, distinct inverted and vague inverted combination for each two-hue pair, arranged in the form a 6 square chequer board. 35 Indian adults, belonging to different socio-cultural level (from medium-low to high) have been tested in Delhi: as in the Italian group of 100 subject, smaller random subgroups of 25 were showing the same results as the total group, the number of 35 seemed reasonable enough. The pair comparison method was followed, having the subjects to choose the combination they liked more from the all 153 pairs. Results again in the average support Spillmann’s hypothesis, almost in the same as Italian results did, in the sense that, inside each hue combinations, correspondent pairs have always been better evaluated than the vague inverted ones, with two exceptions: one regards again the Red-Blue combination, which we have already seen cannot be strictly coded into the category of correspondence / inversion because of the very similar natural lightness of the two hues. The second exception regards the Blue-Yellow combinations, in which case the vague inverted and the correspondent combinations are judged almost in the same way, being the vague inverted a little more preferred. In this case we think that such ‘anomalous’ preference for the vague inverted combination could depend on the high preference Indian subjects show for the particular yellow used in this combinations. In fact, the little whitish and quite blackish nuance of the yellow here coupled with the blue seems to be very common and highly appreciated by Indians: the preference for one colour of the couple is therefore successfully competing, in this case, with the general law that vague inverted combinations are usually very ugly. This exception could parallel that in the Red-Green case we have seen in Italy. Nevertheless further research should look deeper into the interplay of different factors affecting colour combinations pleasantness. Moreover, the variability among Indian subjects seem quite larger than among Italian subjects, indicating that probably a larger pattern of factors seem to influence their choice. Lastly, as regard to the different hue combinations, the Indian order of preference is G-Y, R-Y, R-G, B-G, B-Y, R-B, while for Italian subjects was R-G, B-G, G-Y, R-B, B-Y, R-Y (where the combinations containing yellow were usually less appreciated that the others. This difference does not seem suitable to be further discussed without more extensive research in the subject.
COLOUR RENDERING UNDER THE COMBINATION OF DAYLIGHT AND ARTIFICIAL LIGHT

Many interiors are lit by daylight and artificial light, and the CIE colour rendering index (CRI) of the artificial source alone is not a characteristic of the complex situation. Indeed, coloured objects in this situation are illuminated by a combination of illuminants which is not uniform in space, and which is varying with time. So, it seems interesting to analyse the distribution of the CRI in the lighted space.

First, a typical situation is defined. The artificial relative spectrum is assumed to be independent of time and space. The daylight relative spectrum is assumed to be independent of space, at a given time "t". The interreflections of light do not influence the colour rendering. The visual field is simplified as it is usually done in colour rendering experiments: the coloured object is seen on a neutral background and receives a natural (EN) and an artificial (EA) illuminances. Therefore, the relative spectrum variation in the interior is expressed by the proportion of the combination:

\[
\alpha = \frac{E_N}{E_N + E_A}
\]

(1)

An analysis of daylight spectra [1] showed that typical daylight could be represented by "D" illuminants. As the time dependence of the daylight spectrum is rather random (as it is influenced by the weather and the turbidity of the atmosphere), it is preferred here to consider typical spectra, rather than a rigorous sequence of daylight spectra. The diffuse component of clear sky is represented by standard D illuminant with colour temperature from 6000°K to 12000°K. The global radiation for a clear sky is represented by D5700K (since 97 percents of the analysed spectra were between 5200°K and 6200°K), and the overcast sky by D65.

The CIE test-colour method [2] has been applied to the following spectral power distribution:

\[
s = \left( P, \lambda \right) = \frac{s_A (\lambda)}{Y_A} + \alpha \left( P, t \right) \left( \frac{s_N (\lambda)}{Y_N} - \frac{s_A (\lambda)}{Y_A} \right)
\]

\[
Y_A = 683 \int_{\text{vis}} s_A (\lambda) V(\lambda) \, d\lambda \quad Y_N = 683 \int_{\text{vis}} s_N (\lambda) V(\lambda) \, d\lambda
\]

(2)

It is the combination of the artificial (sA) and the natural (sN) relative spectra, at the location "P" of the coloured object, and at time "t". So, only the proportion \( \alpha \), expressed by (1), depends on time and space and, moreover, it is always comprised between 0 and 1. The colour rendering of the artificial-daylight combination is therefore fully repre-
presented by the graph of the color rendering index $R_i(a)$, for the proportion $0 \leq a \leq 1$.

Several experiments have been performed, applying the CIE test-colour method to nine typical artificial illuminants (H.P. sodium, H.P. mercury, incandescent and fluorescent lamps), and three typical daylight spectra (D5700K, D65 and D10000K). Figures will be shown that give examples of the results obtained, namely the color rendering of some CIE test-colours under the combination of daylight and H.P. sodium light.

The conclusions of the experiments are the following:

- for high colour temperature artificial lights, which have (nearly) the same chromaticity as daylight, the dependence between the CRI and the proportion $a$ is linear, which means that the color rendering of the artificial-daylight combination is always better than the artificial light source alone ($R_i(1)$):

$$R_i(a) = R_i(1) + a (100 - R_i(1)) \quad (3)$$

- significant non-linearities appear for artificial lights with colour temperature less than 3500°K (see fig. 1). However, these non-linearities often lead to a concave graph $R_i(a)$. Therefore, it can also be concluded that the color rendering of the artificial-daylight combination is often better than the artificial light source alone.

- only if the artificial light source has excellent color rendering properties, can one find combinations with lower color rendering indices: the worse situation has been observed for the combination ($a=0.5$) of the incandescent lamp and D10000K, which leads to a general CRI of 91, instead of 100 for each source separately.

- These conclusions do not depend on the algorithm used to calculate the colour rendering indices [1]. Indeed, the experiments have also been carried out with the Nayatani chromatic adaptation transformation (instead of the Von Kries one), the CIELAB uniform colour space, and a fixed reference illuminant (which was the daylight component): the conclusions were the same as above.

Possible applications of this study are the following:

- to readily obtain, from the calculation of the illuminances ($E_A$ and $E_D$), the distribution of the colour rendering indices in a room lit by daylight and artificial light. The linear expression (3) can be used as a first approximation in most cases. This could be applied in the determination of the best locations for workstations, in conjunction with the visual comfort requirements;

- a statistical analysis of the variation of the colour rendering properties in those spaces, from the statistical distribution of daylight illuminances. For example, in reference [1], the yearly average colour rendering indices have been defined.

References

The poster presents a study carried out in 1991-93 and funded by the ARKUS foundation, The Swedish Building Research Council and the Swedish Federation of Painting Contractors. It is published in Swedish (Fridell Anter: Naturens färgpalett. ARKUS 1993), and during 1996 English and German translations will be published by Färginstitutet, Stockholm.

Background
The colours of nature constitute an obvious reference for our perception and judgement of colours. They influence our feelings, reawaken memories and are associated with the seasonal and life-time cycle of growing, maturity and death. They also constitute an emotional basis for the experience of other colours.

For those who work with the colours of building, the colours of nature are particularly important, since houses are always seen against a background of more or less manipulated nature.

One way of gaining knowledge about the colours of nature is to map the inherent colours of its small constituents, e.g. leaves, stones and blades of grass. These inherent colours are, however, not identical with the colours we normally perceive in nature - e.g. the colour of a tree or a lawn - where light, texture, movement and other factors influence the totality.

Questions
The survey of nature's inherent colours was carried out in The Swedish region around Stockholm. It meant to give answers to the following questions:
• Which inherent colours are common in the small constituents of nature and which occur less often or not at all?
• What inherent colours are typical for greenery on ground and trees?
• Autumn leaves?
• Wild flowers?
• Stones?
• Naked sand and soil?
• Is there any typical co-variation between different colour properties of the inherent colours in nature?
• How do nature's inherent colours change during the year?

Method and selection
The inherent colours of vegetation, stones etc. have been assessed visually by comparison with NCS-samples. The assessments where made during different times of the vegetation period, sometimes in different places and sometimes by returning to the same place and even the same plant specimen. Common materials were assessed many times, while unusual materials and colours were assessed considerably fewer times.

The assessed colours were presented and analysed with the help of the NCS colour ceder system. The agreement between the
assessments was often very good, and thus the survey gives a rather good picture of the variation ranges for the inherent colours occurring in the Mid-Swedish landscape.

Results
The survey shows, that the inherent colours of Mid-Swedish nature are very unevenly distributed within the theoretically possible colour range. Some of the most important results are:

- Completely achromatic inherent colours do not occur in nature. The materials which in "normal observation" are perceived as neutral grey have inherent colours with a certain yellowness and sometimes also greenness or redness.

- Inherent colours within the blue-green quadrant do not occur in nature. The materials which during "normal observation" can be perceived as bluish green have inherent colours with a yellowish green hue.

- Inherent colours within the red-blue quadrant occur only in flowers.

- All green inherent colours in nature have yellowness. The inherent colours of green materials such as grass, leaves etc., most often have the hues G40Y or G50Y and nuances within what can be called the typically chlorophyll-green colour range (see figure).

  - Strongly chromatic inherent colours (c=65 or more) occur only in the hues Y and Y70R-R and on flowers with a hue between R and B.

  - Nearly white inherent colours (w=70 or more) occur only in the hues Y - Y40R and in certain parts of plants with hues between G and Y.

  - Nearly black inherent colours (s=80 or more) occur only in the yellow-red quadrant and hue G90Y.

The analysed assessments also make it possible to formulate some feasible hypotheses about the co-variation between different colour properties of the nature's inherent colours. In short, it seems like inherent colours with a large degree of blackness seldom have hues close to yellow, and where the hue lies close to yellow the blackness is usually small.

Presentation
The poster presentations for the AIC conference will include pictures, colour samples and NCS diagrams showing the method of analysis and some of the most important results.
LIGHT, COLOUR, MATTER AND PERCEPTION:  
APPLICATION OF OPACITY-TRANSPARENCY  
TO THE ARTISTIC PERCEPTIVE THEORIES

We are proposing a topic that unites on the one hand the learning of knowing how to look, directing it to the experience from various aspects that are proper of colour in art, on the other the desire of joining together the scientific theories of colour and perception with the idea of entering into what we could call the culture of chromatic observation.

In this essay, colour experience starts from a scientific look to its nature which, in a good measure, awakens a sense of vision that is committed and verified with regards to this knowledge. We consider this as a basic attitude to be able to approach the artistic vision. This last one adds to the previous the development of the contemplative capability, that is opened to different visions. We are going to divide these visions in order to direct them to the presence of the model, to art materials and to the representation, as a basic way of understanding the process of composition which makes up the proper way of the creative as well as recreative visual process.

At present vision is considered again as the original capacity of communication, a capacity which had been limited by optic Physics with its scientific divisions. Modern chromatology unites the science of colour and the psychology of perception. For this reason colour is considered as iconic and visual signs, that is, signs which are proper of the visual language which puts us in contact with the medium.

We must have a clear idea of the relation that exists between visual signs and iconic signs. For this purpose we clarify the different definitions of colour: physical: bright intensity - wave length - relative intensity, perceptual: brightness - shade - saturation, colorimetric or phychophysical: luminosity - tint - purity. The psychophysical names have been created by man in order to organise the colours in systems, diagrams or solids of colours.

So we have what is called material colour. They are proposals, models or colour samples which organise and shape up the structure that forms the visual communication. These are lights, points, tints and so on. It is made up by the external world.

The true colours are made up of the substantial elements - psychic in nature - which have visual meaning. Since they are sensations, they belong only to the level of perception. They cannot be measured and they are not only functional, but they can also be emotional, expressive, symbolic constructive.

Aside from the relations among the different levels of colours, it is important the knowledge of the perceptive process; the way how the iconic and visual units join together to make up superior units and these become compositions with a perceptive background, just because of their similarities with the compositive aspect of artistic language.

The organisation of perceptive compositions that takes place on the physical world have an influence on the organisation of iconic
compositions created by man in arts or in artistic works and vice versa.

Goethe studied the atmospheric colours or phenomena on landscapes. Because of these observations it is known that depth is a determining factor on changes of atmospheric shades. His solution is the amount of light that penetrates, considering the different possible variables between opacity-transparency that are found on wide spaces with clouds, fogs, etc. Naturally, another decisive factor is the changing light during the day, which emphasizes colour adaptation in the steady perceptive process.

When we look at the model we perceive proper chromatic sensations and outline chromatic sensations coming from the iconic figures of the model. However, in these sensations - aside from the influence that exerts the intensity of light in the environment - we also observe the proximity or distance from the visual figures, and the special relation among them according to the measure of colour perception (it is suggested the chromatic saturation). Their influence on the visual texture - which will be more intense when we are nearer - will be disappearing as we move away.

On the other side, the use of materials is done according to the way we are going to perceive it, and therefore, it is subjected to the laws concerning the way we perceive the surroundings. Both of them are iconic and visual signs. Seeing the surroundings in depth implies knowing what they are made up of. Art materials also tell us, in depth, when we know their process of constitution.

When it comes to reproduce a model, the general behaviour of materials has a direct connection with the application of the opacity-transparency theory, which we could call theory of the means or of plastic materials. The original studies of Goethe: the atmospheric medium in contrast with the pictorial medium, from its maximum density (opacity), until its maximum dilution (transparency).

The early understanding, on the part of the student, of the meaning of how it works, in general terms, the diluted materials, passing from middle stages until it reaches density, being used according to the need requested by the work, all this is a forceful proposal. This leads to take advantage of the means he has in a simple manner, but having in mind a very complex amount of indications which, on the other hand, are essential to be able to overcome the natural means and create other means in superior levels of learning.

With regards to colour, the criteria regarding extension of colours which have been established having various densities in the material are different as of brightness, shade and saturation. If the same colour is applied watered down or dense, when it dries will show different results in the texture. They will be different iconic and visual signs, and so on, until we are able to draw general conclusions, when it comes to the use of means to reproduce a model:

The methods of opposite signs: greater or smaller opacity-density of the materials used in representative painting offer the sensation of greater or smaller density or weight of the objects or things reproduced.

The connection among levels of vision in the field of meaning, that we are doing based on authors such as Praz, leads us to reflect on the hypothesis which maintains that the languages of culture are based on the languages of nature; in the case we are presenting it is the nature of visual perception itself.

The learning of the artistic means, and not of arts, implies knowing the physical and spiritual materials through the understanding that is offered to us by an attentive perception in dealing with them.
THE BLUE HOUSE

There are many large and luxurious houses along the coast west of Perth from which there are panoramic views of the Indian Ocean. Most of these houses are painted white. The house at 160 West Coast Highway was one of them and it was not particularly remarkable until it was renovated and repainted. It is the new colour that has made the house so widely known. Fan mail has been addressed simply to "The Blue House". There have also been complaints made to the local council. The house, its owner, and the strong reaction of those who have seen the house have been the subject of stories in the local newspaper and on television. The intensity of the blue exterior is matched by equally intense colours inside. Members of the Colour Society of Australia visited the house. Their comments about their experiences of the house will be included in the poster presentation together with other comments, plans, photographs and paint samples.

The house was built in 1952 and was in a run down condition when it was bought in mid 1994 by David Bianchi. Bianchi himself developed the concepts for renovation and colour treatment. His vision could best be realised with 'Solver' scenic paint, a water based flat acrylic paint developed for such specialist uses as scene painting and sign writing. Bianchi insisted on the use of this paint against the strict advice of both painter and manufacturer. The paint would not be expected to withstand long exposure to the sun or to the wind blowing off the sea. Inside the house the paint surface is vulnerable to normal domestic wear and tear; the surface marks easily and the marks cannot be wiped off. To improve the durability of the surface, and to help prevent "chalking", the paint was mixed with 'Bondcrete', a homopolymer bonding and sealing agent. But Bianchi also has a simpler and more radical solution to problems of deterioration - put on another coat of paint. The exterior still looks good after after five months but there were permanent hand prints on the walls of the staircase and in the main bedroom. Both areas have been repainted. The bedroom was originally painted gold, but that surface was especially vulnerable and the room is now yellow.

Bianchi is passionate about colour and compares Perth unfavourably with the more colourful cities of Europe. He believes in the power of colour to generate a sense of vitality and well-being. Inside the house he has created what he calls "caves of colour" where the same paint has been used on walls and ceiling. The main living and circulation areas are painted 'Solver Red'. The kitchen is 'Solver Orange'. The
main bedroom was 'Solver Rich Gold'; it is now 'Solver Lemon' as is the laundry room. The study and one of the other bedrooms are 'Solver Saxon Green'. The third bedroom is 'Solver Magenta'. The games room and exterior are 'Solver Ultramarine Blue'. Mosaic tiles line the bathrooms, yellow-green in one, dark red in the other. The approximate NCS hues and nuances of each of the paints will be shown on the poster. Each has a chromaticness of at least 80 except for the Saxon Green and Magenta where the chromaticness is about 55.

A unifying element which links the interior and exterior is the timber which is used for doors, windows, venetian blinds and handrails as well as for the high gloss floors. The colour of the timber is echoed in the orange-brown laterite gravel of the paths and the terra cotta planters in the garden. This is one of three colours which dominate the exterior. The others are the ultramarine blue of the walls and the almost unnaturally vivid green of the closely cropped grass lawns. To add sparkle, the drain pipes and metal supports for the handrails have been painted gold. Another element which adds sparkle and which is a strong feature in, around, and beyond the house is water. There is a swimming pool and a large ornamental pond with fountains, more fountains in a channel of water along the boundary wall, two fish ponds on the roof terrace, a large aquarium in the living room and the ocean itself which can be seen from nearly every room in the house.

Commenting on the exterior, many have referred to the curiously flattening effect that the blue paint has had on what is in fact a strongly three-dimensional form. The colour might be described as very "bright" but the painted surface has a Munsell value of only 2.5 which means that the degree of tonal contrast between surfaces in the light and those in shadow is much less than it would be if the house was still painted white. The intensity of colour and the suppression of form contribute to the isolation of the house from its surroundings. People who live nearby have complained that the house is alien and this has prompted suggestions that local councils should impose restrictions on the way people paint their houses.

Inside the house it is difficult to focus on the intensely coloured matte surfaces which seem almost like curtains of heavy mist. Although the colour scheme breaks all the conventional rules many of us were surprised to find that it appears to be so successful, even tasteful. Certainly we found it very exciting and agreed that the house would be a great place for a party. We are less certain about its suitability as a place to live. Our experience of the house led to speculations about possible physiological as well as psychological effects of colour. Apparently the painters complained of headaches after painting the living areas red and one of our members said the house made her feel sea sick. But most of us left the house in a state of great exhilaration.
Several earlier studies by the authors on the shape from shading phenomenon (1,2) have shown that chromatic colour strongly enhances the 3-D impression. The perceived shapes were induced by projecting a spatially modulated illumination onto flat surfaces. It was also found that it did not matter whether the colour was located in the surface or in the illumination. In two following experiments (3) the prediction was confirmed that this effect of chromatic colour also should bring some differences to the perception of simulated shape for "colour-blind" persons. Compared to normals a group with deutan colour vision deficiencies showed decreased 3-D impressions not only on their specific problem colours, but - surprisingly - also on other colours.

In the present study the issue is brought forward to the perception of real 3-D shapes. Seven deutan subjects were compared to normals as to their paired comparisons judgements of "shape distinctness" of scenes holding samples of grey geometric objects. Two identical scenes were independently illuminated by two projectors holding and alternating nine different chromatic filters. All possible pair combinations were presented and the judgements were scaled according to Thurstone's Law of Comparative Judgements (4).

The deutsans showed generally clear differences in perceived distinctness between the conditions, as opposed to the normals. The three conditions they judged as least distinct were two green illuminations and one yellow. The yellow and one of the green illuminations were also the two conditions in the experiment that were compensated for their higher perceived lightness by slightly reduced luminance. In both groups a red-purple (magenta) condition was judged as having the most distinct 3-D appearance.

References:
AN APPROACH TO COLOUR FROM DIFFERENT PERSPECTIVES: 
THE PERCEPTION OF YELLOW AS A PRIMARY COLOUR

The principal aim of the present work is to relate and clarify concepts, terminology, etc. between the different fields which work with colour: psychology, art, technology, science, etc.

This problem is accentuated in the field of colour, as it in itself, as opposed to form, has a number of aspects which directly influence its perception. Colour is a sensation, and therefore is subjective and finally depends on psychological factors. The perception of the colour depends on the material, light, background, form, size, texture, context, and the observer.

Taking this into account, we might ask how we can speak of an objective form of colour a most difficult but necessary question. We have used the methodology of the artist, the mixing of acrylic paints, in addition to the scientific method to unify our efforts.

The first word was the formulation of many colour samples, an Colour Atlas "Mixture of Acrylic Paints". This atlas is a systematic and orderly study in which the colour of the different gamuts was made for only the combination or mixture of two colours. These characteristics easily enable us to repeat any colour. The samples are intended to produce an opaque and homogeneously textured colour effect, thus we can to know the spectral reflectance curves which have been measured with a spectrophotometer. The Atlas has about 3000 colour samples on geler paper with a smooth matte texture, and another 3000 colour samples on watercolour paper with rough texture. The size of the colour samples are 4x4 cm, and with a identification codes which represent the colours used for each gamut. The interval between one colour and another within a same gamut is meant to be the minimum colour stimulus perceptible. The number of samples within the same gamut is not fixed, this number depending on the characteristics of the colour mixture. We have chosen to investigate the following combinations: mixture of basic colour with black and white; mixture of different primary colours; mixture of different secondary and complementary colours.

Thus, there is an arrangement of this gamut in different panels. The most important objective of this Colour Atlas is to facilitate the visualisation and learning of the different chromatic characteristics of the various mixtures. It is possible to compare minimum perceptible differences between colours, and it is possible know and repeat each colour.

Afterwards, diffuse spectral reflectance was measured for each colour sample. Samples were diffusely illuminated with simulated CIE D 65 spectral distribution filtered to eliminate infrared specimen heating. The geometry of observation was eight degrees from a normal specimen. The measuring range was from 400nm to 700nm with a 5nm wavelength interval. This measurement permits us the possibil-
ity of ascertaining the spectral composition of the light of the colour reflected by a colour-object. It is an objective and not a subjective measurement.

Here, we present the characteristics of the yellow colour. In paint and print, the yellow is a primary colour—it is not a mixture of the other colours but rather a colour basic and necessary for obtaining other colours—and psychologically is a basic and primary colour, also. For the additive synthesis we know that the yellow is obtained by mixing of red and green. We can ask you: What is the true idea? Are there opposite concepts or not?

A first view, it is so. When we see the spectral reflectance curves (hereafter s.r.c.) of saturated and light yellow—Cadmium Yellow (AC), Hansa Yellow (AH) and Primrose Permanent Yellow (AP)—we see that it is necessary that the percentage of light reflectance of the middle wavelengths and of the long wavelengths was very higher, about of the 90%, and constant, and percentage of the short wavelengths is negligible.

However, if we view the different colour mixtures with the yellow and their s.r.c. (shown in figures), we may see that:

1.- Mixture with white: Yellow appears desaturated and light. The percentage of s.r.c. of short wavelengths is higher and the middle and long wavelengths are constant. When the percentage of the short wavelengths reach 50%, the colour is perceived as white.

2.- Mixture with black: we might hope that the colour would appear desaturated and dark without change in hue and s.r.c. flat. However, the percentage of the long wavelengths is lower than the middle wavelengths, and therefore, we see a green colour. This happens with only as mall of black.

3.- Mixture with red: the s.r.c. was constant for the short and long wavelengths but fall for the middle wavelengths. The colour appears orange.

4.- Mixture with blue: the s.r.c. fall for the middle and long wavelengths (in the case of the latter faster) and rise the short wavelengths. The yellow colour appears green very quickly with a minimal mixture of blue.

5.- With the mixture of its complementary colour, the purple-violet, yellow desaturates quickly and appears the grey. The s.r.c. changes in a less uniform way than the others.

In conclusion, we can state that minimal changes in mixing yellow with other colour causes the sensation of yellow to disappear. Yellow perception is linked to a hue light and saturation and is not perceived as a mixture with any other colour. Yellow objects reflect most of the middle and long wavelengths and absorb more of the short wavelengths, 90% emitting from 500 nm to 700 nm. Both concepts are true.
Denotative Meaning of the Colour Name

Color names vocabulary distinctive features, its diversity and ability to differentiate between colours are to a great extent a function of cultural and national peculiarities. It does not mean, however, that there are no laws governing colour naming. Thus different languages identify more or less identical regions or spheres of colour space matching the base [focal] colours totalling eleven [Berlin B., Kay P.]. Although the borders between base colours are much less fixed, inter-language differences in identifying such borders do not exceed inter-individual differences between people speaking the same language, according to Stivik L. and Hárd A. One can put it this way: there is various degree of approximation to the unified colour categories which is determined by cultural and historic factors.

The number of colour names is by no means limited to the base colours. There are national traditional colour names. One colour can get several names close in meaning. One on the other hand, there are colour samples for which it is rather difficult to find a name [nominative uncertainty]. In general the correlation between the colour and its name is not unequivocal since any colour name is denotatively uncertain and corresponds to a colour band rather than colour point. Therefore establishment of a correlation "colour name-colour sample" becomes an experimental objective.

In our experiments we used the method of focal colours identification. The Ss undergoing the test was suggested to select just one sample which in the person's view is the best match for a given colour. This method allows to get specific data on the meaning of each colour name which will reflect the ideas of color in the mind of persons speaking certain language, as well as make a conclusion on the need to enter a new term in the structure of colour names. A list of 260 colour names developed by I.V. Penova was used. It was broken down into 10 sections with a base colour at the head [red, orange, yellow, green, blue, light-blue, violet, purple, brown, pink] and its hues with modifiers [light-, dark-, pale-, bright-], names of intermediate colors composed of a main tone and its hues with modifiers, and finally names of achromatic colours with hues of this tone and traditional names.

Colour samples matching the names were taken from the NCS colour atlas. Altogether 30 S with normal colour sight were tested on an individual basis. The parameters calculated were $M + i$ and $/7s/0$ with histograms built for each of the 3 parameters calculated [W-S, S-C, tone]. $M$ allows to identify color coordinates matching a given name; $/7s/0$ reflects the degree of denotative certainty of a given name; $i$ allows to identify a region in the color space corresponding to a given name and to select a correct color sample which corresponds to a given name to the utmost.

1. Base colours

The experiment has shown that different parameters are most certain and unequivocal for different colors. Thus yellow, orange and red colours are practically uniformly selected by W-S parameter, while most of those tested perceive purple color uniformly by tone, while "colourless" parameter remains uncertain. The main colour names have been broken down into the following groups according to the degree of denotative certainty:

1. red, orange, yellow, violet.
2. blue, light-blue, purple.
3. pink, brown, green.

The first group comprised names with the least spread along all the three pa-
rameters, i.e. the most denotatively certain. The second group comprised names which are clearly identified by two parameters out of three. The third group comprised those names which have the maximum spread by all three parameters. The most denotatively certain is red. However, two samples [1080 Y80R and 1080 Y90R] can be with the same probability chosen as optimum match since there are clear peaks by tone. The same conclusion can be made with respect to blue and pink.

The easiest to identify are the color names in the red-yellow sphere. These results correspond to the findings of other authors: the most "intense" spheres correspond to red and yellow color names [L. Sivik, A. Händ]. It may be the fact that the red-yellow sector of the color space is nominally well-developed. There is a name for a color intermediate between yellow and red-orange; yellow and red with a lot of black added to them turn brown, while light and less saturated [with a lot of whiteness] reds are perceived as pink. In the view of the Russian speakers vis-à-vis Sweden color standards, red and green a more yellowish; purple lie in the sphere of Swedish red; blue and light-blue are also shifted in the direction of red.

2. Intermediate colors
Denotative certainty of intermediate color names is lower than in the case of base colors. The more definite correspondence between names and colors is in the red-yellow spectrum, just like with base colors. Purple-blue turned to be severely spread along all the parameters. Some of the tested found it difficult to find a sample matching the name and some simple denied knowledge of such color name. Similar data was obtained with respect to olive-yellow color.

3. Traditional color names
The 5% tested had pretty good knowledge of most of the national names, although some of the names showed a rather big spread. Thus the maximum divergence [especially in tone] was characteristic of "pistachio" and "olive" colors. Some of those tested acknowledged that they have only a slight idea of these colors would be like, others simply refused to identify a sample for these names. The most clearly identified were the following traditional names: lilac, crimson, brick-colored, ruby, violet and ivory. Colors corresponding to traditional names are grouped around base and intermediate colors. Thus, claret-colored, cherry, crimson and ruby surround the purple color; coffee, beige, sandy and peachy surround the brown color. In this way the abovementioned color names are in a way synonymous to the base color names. In other words, they are more specific versions of abstract color names and do not fill nominally undeveloped fields. For color names identified by those tested in several bands of a color tone, the following conclusion can be reached: the band may influence the selection of samples corresponding to the names. However, the overall influence is not significant. If the suggested band of color tones is expanded by merging different bands, the data obtained may be much more uniform.

Several names have been distinguished for which within every band there are clearly identified samples with greatly divergent medians, for example spread of samples matching the name "creme-colored". All the best creme samples are quite well defined along the parameter of W and C - these are light, low-saturated colors [0020 Y30R, 0020 Y50R, 0020 Y70R], but they are more divergent by tone. There are yellow-creme, orange-creme, pink-creme. Apparently one can speak about a group of "creme" colors in this case.

Also indefinite was the selection with respect to color names "sea wave" and "turquoise". The was a trend to distinguish between the green [3050 B50G] and blue [3050 B30G] sea wave*, as well as green [2050 B50G] and blue [2050 B50G] turquoise.
THE PLEASANTNESS OF GREEN-BLUE COLOUR COMBINATIONS

IN POLISH CHILDREN

Many colour order systems have been devised to help users both to analyze colour combinations and to assemble colours in pleasant ways. A theory, independently proposed by Abbot and Müller, states that two colours of different hue are pleasantly combined when the colour belonging to the naturally lighter hue is the lighter colour of the couple (the combination is then named correspondent); when such relationship is otherwise inverted the combination should be unpleasant. This theory refers to colour order systems in which lightness is one of the three major colour dimensions. A further development of this theory, advanced by W. Spillmann, refers to colour order systems in which whiteness and blackness are considered more prominent perceptive aspects than lightness, and states that a third possibility exists apart of the two correspondent and inverted combinations: if one colour is more whitish and also more blackish of the other, the couple is called vague inverted and should appear unpleasant, while the inverted combinations could be sometime considered pleasant by particular persons.

In this research we wanted to verify whether Polish children preference for some green/blue bi-colour combinations is in accordance with Spillmann’s theory, and whether their evaluations agree with those showed by Italian children of the same age. Moreover we wanted to establish whether sex, socio-cultural and educational differences affect Polish children preferences for the submitted colour combinations, and how much stable are these preference in a period of about two weeks. Lastly we aimed at verifying whether preferences for the colour combinations depended on preferences for the single colours.

Three correspondent, one inverted and two vague inverted combinations where prepared: in each of the six stimulus cards, forming the colour combination series, a slightly greenish blue (10 70 B10G) was coupled with one of six nuances of a rather yellowish green (G30Y),
arranged in the shape of a six-square chequer-board over a white background. Each yellowish green nuance was also mounted over a white card to form the single colour series.

Each stimulus series was randomly displayed over a white table in natural light and subjects had to rank the cards in order of preference, alternating the most and the least favourite ones. Average scales of preference with regard to all the subjects and to different sub-groups were derived using a standard ranking method.

64 male and 59 female children, 10 years old in the average, from six different elementary schools of Torun, Gabcín, Szadłowice and Znin (Poland), were twice singularly tested at a distance of about two weeks.

Results are in almost perfect agreement with Spillmann's hypothesis, showing that the three correspondent colour combinations are the most preferred and the two vague inverted combinations are the least preferred; the inverted combination usually appear placed in the middle of the scale, but in different sub-groups it can rank from the first to the last place. The results agree also with what found in a previous research performed in Italy by da Pos, in which 250 elementary school children were similarly tested. Both the results obtained with children in Italy and in Poland differ from results obtained with adults in Italy and in India as far as the inverted combination is concerned: this combination is the least preferred by Italian adult subjects, while it is highly appreciated by Indian adults (Broota & da Pos. No difference has been found between male and female subjects, between country towns and main city, between the first and the second session. Correlations between scales of preference for color combinations and for single colours are relatively high, but not enough to state that the preferences for single colours are determining the preferences for colour combinations.
A Vision of Clear Terms.

Scientific terms must communicate clearly

This paper gives a base for a concept analysis of the definitions concerning light and colour. Many of the terms used in the field of light, colour and vision are not clearly defined. Some definitions have their origin in theories on light and vision, long outmoded. Today, it is not possible to present neither basic knowledge, nor scientific discussions on light and vision in a consistent way. My paper is an attempt to describe the basic knowledge of light and vision in a way that is easy to understand, using a developed vocabulary.

Visual and physical

The basics of vision and seeing describe i.a. the relations between what we see and light in its physical sense, here defined light\textsubscript{phys}. This knowledge deals with connections between a physical reality, and their visual impressions (stimulus = perception). To describe these connections in a clear way, we need terms that clearly define the physical and the visual. Visual qualities cannot be described in physical terms, as little as physical factors can be defined in visual terms. Therefore, we need two equal vocabular spaces, one visual, one physical, to clearly describe the basics of light\textsubscript{phys} and vision. To understand the conditions of vision it is necessary to always keep the distinction between visual and physical. The established vocabulary of today does not fulfill this requirement.

Current theories on light and vision have been developed in a physical context. The vocabulary is influenced hereby, as well as the direction of scientific research on light and vision. Many physical terms have their roots in common words, often developed from experiences of the senses. Consequently, one and the same word has both a common meaning, acquired by experience, and is also used as a scientific term in a totally different meaning.

Definitions need to be revised

To reach clarity, certain terms of today’s vocabulary must be revised. The most obvious example is the term light. Light in common language means something seen, the original meaning of this word. In physics, light means electromagnetic radiation. In the CIE Vocabulary, the term “light” is defined:

1. visual (perceived light)
2. physical (visible radiation).

Today, nobody would present the idea to define stimulus and perception with the same term. But, unfortunately, it was done three hundred years ago. It all goes back to the basic question: What is light?... The term itself gives no indication whether it is used as visual or physical. It is occasionally clarified by the context, but far from always. This certainly prevents a distinct communication in the field of lighting, and gives rise to conflicting and obscure interpretation.

"Visible radiation" a mistake.

We all know the physical truth about light, being visible radiation, combining rays of different colours as seen in the spectrum, together creating uncoloured radiation, called white light. This statement has its roots in the sphere of physical science around 300 years ago.
Almost every book on light or colour today describes the fundamentals of light that way. As if the pioneering results from vision research during the last century do not exist. We have long known that vision is the result of complex processes in several visual centers of the brain. Fundamental to these interpretation processes is retinal information, produced by electromagnetic radiation entering the eye. Through biochemical processes, this radiant energy is transformed by rods and cones into neural signals, being transported through the vision nerve to the visual centers of the brain. It is to remain at the 17th century level of knowledge, to assert that what we see as light should be visible rays or radiation.

This conclusion is false, and always has been.

At the CIE conference in New Dehli 1995, I presented a paper, entitled Re-define the term "light", a proposal to initiate a revision of the CIE International Lighting Vocabulary, regarding today’s knowledge of the physical stimuli and the processes of visual perception.

My paper to AIC 96 exemplifies the use of a terminology developed at our department at KTH, Stockholm. We have searched for terms that clearly describe their meaning. The characteristics of what we see are visual, while the properties of light are physical. If these concepts are kept separate, the knowledge of light and vision can clearly be described.

Light is what we see
The term light is used only in its visual sense. Light in its physical meaning is called light-physics or radiant energy, light energy, light radiation, stimulus to vision etc. But not light. And not visible radianse, as light-physics is not visible – though being the stimulus to vision.

Let us develop terms to explain the physics of optic radiation in a correct way. Let us also extend the vocabulary of light in its visual sense. The terminology regarding the perceptual implications connected to light has a very determined representation in the CIE Vocabulary.

My paper to AIC 96 suggests a set of terms needed to give a clear description of basic knowledge of light-physics and vision, also presented by examples from a report in preparation.

It is possible to develop a functional terminology that gives a clear understanding of separate factors as well as of the context, these terms are used to describe. It is not possible, however, to make a clear description of knowledge without strictly defined terms. So, it is a question of choosing the way: to establish a clear terminology, or to waive. The latter alternative will not combine with scientific pretentions.

To develop and introduce new and adequate terms will certainly need creativity, patience and time. I am convinced, however, that a developed terminology will contribute to a more consistent understanding among the different groups in the vast field of lighting and vision. Education, research work as well as planning and product development will gain hereby.
THE POWER OF IMAGES
THE STENDHAL SYNDROME

The poster deals with the disturbing emotional impact exerted on two observers by the pictures of Caravaggio, the renowned 16th century painter. Both cases exemplify the psychopathological reactions to which elsewhere I have applied the name “The Stendahl Syndrome”.

Stendahl described, in 1817, the severe malaise he suffered after visiting and viewing for the first time the marvels of the church of Santa Croce in Florence, particularly Volterrano’s frescoes. I have documented similar transitory disorders among contemporary travellers overcome by the aesthetic experience generated by famous masterpieces in great museums.

Here I shall focus on the unsettling power of light and of color in the perception of certain of Caravaggio’s provocative portraits – a power that served to elicit momentary crises in the observer’s sense of identity.

Franz, a middle-aged Bavarian bachelor, felt faint in front of Caravaggio’s Adolescent Bacchus. He studied the painting for hours, seeing colors he had never seen before, feeling dazed, his senses struck and disconcerted by the chromatic waves assailing and disoriented him.

Henry, a young American, started to feel perturbed by the ever-shifting lighting system at an exhibit of Caravaggio’s works in Florence. The oscillations of light and dark made him dizzy, causing him to lose the sense of his own existence as well as that of the pictures. Certain paintings, such as Bay Being Bitten by a Lizard, The Sick Little Bacchus, Boy with a Fruit Basket, The Lute Player, and in particular Narcissus, forced him to flee, fearing a breakdown.

These phenomena will be interpreted in a psychoanalytical context which focuses on the emergence of unconscious experiences, split-off and repressed aspects of the personality.

Colored illustrations of the pictures mentioned are reproduced in the poster.
AIC Interim Meeting '96
June 15-18 1996 --- Göteborg, Sweden

Colour & Psychology

Organised by
the Swedish Colour Centre Foundation, AIC Member Body

Organising committee:
Lars Sivik
Berit Bergström

Sponsors:
Swedish National Building Research Foundation
Scandinavian Colour Institute

Saturday, June 15
Place: NOVOTEL

17.00 - 18.30 Registration

18.30 Opening Session:
Lucia R. RONCHI
President of AIC

Mikaela ECKERED
Chaim. Sw. Colour Centre Foundation

Erling ZANDFELD - "Color as Messenger"
Swedish Fed. of Painting Contractors

19.00 Welcome Reception
PERSONALITY AND COLOUR PREFERENCES

COULD PERSONAL COLOURING BE THE MISSING LINK?

As part of a research project in Design, a triangular model of relationships between personality, colour preferences and personal colouring was proposed. The genetic relationship between personality and personal colouring was inferred from recent studies of identical twins reared apart from birth and from studies of selective breeding in animals to give rise to desired temperamental traits. The relationship between personality and colour preferences has been extensively studied by psychologists such as Max Luescher, who recognise colour combinations as a universal non-verbal language system. The verbal messages implied by colour combinations have been mapped by S. Kobayashi using Warm-Cool and Soft-Hard axes to form a 'Color Image Scale'. The like-dislike dimension of colour preferences based on these 'images' may be an expression of personality traits.

Personal Colouring, defined as four basic hair colourings and four basic skin colourings, was classified into 16 combinations according to the Color Image Scale. PERSONALITY was defined as two possible ways of relating to the external world of people and things (Extraversion and Introversion), two ways of gathering information (Sensing and Intuition), and two ways of making decisions (Thinking and Feeling), according to Jung's "bottom line" traits. The authors of the Myers Briggs Type Indicator (MBTI), which was used in this investigation, add a preference for gathering information (Perceiving) against a preference for making decisions (Judging), so that again there are 4x4 or 16 possible combinations. Colour Preferences were defined as a limited palette chosen in a similar way to the "self portrait" task originally given by Johannes Itten to his art students; the formation of a 20 square pattern made up of 5 to 10 colours the subjects felt they could personally identify with, "own", or "love". Each of the 4 palettes used for Personal Colours Analysis was arranged according to the Color Image Scale's four quadrants, making 16 squares. Correspondence between the Color Image Scale and the MBTI types had been made by using the Luescher Color Test (1989), which uses 4 versions of each of the basic reference col-
ours (yellow, red, blue and green) and can be aligned easily with the Color Image Scale. Colours chosen by subjects for this exercise could be analysed according to this "modified" Color Image Scale.

Subjects were asked to complete the MBTI and verify their "Type". They were also asked to choose 20 chips in 5 - 10 colours they felt particularly drawn to, and fill a 20-square grid with a pattern they found satisfying. As a cross check, they also completed a "Subjective Colours Test" based on the four palettes used for Personal Colours Analysis. The subjects' personal colouring, MBTI preferences and Subjective Colours Test results were each recorded on a 16 square grid. Where there was correspondence between personal colouring and MBTI preferences, (indicated by a similar position on the 16 square grid), a prediction was made that a subject's colour preferences would fall in a similar position on the 16 square grid of the "modified" Color Image Scale. Of 18 adult subjects a clear 3 way relationship was demonstrated in 8 cases. In another 5 cases there was either variation between personal colouring and MBTI in only one of the four MBTI dimensions, and the colour preferences matched, or correspondence occurred without exact matching of colour preferences. The results were sufficiently encouraging to warrant further research.
THE "PALETTE" OF NOVEL WRITERS

During the past few years, we have been going through the literature (e.g., the most widely known novels and romances) to record how the writers use color names (of course, without displaying the quoted color in flanking illustrations, in the written context). First of all, we subdivided various books according to whether (a), only a few basic monolexic color names are used, intended to represent the current symbolic or idiomatic meaning, or (b), the descriptions of the environment, be it natural landscape or interior decoration, or of psychological situations, of dresses, of eye, hair, etc. are imbedded to color names and/or to references to color. In case b), the gamut is very wide, and much depends on writer's aims and initiatives.

Now, it is known that the visual effects of light and color cannot be disentangled from one another. This fact has a counterpart in the literature (case b).

In the present poster, after an abridged review of the use of color naming in case a), we pass to case b), having in mind the history of light sources, from candles to fluorescent tubes, through gaseous and incandescent sources, as well as the development of the use of general lighting, say, practically up to the twenties of the present century. All it had a strong influence on the appearance of the environment and on human performance, and it is mirrored in the literature where the writers have been utilizing two important tools they had at their disposal: light and color.

The psychological influence of the cycle of natural light was very strong, before the advent of general lighting, by creating a sharp distinction between poor and rich human beings. The former did not need to consult the watch, their habits being driven by the diurnal cycle of sunlight. After sunset, the flame of the candle, the peculiar quality and quantity of the emitted light, was often quoted to a